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Assessment of Abundance and Richness of Urban Bird Species in Green and Non-Green Areas in Gombe Metropolis, Gombe State, Nigeria

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ABSTRACT
Urbanization is one of the major forms of land-use change affecting biodiversity and ecosystem functioning. This study assessed the abundance and richness of urban bird species in green and non-green areas of Gombe Metropolis, Gombe State, Nigeria. A random sampling design was employed, with the study area stratified into green and non-green habitats. Birds were surveyed using the fixed-cardinal point count method, with sampling points established approximately 100 m apart. Each observation lasted 15 minutes within a 50 m radius and was conducted during morning and afternoon/evening periods. Bird identification was done based on standard field guides ABC Bird of Africa field guide (2020) and binocular for visual and auditory identification. A total of 6,713 individual birds belonging to 60 species, 44 genera, 27 families and 16 orders were recorded. Laughing Dove (*Spilopelia senegalensis*) was the most abundant species with 1,577 individuals, The feeding-guild composition was dominated by granivores, which accounted for 20 species (33.3%), followed by insectivores and omnivores with 11 species each (18.3%). Morning observations recorded 3,532 individuals representing 60 species, whereas afternoon/evening observations recorded 3,181 individuals representing 58 species. Seasonal variation was also evident, with the wet-season sampling period recording 5,885 individuals and 60 species compared with 828 individuals and 42 species during the dry-season sampling period. Green areas supported 4,437 individuals (66.1%), while non-green areas supported 2,276 individuals (33.9%). However green areas play a critical role in maintaining bird diversity. Public awareness should be raised to inform the local populace on conserving green areas used by bird species.

Keywords: Urban birds, Habitat, Gombe metropolis

INTRODUCTION

Urbanization is one of the most significant and rapidly expanding forms of land-use change globally, with profound implications for biodiversity and ecosystem functioning. As human populations continue to increase, particularly in developing regions, natural landscapes are increasingly transformed into urban environments characterized by buildings, roads and other infrastructure. Such transformation frequently results in habitat loss and fragmentation, thereby altering ecological processes and species composition (Aronson *et al.*, 2020; Awoyemi *et al.*, 2024). Urbanization also represents a broader socioeconomic and cultural transition involving changes in land use, human settlement patterns and resource utilization. Increasing demand for residential, commercial and transportation infrastructure often results in the replacement of natural and semi-natural habitats with built-up surfaces. These changes can reduce the availability of vegetation, nesting sites, feeding resources and shelter required by wildlife.

Birds are particularly useful organisms for assessing environmental changes because they are widely distributed, relatively easy to observe and responsive to changes in habitat structure and resource availability. Changes in bird abundance, species richness and community composition can therefore provide valuable information about the ecological condition of urban environments (Basile *et al*., 2021; Rega-Brodsky & MacGregor-Fors, 2024).

Urban landscapes generally consist of a mixture of green and non-green habitats. Green areas include parks, gardens, institutional grounds, woodland patches and other vegetated environments, while non-green areas include roads, commercial centres, residential buildings and other highly developed locations. These habitat types differ in vegetation structure, food availability, microclimate, shelter and human disturbance, which can influence bird distribution and abundance. Green spaces are particularly important because they provide food, nesting sites, shelter and breeding habitats. Vegetation complexity also creates several ecological niches that can accommodate birds with different feeding and habitat requirements. Large and structurally complex green spaces can support insectivorous, frugivorous and woodland bird species by providing natural food resources and reducing the effects of habitat fragmentation (Lu *et al*., 2024; Wang *et al*., 2024). In contrast, non-green areas tend to favour adaptable generalist species capable of exploiting anthropogenic food resources and artificial structures. Such conditions may lead to the dominance of a small number of disturbance-tolerant species while reducing the occurrence of habitat specialists (Callaghan *et al*., 2021; Danmallam *et al*., 2024). Despite the ecological importance of urban birds, information on urban avifauna remains limited in many Nigerian cities. This is particularly relevant to Gombe Metropolis, where increasing urban development has resulted in substantial modification of the natural landscape. Understanding how birds respond to different urban habitats is therefore important for biodiversity

conservation and sustainable urban development. The present study assessed bird species abundance and richness in green and non-green areas of Gombe Metropolis. Specifically, the study documented the bird species present, examined their feeding guilds, investigated the effect of time of day, assessed seasonal variation, and identified habitat-associated species and compared bird abundance and richness between green and non-green areas.

MATERIALS AND METHODS

Study Area

The study was conducted in Gombe Metropolitan Area, Gombe State, northeastern Nigeria. Five major sampling axes were selected: Dukku axis, Central axis, Tumfure Road axis, Kaltungo-Yola Road axis and Biu Road axis. The vegetation of the area is predominantly Sudan savanna woodland, characterized by grasses, shrubs and scattered trees. The climate is characterized by distinct wet and dry seasons. The wet season generally occurs from April to October, while the dry season occurs from November to March. These seasonal differences influence vegetation growth, water availability and food resources, which can consequently affect bird abundance and distribution.

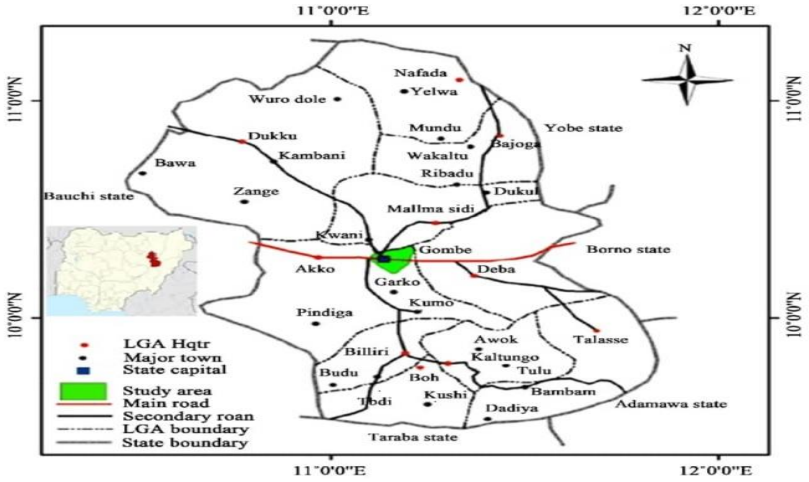


Figure 1: Map of Gombe State showing the study area

Sampling Design

A random sampling approach was adopted. The study area was stratified into green and non-green areas to facilitate comparison of bird abundance and richness between contrasting urban habitats. Sampling points were established approximately 100 m apart to minimize the possibility of recording the same individuals at adjacent points (Bibby *et al*., 2000). Bird observations were conducted using a fixed-cardinal point-count method.

Bird Survey

Each point count lasted 15 minutes, during which all birds seen or heard within a 50 m radius were recorded. Surveys were conducted during peak activity periods in the morning from 06:30am to 09:30am, and afternoon/evening, from 15:30pm to 18:30pm over a period of six month (July-December) when bird detectability is highest (McClure *et al*., 2020). Birds were identified using binoculars and standard field identification guides, including (Burrow & Demey, 2023) and Birds of Western Africa. Both visual and auditory observations were considered during the surveys.

Data Analysis

The recorded data were summarized using species abundance and species richness. Analysis of Variance (ANOVA) was used to determine differences in bird abundance and richness of the green and non-green habitat. Descriptive statistics were used to summarize species abundance, richness and the bird species Seasonal relationships were assessed using chi-square analysis. Statistical significance was evaluated at $p < 0.05$.

RESULTS AND DISCUSSION

Results

Species Composition and Abundance

A total of 6,713 individual birds belonging to 60 species, 44 genera, 27 families and 16 orders were recorded during the study. The most abundant species was Laughing Dove (*Spilopelia senegalensis*) with 1,577 individuals. Speckled Pigeon (*Columba guinea*) was the second most abundant species with 919 individuals, followed by Cattle Egret (*Bubulcus ibis*) with 552 individuals. Purple Starling recorded 504 (*Lamprotornis purpureus)* individuals, Piapiac (*Ptilostomus afer)* recorded 350 individuals, while Village Weaver (*Ploceus cucullatus*) recorded 246 individuals. Some species were recorded only once during the study. These included Black-headed Heron (*Ardea melanocephala*) and Green Wood Hoopoe (*Phoeniculus purpureus*). The occurrence of these species at very low abundance indicates differences in habitat use and resource requirements among species.

Table 1: Bird Species Composition in Gombe Metropolitan Area

S/N	Common Name (Species)	Scientific name	Occurrence
1	Abdim's Stork	*Ciconia abdimii*	2
2	Abyssinian Roller	*Coracias abyssinicus*	26
3	African Grey Hornbill	*Lophoceros nasutus*	7
4	African paradise flycatcher	*Terpsiphone viridis*	6
5	African Silverbill	*Euodice cantans*	137

S/N	Common Name (Species)	Scientific name	Occurrence
6	African Thrush	*Turdus pelios*	85
7	Bearded barbet	*Lybius dubius*	27
8	Beautiful sunbird	*Cinnyris pulchellus*	3
9	Black headed heron	*Ardea melanocephala*	1
10	Black-Headed Lapwing	*Vanellus tectus*	131
11	Bronze Mannikin	*Spermestes cucullata*	5
12	Brown Babbler	*Argya rubiginosa*	38
13	Cattle Egret	*Bubulcus ibis*	552
14	Chestnut-bellied Starling	*Lamprotornis pulcher*	61
15	Common bulbul	*Pycnonotus barbatus*	176
16	Common waxbill	*Estrilda astrild*	35
17	Copper sunbird	*Cinnyris cupreus*	4
18	Crested lark	*Galerida cristata*	14
19	Feral pigeon	*Columba livia domestica*	130
20	Fox krestel	*Falco alopex*	13
21	Gabar goshawk	*Micronisus gabar*	75
22	Green oriole	*Oriolus auratus*	4
23	Green wood hoopoe	*Phoeniculus purpureus*	1
24	Grey headed kingfisher	*Halcyon leucocephala*	4
25	House sparrow	*Passer domesticus*	107
26	Lanner Falcon	*Falco biarmicus*	128
27	Laughing Dove	*Spilopelia senegalensis*	1577
28	Little weaver	*Ploceus luteolus*	2
29	Long Tail Glossy Starling	*Lamprotornis caudatus*	229
30	Melodious warbler	*Hippolais polyglotta*	96
31	Mosque swallow	*Hirundo senegalensis*	74
32	Mourning Collared Dove	*Streptopelia decipiens*	7
33	Northern grey-headed Sparrow	*Passer griseus*	90
34	Northern Red Bishop	*Euplectes franciscanus*	1
35	Northern Red-billed hornbill	*Tockus erythrorhynchus*	105
36	Orange-cheeked wax-bill	*Estrilda melpoda*	29
37	Pearl-spotted Owlet	*Glaucidium perlatum*	17
38	Piapiac	*Ptilostomus afer*	350
39	Pied crow	*Corvus albus*	26
40	Pin-tail Whydah	*Vidua macroura*	1
41	Purple starling	*Lamprotornis purpureus*	504
42	Pygmy Sunbird	*Hedydipna platura*	58
43	Red-billed fire finch	*Lagonosticta senegala*	22
44	Red-billed Quelea	*Quelea quelea*	17
45	Red-cheeked cordon bleu	*Uraeginthus bengalus*	92
46	Rose-ringed Parakeet	*Psittacula krameri*	61
47	Scarlet-chested Sunbird	*Chalcomitra senegalensis*	48
48	Senegal Coucal	*Centropus senegalensis*	43
49	Senegal Parrot	*Poicephalus senegalus*	28
50	Speckled Pigeon	*Columba guinea*	919
51	Sun Lark	*Galerida modesta*	20
52	Tawney-flanked prinia	*Prinia subflava*	16
53	Village indigobird	*Vidua chalybeate*	56
54	Village Weaver	*Ploceus cucullatus*	246
55	Western-grey Plantain-eater	*Crinifer piscator*	73
56	White-throated Francolin	*Campocolinus albogularis*	13
57	Yellow-billed Kite	*Milvus aegyptius*	12
58	Yellow-billed Shrike	*Corvinella corvine*	77
59	Yellow-crowned Gonolek	*Laniarius barbarous*	5
60	Yellow-fronted Tinkerbird	*Pogoniulus chrysoconus*	27
	Total		6713

Feeding Guild Composition

Table 2 shows the distribution and classification of the bird species by their feeding guilds. The recorded bird species were classified into six feeding guilds based on their primary feeding habits. Granivorous birds constituted the largest feeding guild with 20 species (33.3%). Insectivorous and

omnivorous birds each accounted for 11 species (18.3%), while carnivorous birds comprised 9 species (15.0%). Frugivorous birds were represented by 5 species (8.3%), whereas nectarivorous birds formed the smallest feeding guild with 4 species (6.7%). The analysis further reveals a statistically significant variation among the feeding guilds, indicating differences in resource utilization and ecological roles among the species present.

Table 2: Types of Feeding Guilds

S/No	Feeding Guild	Number of Species (Occurrence)	Percentage (%)
1	Granivore	20	33.3
2	Insectivore	11	18.3
3	Omnivore	11	18.3
4	Carnivore	9	15.0
5	Frugivore	5	8.3
6	Nectarivore	4	6.7
	Total	60	100.0

Effect of Time of Day on Bird Abundance and Richness

Fig 2 shows the effect of time of day on bird species abundance and richness in the Gombe Metropolitan Area. A total of 3,532 individual birds belonging to 60 species were recorded during the morning sampling period, whereas 3,181 individuals representing 58 species were recorded during the afternoon/evening sampling period. The results indicate that both species abundance and species richness were higher during the morning than in the afternoon/evening.

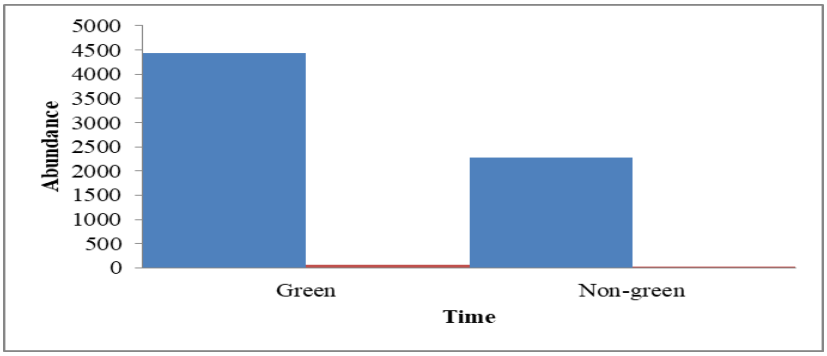


Figure 2: The effects of time of the day on species abundance and richness

Seasonal Variation

The results indicate that the dry season recorded the highest species abundance and richness compared to the wet season. Seasonal variation in bird species abundance and richness in the Gombe Metropolitan Area is presented in Figure 3 A total of 5,885 individuals representing 60 species were recorded during the wet season (June–October), while 828 individuals representing 42 species were recorded during the dry season (November–December). The highest monthly abundance was recorded in September, followed by July and October, whereas the lowest abundance was recorded in December. Statistical analysis further revealed a significant relationship in species abundance and richness between the seasonal periods X2 (24, N= 3424), = 1755.22, P = 0.003).

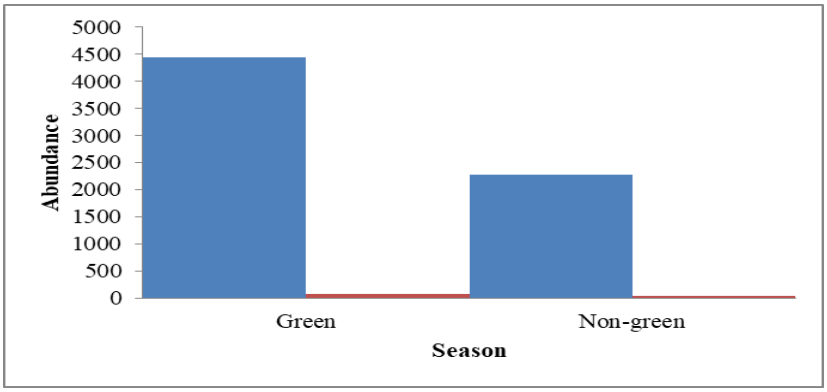


Figure 3: Seasonal variation in species abundance and richness in the study area

Bird Abundance in Green and Non-Green Areas

The comparison of bird species abundance between green and non-green areas is presented in Table 4.5. A total of 6,713 individual birds were recorded across all sampling sites. Of these, 4,437 individuals (66.1%) were recorded in the green areas, whereas 2,276 individuals (33.9%) were recorded in the non-green areas. The results indicate that green areas recorded a higher number of individuals (4,437), whereas non-green areas had a lower number (2,276). This difference is statistically significant, demonstrating that species abundance is considerably greater in green habitats compared to non-green areas ($F(1, 22.04) = 4.207$, $p < 0.04$).

Table 3: The Abundance of Bird Species in Green and Non-Green Areas in the Study Area

Habitat	Abundance (Individuals)	Percentage (%)
Green areas	4,437	66.1
Non-green areas	2,276	33.9
Total	6713	100

Discussion

The recording of 60 bird species in Gombe Metropolis demonstrates that urban areas can retain considerable avian diversity. The presence of 27 families and 16 orders indicates that the metropolitan landscape contains a range of habitat conditions capable of supporting species with different ecological requirements. The high abundance of Laughing Dove, Speckled Pigeon and Cattle Egret suggests that adaptable species are particularly successful within the urban environment. These species can exploit a broad range of resources and tolerate human disturbance. Similar patterns have been documented in urban ecological studies, where habitat generalists tend to dominate urban communities while habitat specialists become less common as urbanization intensifies (Aronson *et al*., 2023; Callaghan *et al*., 2023). This level of diversity is consistent with recent urban avifaunal studies in other Nigerian cities. For example, (Adeleke *et al*., 2023) recorded 58 species in Ilorin, and (Ibrahim & Okeke, 2024) documented 62 species in Zaria urban landscape. Like these studies, our findings show that urban centers in northern Nigeria can sustain appreciable bird diversity despite intense anthropogenic disturbance.The dominance of families such as Columbidae, Passeridae, and Ploceidae can be attributed to their ecological flexibility and adaptation to urban environments. These birds are typically generalists with broad diets and high tolerance to human disturbance. Their success in the study area is therefore a direct consequence of urban resource availability, including food waste, cultivated crops, and artificial nesting sites. In contrast, more specialized species were less represented because urban conditions often lack the specific resources they requireThe dominance of species from Columbidae, Passeridae, and Ploceidae in Gombe reflects patterns reported in Kano and Abuja, where generalist species exploit urban resources more effectively than habitat specialists (Abdulrasheed *et al*., 2022; Musa & Hassan, 2021). This similarity suggests that urbanization filters bird communities in Nigerian cities toward a core set of adaptable taxa.

Granivores were the most represented feeding guild, accounting for 20 species or 33.3% of the recorded bird community. The dominance of granivores suggests that seeds and grain-related resources are widely available within the urban environment. The relatively high representation of insectivores also demonstrates that vegetation within Gombe Metropolis continues to provide resources for insect-feeding birds. Vegetated areas can support arthropods and other invertebrates, which constitute important food resources for insectivorous species (Wang *et al*., 2024). This finding is consistent with recent studies showing that habitat modification disproportionately affects specialist feeders compared with generalist species, leading to declines in frugivorous and nectarivorous birds in urban ecosystems (Şekercioğlu *et al*., 2019; Callaghan *et al*., 2023). . Similarly, a study in Kumasi found omnivores were resilient to habitat modification due to their flexible diets. The relatively lower abundance of insectivores and frugivores in built-up parts of Gombe also aligns with findings from Ibadan and Lagos, where these guilds concentrated in vegetated patches with richer food resources (Onyekwelu & Akinyemi, 2024). This indicates that feeding guild composition in urban bird communities globally tends to reflect local habitat quality, with green spaces acting as refugia for more specialized feeders.

Time-of-day influenced bird activity in Gombe, with early morning peaks and midday troughs Results: Fig 2. The findings of the present study revealed that bird species abundance and species richness were higher during the morning sampling period than during the afternoon/evening period. A total of 3,532 individual birds representing 60 species were recorded in the morning compared with 3,181 individuals belonging to 58 species recorded during the afternoon/evening. This pattern indicates that the time of day significantly influences bird activity and detectability within the Gombe Metropolitan Area. Similar observations have been reported by (Ralph *et al*., 1995), (Bibby *et al*., 2000), and (Bai *et al*., 2025), who noted that bird surveys conducted during the early morning generally record greater abundance and species richness than surveys conducted later in the day. The higher abundance and richness observed during the morning can be attributed to the natural circadian rhythm of birds. Most bird species are highly active shortly after sunrise when they engage in intensive foraging, territorial defence, mate attraction, and vocal communication. These behaviours increase the probability of both visual and auditory detection during field surveys (Bibby *et al*., 2000; Sutherland *et al*., 2004). (Bai *et al*., 2025) further reported that bird vocal activity reaches its peak during the early morning hours, making this period the most suitable for estimating bird abundance and species richness.

The observed seasonal pattern higher bird abundance and richness in the wet season than dry season as illustrated in Fig 3. The present study demonstrated a pronounced seasonal variation in bird species abundance and richness within the Gombe Metropolitan Area. A substantially higher abundance (5,885 individuals) and species richness (60 species) were recorded during the wet season compared with the dry season, which yielded 828 individuals and 42 species. This pattern indicates that seasonal changes strongly influence the composition and distribution of bird communities in the study area. The findings of this study are consistent with previous studies conducted in tropical Africa and other tropical regions, which have demonstrated that rainfall is one of the strongest environmental factors influencing bird abundance, species richness, breeding success, and habitat use. (Callaghan *et al*., 2021) reported that seasonal environmental productivity strongly determines bird occurrence and community composition across different ecosystems. Likewise, (Bregman *et al*., 2019) found that bird diversity increases in habitats with greater vegetation productivity and food availability. (Sullivan *et al*., 2023) further demonstrated that seasonal climatic conditions influence bird movements, distribution patterns, and local population sizes worldwide using large-scale monitoring data. Similar findings have also been reported by (Newbold *et al*., 2020), who showed that habitat quality and seasonal resource availability are major determinants of biodiversity persistence in human-modified landscapes. During the dry season, reduced vegetation density may make food resources more visible and accessible, thereby increasing detectability of birds during sampling. Additionally, water sources become more concentrated, attracting birds to specific locations and increasing observed abundance. The presence of migratory species during certain

periods further contributes to seasonal fluctuations in species richness. is not consistent with ecological studies in West African savanna cities. For example, (Sanusi & Bassey, 2022) documented significant seasonal fluctuations in Calabar, with wet-season peaks attributed to increased insect biomass and vegetative cover. A similar trend was reported by (Johnson *et al*., 2023) in Ouagadougou, Burkina Faso, where migratory and resident insectivores responded strongly to rainfall-driven productivity. However in terms of abundance, wet season has higher number of relative abundance than the dry season due to food availability and other factors (Sabo et al., 2021). The significantly higher abundance of birds in green areas was one of the most important findings of the study. Green areas supported 4,437 individuals, representing 66.1% of all birds recorded, whereas non-green areas supported 2,276 individuals, representing 33.9%. The findings of this study agree with those of (Callaghan *et al*., 2021), who reported that urban green spaces consistently support greater bird abundance because they provide essential ecological resources throughout the year. Similarly, (Bregman *et al*., 2019) found that habitats with greater vegetation complexity and higher primary productivity sustain larger and more diverse bird communities than simplified urban environments. (Sullivan *et al*., 2023) also demonstrated that habitat quality and vegetation cover are among the strongest predictors of bird occurrence and abundance across different ecosystemsThe greater abundance in green areas can be explained by the availability of food, nesting sites, shelter and vegetation structure. Trees, shrubs and grasses provide multiple layers of habitat that can support birds with different feeding and nesting requirements (Lu *et al*., 2024). The finding agrees with previous studies showing that urban green spaces can support greater bird diversity and abundance than highly built-up areas (Beninde *et al*., 2015; Callaghan *et al*., 2021). Recent evidence also emphasizes the role of urban green infrastructure in supporting ecological resilience and avian biodiversity (McCloy et al., 2024; Mühlbauer *et al*., 2025).

Conclusion

The study demonstrates that Gombe Metropolis supports a diverse urban bird community consisting of 60 species and 6,713 individuals with higher abundance and richness of bird species in the green areas and lower in the non green areas. However, the distribution of birds was not uniform across the metropolitan landscape. The findings therefore recommend the need to conserve existing green spaces, restore degraded vegetation and incorporate biodiversity conservation into urban planning. Maintaining a network of green habitats would provide important resources for birds and contribute to the ecological sustainability of Gombe Metropolis.

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