



HABITAT CHARACTERISTICS AND THEIR ASSOCIATION WITH WILDLIFE SPECIES DIVERSITY AND ABUNDANCE

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ABSTRACT

Habitat features are vital to the diversity and abundance of wildlife species in ecological systems. A secondary ecological data set was used to assess the relationship between wildlife biodiversity and ecological realm, climate, biome, protected-area status, taxonomic group, species richness, abundance, sampling effort and study area. A total of 267 records of wildlife use were analysed after excluding plant and fungal records. To examine biodiversity patterns under ecological conditions, descriptive statistics, comparisons of groups, correlation analysis and multivariable regression were used. There were considerable differences in wildlife species richness and abundance between ecological realms and climatic categories, and values in the marine category were generally higher than those for the freshwater and terrestrial categories. Unadjusted analyses also revealed that there were significant differences between protected and unprotected records, but those differences were not as great after adjusting for ecological and sampling characteristics. The species richness was positively associated with the total abundance, sampling effort and study area and the abundance with the number of samples. Ecological realm and sampling characteristics were also important for explaining variation in observed biodiversity patterns in the multivariable analysis. These results show that diversity and abundance of wildlife are determined by a range of habitat, environmental and methodological factors. Habitat quality, ecological context, landscape characteristics and standardised approaches to sampling should therefore all be taken into account when assessing wildlife communities for the purpose of effective biodiversity assessment and conservation planning.

Keyword: habitat characteristics; wildlife diversity; species abundance; ecological realm; biodiversity conservation

Introduction

The nature and quality of wildlife habitats where species are present significantly impact wildlife diversity and abundance. Habitat also supplies the necessary resources to meet basic needs like food, cover, breeding areas, water and protection from predators and environmental stresses. The number of species that an ecosystem can support may thus be a function of differences in vegetation structure, landscape composition, climatic conditions, ecosystem size, and availability of natural resources. Habitat complexity can also lead to a higher number of ecological niches, which enables species with different feeding and nesting habits and behaviours to live together. Differences in avian functional diversity and their habitat use have been correlated with forest structural attributes and tree diversity, highlighting the importance of vegetation characteristic on shaping wildlife communities (Bitani et al., 2023). Similarly, landscape naturalness can positively influence the habitat condition and increase bird diversity (Chang et al., 2024).

Altered natural habitats have been an important factor affecting patterns of biodiversity, due to human modification. Urbanization, agricultural expansion, habitat fragmentation and land-use change can impact vegetation, resources, connectivity and ecological processes. Residential landscapes can still be significant habitat for many species if gardens and other green spaces have a variety of vegetation and resources, but the biodiversity value of the landscape varies depending on the management and landscape context (Delahay et al., 2023). Other studies on bird communities have also revealed significant differences in species composition and relative abundance of bird species in different habitats, showing that ecological characteristics of the habitats are important for the bird community structure (Desalegn & Negussie, 2022). The amount of habitat available and environmental characteristics can also play a role in avian species richness in urbanized landscapes in addition to build infrastructure (Humphrey et al., 2023).

The agricultural landscapes also highlight that habitat attributes are important to the diversity and abundance of wildlife. When adequate habitat resources are available, even relatively low amounts of farmland can contribute to the feeding, movement and shelter needs of birds (Lee et al., 2022). Good habitat management is therefore essential in maintaining wildlife numbers, especially in habitats that have been modified and/or have been diminished. Adequate habitat features and water quality can be maintained, and the availability of wildlife habitat can be improved, with management practices that maintain vegetation structure. Specific habitat features may also have different preferences for different wildlife species, as there is variation in ecological requirements and responses to human land use (Pike et al., 2022). On the other hand, habitat degradation can lead to a decline in ecological quality and impact on the survival of wildlife, underscoring the need for habitat conservation and restoration (Satapathy et al., 2024).

Effective assessment of biodiversity is vital to understanding these habitat–wildlife relationships. In human-modified landscapes, assessment methods can be used to identify ecological features that are associated with higher biodiversity, and to guide habitat management for biodiversity conservation (van

Heezik et al., 2023). Vegetation characteristics are especially significant, since modifications in the structure and composition of vegetation can impact food resources, nesting opportunities, shelter, and other factors affecting wildlife communities (Xu et al., 2022). In addition, modified agricultural systems can have conservation value, with the conservation of habitat components that are beneficial to wildlife, such as agroforestry habitats, that can offer opportunities for conservation of avian biodiversity in intensively managed systems (Yahya et al., 2023; Malone et al., 2023).

While more researchers are becoming aware of habitat–biodiversity relationships, the comparative assessment under a variety of habitat, biome, climatic and conservation conditions still play an essential role. When both species diversity and abundance is measured, a more complete picture of ecological variation's impact on wildlife communities can be gained. The present study thus examines the habitat and environmental attributes in regard to wildlife species diversity and abundance based on secondary ecological data.

Objectives

- To describe the habitat, environmental, and wildlife characteristics represented in the dataset.
- To compare wildlife species diversity and abundance across habitat types, biomes, climatic categories, and protected-area conditions.
- To determine the association between habitat characteristics and wildlife species diversity and abundance.

2. Materials and Methods

2.1 Study Design

The design of this study was quantitative and cross sectional (secondary data) to assess the relationship between wildlife species diversity and abundance and habitat characteristics. The analysis used an existing ecological data set that included data on habitat conditions, environmental characteristics, taxonomic groups, species richness, abundance, sampling effort, geographical location, and time of study.

2.2 Data Source and Study Dataset

This secondary data comprised of ecological study records (n=381) and variables (n=42) (Ma, 2025). These variables included the ecological realm, climatic zone, habitat type, protected-area status, biome classification, taxonomic group, organism type, geographical coordinates, number of species, number of samples, total abundance, study area, sampling grain, study period and abundance measurement type. To ensure the records were consistent with the wildlife focus of the study, animal-based records were kept but plant only records were removed.

2.3 Study Variables

The main independent variables were habitat type, ecological realm, climatic category, biome and protected-area status. The main outcome variables were wildlife species diversity and abundance. The wildlife abundance (TOTAL variable) and its appropriate ABUNDANCE_TYPE provided an indicator of species diversity (NUMBER_OF_SPECIES variable). The data set was characterized by other variables such as taxonomic group, number of samples, study area, sampling grain, geographical coordinates, start year and end year, which were used to help interpret the results.

2.4 Data Preparation and Eligibility Criteria

The data was checked for inconsistencies, missing values, implausible numeric values, and duplicate records. Records were included if they included identifiable animal taxa, habitat data, and uses for biodiversity. Plant observations and records were only included in the appropriate analyses if there was sufficient information on habitat, species richness or abundance. Categorical data were standardized as needed and continuous data were assessed for distribution and outliers.

2.5 Assessment of Wildlife Diversity and Abundance

The diversity of wildlife was primarily measured as species richness, and compared between habitat types, between biomes, between climatic categories, between ecological realms and between protected-area status. The total abundance reported was used to gauge the abundance of wildlife. When interpreting variation in species richness and abundance, sampling effort, study area, sampling grain and taxonomic group were all considered.

2.6 Statistical Analysis

Categorical variables were described in terms of their frequencies and percentages, whilst continuous variables were described in terms of mean values with standard deviations or medians with interquartile ranges as appropriate. Independent-samples t-tests, Mann–Whitney U tests or Kruskal–Wallis tests were used as appropriate to assess group differences. Pearson or Spearman correlation was performed to assess the correlation between continuous ecological and biodiversity variables. Multiple regression analysis was used to determine habitat and environmental factors that were independently associated with species richness and abundance. A p value of < 0.05 was considered to indicate statistical significance.

2.7 Ethical Considerations

The study relied on secondary ecological data and there was no human or animal interaction. No new specimens were collected, handled or manipulated in experiments. As the analysis was based entirely on existing data, no further ethical approval was needed for this secondary data analysis. Data were only used for scientific research and interpreted in the spirit of good research and reporting.

3. Results

3.1 Characteristics of the Wildlife Dataset

Following exclusion of terrestrial plants, marine plants, freshwater plants, and fungi, a total of 267 records of wildlife-related ecology were selected for analysis. Marine studies were the most common ecological studies followed by terrestrial and freshwater studies. Many records were from temperate climatic areas, and most were not from protected areas. The most common taxonomic groups were fish, marine invertebrates, birds, terrestrial invertebrates and mammals. The distribution of the study records overall is given in Table 1, and the taxonomic composition is shown in Figure 1.

Table 1. General characteristics of the wildlife records included in the analysis

Characteristic	Category	n	%
Ecological realm	Marine	142	53.2
	Terrestrial	99	37.1
	Freshwater	26	9.7
Climate	Temperate	192	71.9
	Tropical	26	9.7
	Temperate/Tropical	25	9.4
	Polar	11	4.1
	Polar/Temperate	10	3.7
	Global	3	1.1
Protected-area status	Non-protected	221	82.8
	Protected	46	17.2
Abundance measure	Count	184	68.9
	Density	35	13.1
	Presence/absence	26	9.7
	Mean count	7	2.6

Not specified

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5.6

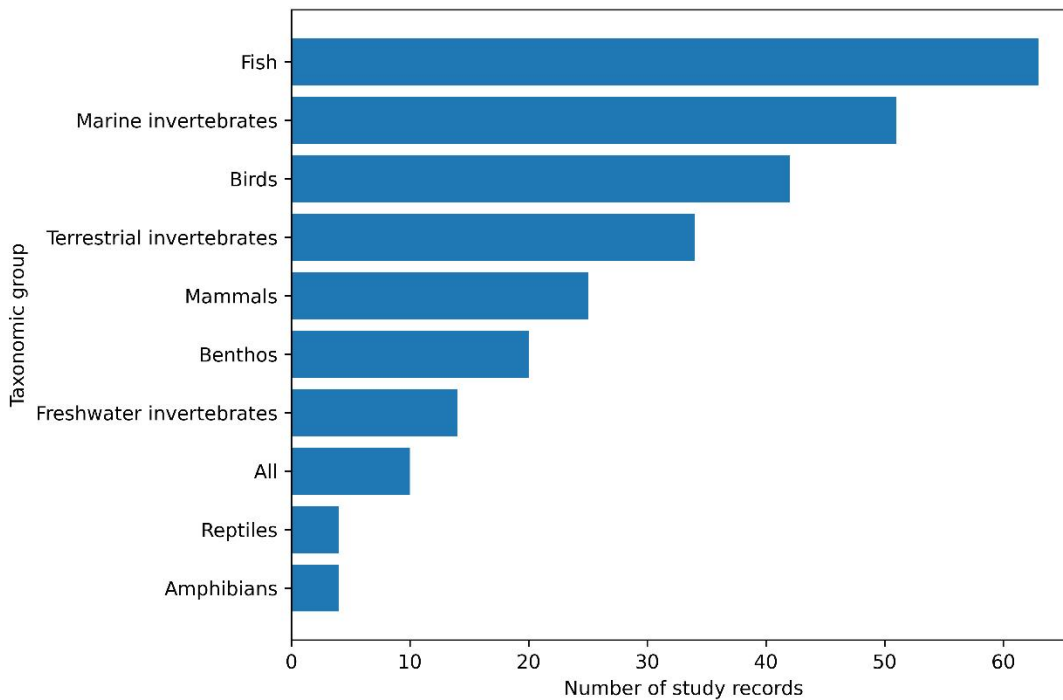


Figure 1. Distribution of wildlife records according to taxonomic group

Fish represented the largest individual taxonomic category, followed by marine invertebrates and birds. Mammals, freshwater invertebrates, benthic organisms, reptiles, and amphibians were represented by smaller numbers of records (Figure 1).

3.2 Species Diversity and Abundance Across Taxonomic Groups

There was a high heterogeneity in species richness and total abundance among taxonomic groups. Benthic species had the highest median number of species followed by the fish and marine invertebrates. The median species richness of mammals, reptiles and amphibians was generally lower. There was also a large variance in abundance, with median abundances in the benthic and mixed-taxon datasets being relatively high. A detailed value is given in Table 2.

Table 2. Species richness and abundance according to taxonomic group

Taxonomic group	n	Species richness, median (IQR)	Total abundance, median (IQR)
Fish	63	127.0 (53.0–275.5)	6,287.0 (1,673.0–25,481.5)
Marine invertebrates	51	163.0 (51.0–378.0)	6,329.0 (2,163.5–15,372.0)

Birds	42	52.0 (33.3–82.0)	961.0 (346.0–14,101.3)
Terrestrial invertebrates	34	43.0 (36.5–60.3)	1,053.0 (793.3–2,863.0)
Mammals	25	13.0 (9.0–24.0)	1,380.0 (118.0–7,122.0)
Benthos	20	327.5 (148.5–827.3)	11,813.5 (2,032.3–98,118.8)
Freshwater invertebrates	14	32.0 (18.3–64.8)	1,809.5 (468.0–6,703.0)
Mixed taxa	10	95.5 (38.0–173.3)	24,473.0 (9,778.3–59,358.3)
Amphibians	4	13.0 (8.5–30.3)	288.5 (222.0–728.0)
Reptiles	4	11.5 (3.8–19.5)	801.5 (52.0–1,824.3)

IQR = interquartile range.

3.3 Variation in Species Richness Across Habitat-Related Characteristics

Species richness was significantly different among ecological realms. The median richness of marine records was 153.5 species, while those from terrestrial and freshwater environments were 40.0 and 34.0 species, respectively. This difference was found to be statistically significant ($H = 63.21$, $p < 0.001$) as displayed in Table 3 and Figure 2. The species richness was also significantly related to climate ($H = 32.47$, $p < 0.001$). The median richness was high for temperate/tropical records, and there was much variation between climatic groups. A higher unadjusted median species richness was found in the non-protected records compared with the protected records ($p = 0.006$), with species richness also varying among protected-area status. The results of these are summarised in Table 3.

Table 3. Species richness and abundance across major habitat-related characteristics

Characteristic	Category	Species richness, median (IQR)	Abundance, median (IQR)
Realm	Freshwater	34.0 (16.5–64.8)	1,455.0 (468.0–6,703.0)
	Marine	153.5 (51.0–343.3)	7,606.5 (2,163.0–27,937.8)
	Terrestrial	40.0 (19.0–57.0)	946.0 (215.5–3,147.5)
Climate	Polar	50.0 (27.5–194.0)	2,633.0 (1,085.0–7,666.5)
	Polar/Temperate	146.0 (41.8–297.8)	7,287.0 (5,501.8–14,379.8)

	Temperate	48.0 (27.8–141.8)	1,943.5 (543.0–14,952.5)
			18,535.0 (4,125.0–40,884.0)
	Temperate/Tropical	430.0 (148.0–734.0)	
	Tropical	109.5 (34.0–248.5)	2,318.5 (782.0–26,438.3)
Protected area	No	69.0 (29.0–251.0)	5,187.0 (1,072.0–22,347.0)
	Yes	43.0 (33.3–61.8)	829.5 (206.5–1,329.8)

For species richness: realm, $p < 0.001$; climate, $p < 0.001$; protected-area status, $p = 0.006$.

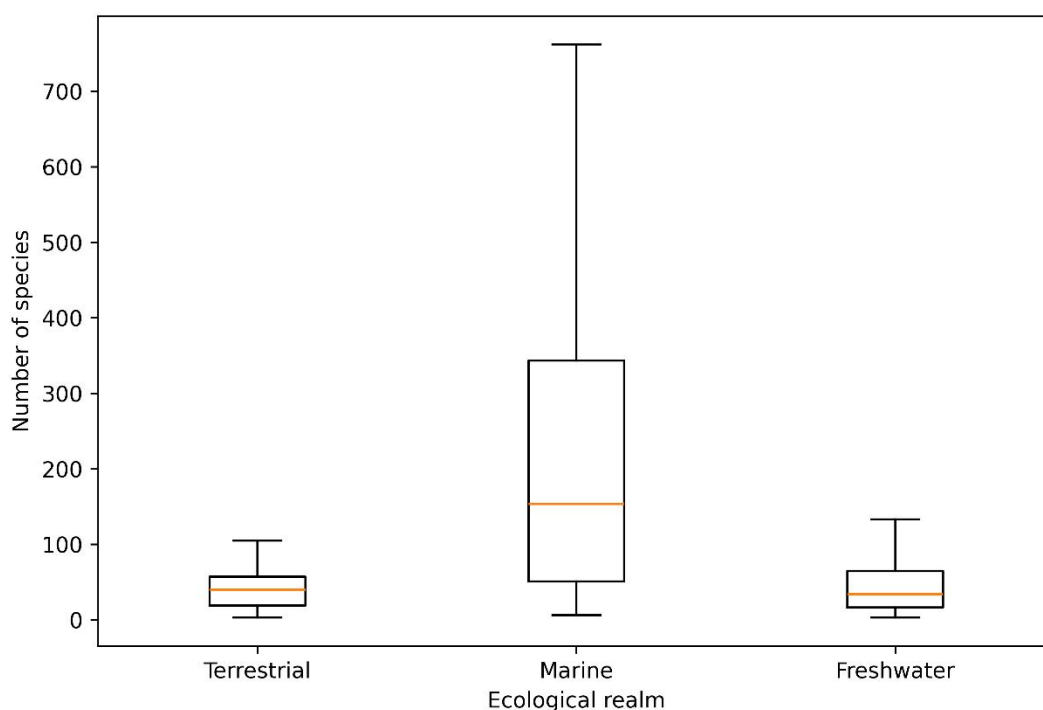


Figure 2. Distribution of wildlife species richness across freshwater, marine, and terrestrial ecological realms

The graphical distribution further demonstrated substantially greater variation and generally higher species richness among marine records than freshwater or terrestrial records (Figure 2).

3.4 Variation in Wildlife Abundance

Total abundance also differed significantly among ecological realms ($H = 48.72$, $p < 0.001$). Marine studies showed the highest median total abundance, whereas terrestrial studies showed the lowest median value. Abundance differed significantly among climatic categories ($H = 22.11$, $p < 0.001$) and between protected and non-protected study records ($p < 0.001$). The corresponding abundance distributions are reported in Table 3 and illustrated in Figure 3.

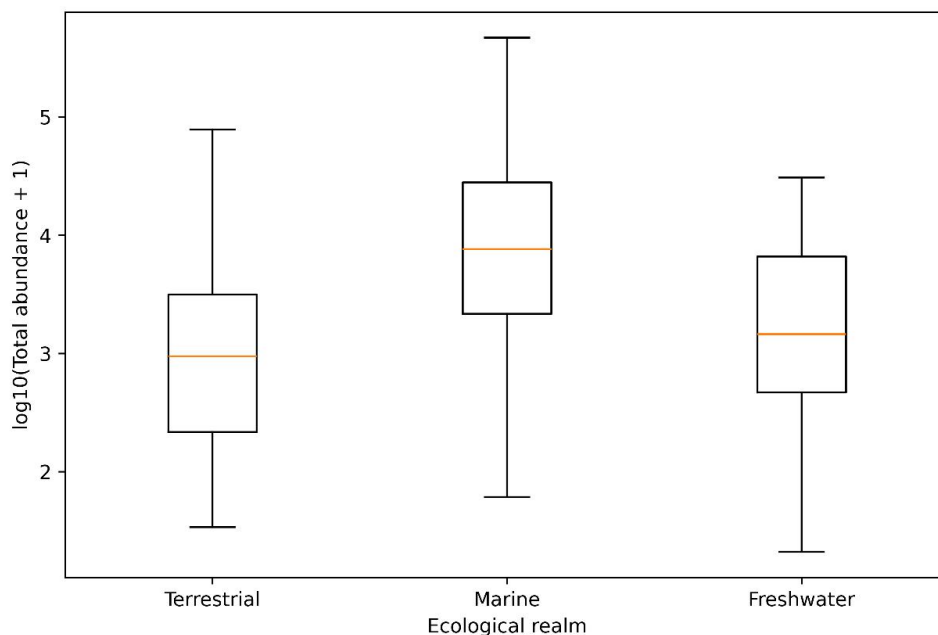


Figure 3. Distribution of total wildlife abundance across ecological realms

Because the abundance values were highly skewed, the graphical presentation used a logarithmic transformation for visualization. Marine datasets showed higher overall abundance values than freshwater and terrestrial datasets, although considerable within-group variability was evident (Figure 3).

3.5 Correlations Between Biodiversity and Sampling Characteristics

Overall, there was a high positive correlation between species richness and total abundance ($r_s = 0.649$, $p < 0.001$). Richness was also positively correlated with the number of samples ($r_s = 0.439$, $p < 0.001$) and study area ($r_s = 0.541$, $p < 0.001$). Total abundance had the strongest relationship with sampling effort ($r_s = 0.879$, $p < 0.001$) and moderate to strong relationships with study area ($r_s = 0.601$, $p < 0.001$). No significant relationships were found between richness and abundance and sampling grain (Table 4).

Table 4. Spearman correlations among biodiversity and sampling variables

Variables	r_s	p value
Species richness vs. total abundance	0.649	<0.001
Species richness vs. number of samples	0.439	<0.001
Species richness vs. study area	0.541	<0.001
Species richness vs. sampling grain	-0.090	0.143
Total abundance vs. number of samples	0.879	<0.001

Total abundance vs. study area	0.601	<0.001
Total abundance vs. sampling grain	−0.015	0.804
Total abundance vs. number of data points	0.295	<0.001

The positive relationship between species richness and total abundance is also shown in Figure 4, with datasets containing larger numbers of species generally tending to report greater total abundance.

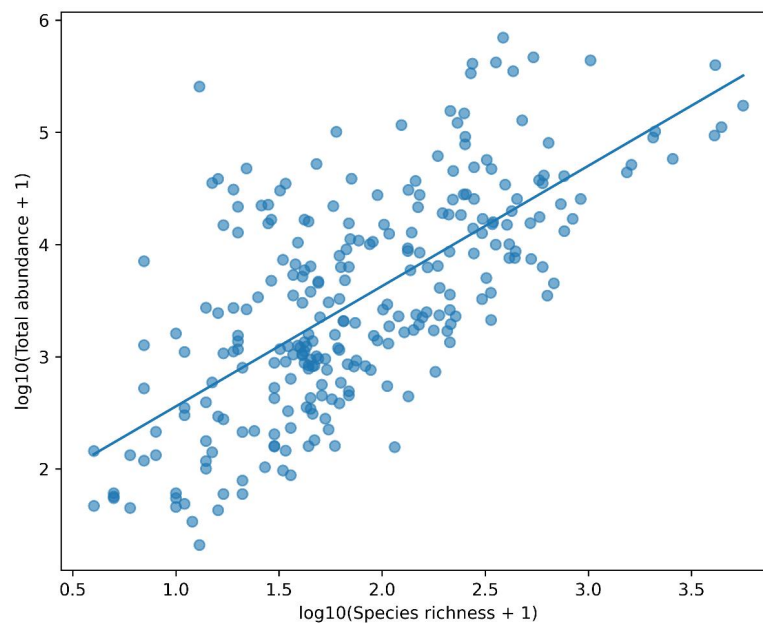


Figure 4. Association between wildlife species richness and total abundance

3.6 Multivariable Analysis of Species Richness and Abundance

Log transformed outcomes were used in multiple linear regression to determine characteristics independently associated with species richness, and abundance, accounting for sampling effort and study-area characteristics. The species-richness model was statistically significant, accounting for ~36.0% of the variance. Marine ecological records had an independent positive association with species richness ($p = 0.002$) compared with freshwater studies. There was also a positive association between greater sampling effort and greater richness, and a greater study area and richness. The variance in the abundance model accounted for about 77.7% of the variance. The closest independent positive associations with total abundance were sampling effort ($p < 0.001$), while ecological realm, protected-area status, and sampling grain were not associated with abundance after adjustment (Table 5).

Table 5. Multivariable regression models for species richness and wildlife abundance

Predictor	Species richness β	p value	Abundance β	p value
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Marine realm vs. freshwater	0.834	0.002	0.412	0.097
Terrestrial realm vs. freshwater	0.210	0.418	0.086	0.724
Protected vs. non-protected	0.314	0.133	0.060	0.758
Log number of samples	0.116	0.002	0.741	<0.001
Log study area	0.070	<0.001	0.030	0.062
Log sampling grain	0.027	0.751	0.073	0.356

Species richness model: $R^2 = 0.360$, adjusted $R^2 = 0.345$, overall $p < 0.001$.

Abundance model: $R^2 = 0.777$, adjusted $R^2 = 0.772$, overall $p < 0.001$.

Overall, the results demonstrate substantial variation in wildlife diversity and abundance across ecological settings. Ecological realm, climate, study area, and sampling characteristics showed important relationships with biodiversity measures, while some apparent unadjusted differences, particularly those associated with protected-area status, were reduced after accounting for sampling and ecological characteristics.

4. Discussion

In the present study, the number of wildlife species and abundance were found to significantly differ among the ecological realms, climatic conditions, taxonomic groups and habitat related factors. The species richness and abundance of marine records were greater than those of the freshwater and terrestrial records, and climatic category was also significantly correlated with patterns of biodiversity. The results are consistent with the general ecology that the presence and abundance of organisms vary between habitat conditions and seasons (Alkathiry et al., 2022). The heterogeneity observed between ecological contexts also includes the interaction of the various environmental features and the availability of resources and habitat structure, which can interact to influence the presence of species and the composition of communities (Boulanger et al., 2024).

Differences in species richness between ecological realms could partly be attributed to the differences in habitat complexity and resource availability. Structural and ecological diversity is likely to be greater in environments that contain more structural and ecological heterogeneity, which in turn can support more ecological niches and species. Research on birds in urban areas has also revealed that the abundance and availability of environmental resources can significantly influence community composition and the abundance of species (Brown et al., 2022). Habitat configuration is also of importance as wildlife could react not only to the amount of habitat, but to how suitable habitat patches are arranged in a landscape (Ciach et al., 2023). This high inter-regional (or inter-ecoregional) variability found in the present study is

thus corroborated by the fact that higher habitat complexity may alter the ecological interactions, impacting the biological outcomes at multiple scales (Dagostin et al., 2024; Shilireyo et al., 2023).

There was significant variation in species richness and abundance also between taxonomic groups. Richness of benthic organisms, marine invertebrates and fish were relatively high, while mammals, reptiles and amphibians, by and large, had low median richness. These differences would be expected due to variations in ecological needs, ability to disperse, habitat specificity and responses to environmental conditions among taxa. This is also the case for pollinators, with local environmental factors being correlated with changes in both the richness and abundance of pollinators (de Montaigne & Goulson, 2024). On a larger spatial scale, the influence of habitat on wildlife can also vary when considering the landscape context such as for grassland and forest birds in an agricultural landscape (de Zwaan et al., 2024). Similar relationships between habitat type, diversity and abundance have also been found with mammals (Derebe et al., 2022).

Significant differences were also found in the richness and abundance of areas with and without protection, but these differences were not significant after controlling for ecological and sampling characteristics. This indicates that protection status alone might not be an adequate explanation of biodiversity patterns. Other factors, such as habitat quality, intensity of management practices, landscape structure, and local resource availability may also be of equal importance. There is evidence from managed landscapes that wildlife-friendly practices can lead to higher species and abundance if they lead to higher habitat quality or greater provision of resources (Hordley & Fox, 2024). In contrast, the effects of fragmentation and land-cover structure could be species-specific, especially in human-dominated landscapes (Larson & Sander, 2025). Responses are also likely to be influenced by species' life history traits that can affect their capacity to adapt to altered or urban habitats, (Lettoof et al., 2023).

An important result was the good positive correlation of sampling effort and reported abundance. This should be kept in mind when comparing abundance from different studies as this could be partially due to methodological variation. Estimates of wildlife abundance may contain significant sampling error and/or detection error bias (Mathis et al., 2024). Likewise, sampling conditions and land use use may interact to affect the diversity and abundance of mammals observed (Shilireyo et al., 2023). There is also the possibility that there is a broader landscape inequality that could influence habitat and modern-day biodiversity distributions (Wood et al., 2024).

The results overall suggest that the wildlife biodiversity is influenced by a variety of habitat and environmental factors rather than any one factor. The extensive ecological range of the data was a significant asset, but the differences in the nature of the taxa, effort, abundance units and design of the studies prevented straight comparisons. Future research needs to adopt consistent sampling methods and more fine-scale habitat measurements to better understand the relationship between habitat measures and wildlife diversity and abundance.

5. Conclusion

The present study shows that the species diversity and abundance of wildlife is closely related with habitat and environmental features. Significant differences between ecological realms, climatic categories, taxonomic groups and habitat conditions suggested a strong ecological context dependency in biodiversity responses. Across all records, marine records tended to be higher in species richness and abundance than terrestrial and freshwater records and climatic conditions also played a role in the variation in biodiversity patterns. Richness was positively correlated to abundance, study area and sampling effort, indicating that both ecological and methodological factors affect the observed richness. The analysis also revealed that apparent differences between protected/non-protected areas were minimized with consideration of ecological and sampling variables. This implies that habitat quality, landscape structure, resource availability and management practices should not only be taken into account in a Protected Area (PA), but also that the PA status alone may not be sufficient to ensure the outcome of biodiversity. High correlation between abundance and sampling effort emphasizes the need to consider methodological variation when comparing populations of wildlife from various studies. In summary, it was shown that the habitat characteristics play an important role in explaining wildlife distribution, richness and abundance in different habitats. Conservation strategies should therefore aim at habitat complexity, ecological connectivity and environmental conditions as well as protection of areas. Future studies should use standardized sampling procedures, standardized abundance metrics, and incorporate finer-grained habitat-level data to enhance ecological comparisons and aid biodiversity conservation planning.

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