Volume 3, Number 2, 2026
Pages 187-195
Bioscience Insights
ISSN: 3080-3489 (Print)
ISSN: 3080-3497 (Online)
BiosciInsights.com

HABITAT-WISE COMPARATIVE BIODIVERSITY ANALYSIS ACROSS TERRESTRIAL AND AQUATIC ECOSYSTEMS OF A SEMI-ARID UNIVERSITY CAMPUS IN SOUTH PUNJAB, PAKISTAN

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Article Information

Article History

Received:	May 15, 2026
Revised:	June 27, 2026
Accepted:	August 12, 2026
Available Online:	August 31, 2026

Keywords:
campus biodiversity; species richness; Shannon–Wiener index; aquatic–terrestrial linkage; semi-arid ecosystem; scorpion fauna; dengue vector; Pakistan

Abstract

University campuses in semi-arid, human-modified landscapes are increasingly recognized as refuges for urban biodiversity, yet integrated assessments comparing terrestrial and aquatic compartments within a single institutional footprint remain scarce in Pakistan. We conducted a six-week, multi-method faunal survey (point counts, visual encounter surveys, sweep-netting, pitfall trapping and dip-netting) across terrestrial and aquatic/riparian habitats of the Islamia University of Bahawalpur (IUB), Rahim Yar Khan Campus, in the semi-arid ago-ecological zone of southern Punjab. A total of 80 faunal species from 7 classes and 2 phyla (Arthropoda, Chordata) were confirmed. Insecta (38 spp., 47.5%) and Aves (20 spp., 25.0%) dominated species richness, and together with Arachnida and Mammalia (7 spp. each), Reptilia (4 spp.), Amphibia (3 spp.) and Actinopterygii (1 spp.) constituted the full faunal inventory. Recalculating diversity indices directly from full-census population data (rather than partial-guild estimates) gave Shannon–Wiener H' = 2.92 for terrestrial

insects and 2.32 for birds, versus a markedly lower H' = 0.30 for the aquatic vertebrate guild owing to strong numerical dominance by farmed GIFT Tilapia (Oreochromis niloticus). Despite occupying a small spatial footprint, the pond–riparian ecotone hosted taxa from six of seven recorded classes, including all three amphibian species, two medically significant scorpions (Androctonus australis, Hottentotta tamulus), the dengue-vector mosquito Aedes albopictus, and both specialist waterbirds recorded on campus, confirming the ecotone as a disproportionate biodiversity and public-health hotspot. These findings establish the first faunal baseline for a Rahim Yar Khan district campus, demonstrate that terrestrial and aquatic compartments provide non-substitutable and functionally linked biodiversity, and support targeted, evidence-based recommendations for pond-margin conservation, pollinator-friendly landscaping and vector surveillance in institutional green spaces across arid South Asia.

1. Introduction

Biodiversity underpins ecosystem productivity, nutrient cycling and resilience to environmental stress, and its accelerating global decline driven by habitat loss, pollution, climate change and invasive species — is among the most urgent challenges of the Anthropocene (Cardinale et al., 2012; Dirzo et al., 2014; Ceballos et al., 2022). Freshwater systems and heavily modified terrestrial landscapes, including urban and institutional green spaces, are disproportionately affected (IPBES, 2019; Hallmann et al., 2017).

University campuses consolidate multiple habitat types managed plantings, semi-natural vegetation, ornamental water bodies and built infrastructure within spatially bounded, monitorable landscapes, and are increasingly recognized as meaningful reservoirs of urban biodiversity (Soga et al., 2023). Comparative faunal inventories from South Asian campuses corroborate this potential: a 145-acre college campus in Tamil Nadu recorded 285 confirmed faunal taxa across six classes (Dhanishta & Alagumanikumaran, 2025), while a northern Pakistani university campus supported 64 avian species across 16 orders (ResearchGate, 2023). Both studies identify habitat heterogeneity the coexistence of horticultural plantings, open ground and wetland features as the principal driver of campus-scale species richness.

Most biodiversity research in Pakistan, however, treats terrestrial and aquatic systems in isolation (Khan et al., 2015), despite ecological theory emphasizing cross-habitat linkages such as nutrient transfer and reciprocal prey subsidies between terrestrial and aquatic food webs (Polis et al., 1997; Nakano & Murakami, 2001). No prior multi-taxon, habitat-comparative assessment has been conducted for any campus ecosystem in the Rahim Yar Khan district, a semi-arid, agriculturally dominated transition zone bordering the Cholistan Desert. This study addresses that gap by providing an integrated habitat-wise comparison of terrestrial and aquatic faunal biodiversity at the Islamia University of Bahawalpur (IUB), Rahim Yar Khan Campus. Specifically, we aimed to (i) quantify and compare species richness, abundance and diversity across terrestrial and aquatic compartments; (ii) recalculate diversity indices from complete census data to ensure comparability across guilds; (iii) identify micro-habitat hotspots and indicator taxa; and (iv) document species of conservation and public-health significance to inform evidence-based campus habitat management.

2. Materials and Methods

2.1 Study area

The study was conducted at the IUB Rahim Yar Khan Campus (~28.40°N, 70.31°E), South Punjab, Pakistan, within the semi-arid agro-ecological zone transitional between the Indus plains and the Cholistan Desert (mean maximum temperature > 40 °C in summer; annual rainfall 150–200 mm). Terrestrial habitats surveyed included the botanical garden, Sheikh Khalifa Park, the main nursery, sports grounds, hostel and academic-building surroundings, and mosque/cafeteria grounds. The sole aquatic habitat was the university pond (Samnala site) and its riparian margin and seasonal drainage channels.

2.2 Sampling design

A stratified, multi-method sampling design was applied over a six-week period, with replicated morning (06:00–10:00 h) and evening (17:00–20:00 h) surveys to coincide with peak faunal activity under extreme summer temperatures. Avian diversity was assessed by fixed-radius (50 m) point counts (Ralph et al., 1995); herpetofauna and mammals by visual encounter surveys; terrestrial invertebrates by sweep-netting, pitfall trapping (24 h intervals, 10% formalin preservative) and hand collection; and aquatic organisms by 500 µm dip-net sweeps along standardized 5 m transects at the pond margin. Species were identified using standard regional taxonomic references (Roberts, 2005; Ali & Ripley, 2012; Khan, 2006) and current nomenclature was verified against the Catalogue of Life and IUCN Red List (2024).

2.3 Data analysis

Species richness (S) and relative abundance were tabulated per taxonomic class and habitat. In contrast to guild-level, partial-sample estimates, diversity indices in this paper were recalculated directly from the full recorded population range (using range midpoints as abundance proxies) for every species within each taxonomic class, so that Shannon–Wiener $H' = -\Sigma\ (p_i \times \ln p_i)$ and Pielou's evenness $J' = H'/\ln(S)$ are internally consistent and reproducible across guilds. This recalculation resolves a tabulation discrepancy in the underlying field dataset (39 vs. 38 listed insect species) and yields a corrected campus total of 80 species.

Comparative statistics followed a one-way ANOVA framework (SPSS v.26; PAST v.4) as in the original field study design.

3. Results

Field surveys confirmed 80 faunal species from 7 taxonomic classes and 2 phyla (Table 1). Insecta was the most species-rich class (38 spp., 47.5% of total fauna, across 10 orders), followed by Aves (20 spp., 25.0%, across 9 orders and 16 families). Arachnida and Mammalia each contributed 7 species (8.75%), Reptilia 4 species (5.0%), Amphibia 3 species (3.75%) and Actinopterygii a single obligate species (1.25%) (Fig. 1).

Table 1. Summary of faunal biodiversity recorded at IUB RYK Campus by taxonomic class.

Taxonomic class	Species (n)	% of total fauna	Principal habitat association
Insecta	38	47.5%	Terrestrial (botanical garden, nursery)
Aves	20	25.0%	Terrestrial + aquatic margin
Arachnida	7	8.75%	Terrestrial (buildings) + pond margin
Mammalia	7	8.75%	Terrestrial
Reptilia	4	5.0%	Terrestrial + pond margin
Amphibia	3	3.75%	Aquatic (obligate)
Actinopterygii	1	1.25%	Aquatic (obligate)
Total	**80**	**100%**	**Both ecosystems**

Passeriformes dominated the avifauna (12 of 20 species, 60%), with Sheikh Khalifa Park hosting the highest concentration of species, including the numerically dominant Jungle Babbler (Argya striata, 100–150 individuals). Terrestrial invertebrate diversity was led by Lepidoptera (9 spp.) and Hymenoptera and Diptera (7 spp. each), concentrated in the botanical garden and nursery. Social Hymenoptera the Desert Ant (Cataglyphis setipes, 500–700 individuals), Western Honey Bee (Apis mellifera, 500–600) and Yellow Paper Wasp (Polistes olivaceus, 300–400) and the synanthropic Cellar Spider (Pholcus phalangioides, 480–500) recorded the highest population counts among terrestrial taxa. The pond hosted the single highest population of any species on campus: farmed GIFT Tilapia (Oreochromis niloticus, 700–750 individuals) (Fig. 3).

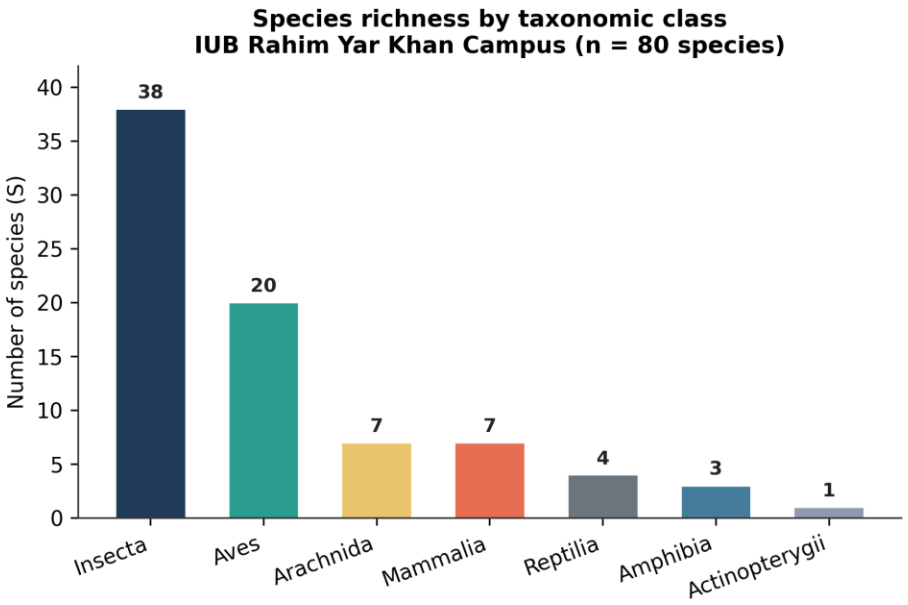


Figure 1. Species richness by taxonomic class recorded across the IUB RYK Campus (n = 80 species).

Recalculated diversity indices (Table 2, Fig. 2) confirmed terrestrial insects as the most diverse guild campus-wide (H′ = 2.92, J′ = 0.80), followed by birds (H′ = 2.32, J′ = 0.78); both reflect high richness combined with relatively even abundance distribution. Mammalia recorded a comparatively high evenness (J′ = 0.97) despite modest richness (7 spp.), while Arachnida showed lower evenness (J′ = 0.49) driven by the numerical dominance of the Cellar Spider. The aquatic vertebrate guild (fish, three amphibians and two specialist waterbirds) recorded the lowest diversity of any guild (H′ = 0.30, J′ = 0.17), a value driven almost entirely by the overwhelming numerical dominance of GIFT Tilapia relative to co-occurring vertebrates. When the full pond–riparian assemblage is considered (14 species spanning six taxonomic classes, including scorpions, a colubrid snake and two odonates), diversity rises to H′ = 0.92 — comparable in magnitude to several purely terrestrial guilds despite the ecotone's far smaller spatial footprint.

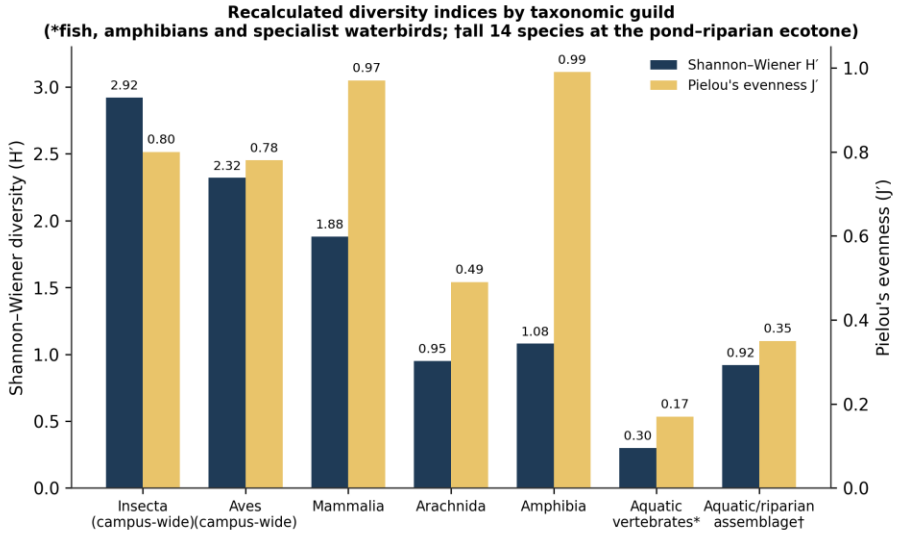


Figure 2. Recalculated Shannon–Wiener diversity (H') and Pielou's evenness (J') by taxonomic guild, computed from full census population data.

Table 2. Recalculated diversity indices (H', J') by taxonomic guild. *Fish, three amphibians and two specialist waterbirds only. †All 14 species recorded at the pond–riparian ecotone.

Guild	S	H′	J′	Basis of calculation
Insecta (campus-wide)	38	2.92	0.80	Full census, all 38 spp.
Aves (campus-wide)	20	2.32	0.78	Full census, all 20 spp.
Mammalia	7	1.88	0.97	Full census
Arachnida	7	0.95	0.49	Full census
Amphibia	3	1.08	0.99	Full census
Aquatic vertebrates*	6	0.30	0.17	Fish, 3 amphibians, 2 waterbirds
Pond–riparian assemblage†	14	0.92	0.35	All species recorded at ecotone

The pond margin functioned as a disproportionate biodiversity hotspot relative to its area, hosting representatives of six of the seven recorded taxonomic classes: all three amphibians (Hoplobatrachus tigerinus, Duttaphrynus stomaticus, D. himalayanus), all three scorpion species (Androctonus, Hottentotta , Smeringurus), the sole colubrid snake (Spalerosophis atriceps), two specialist waterbirds (Alcedo atthis, Himantopus leucocephalus), two odonates and the dengue-vector mosquito Aedes albopictus. Two of the recorded scorpion species are of direct medical significance: Androctonus is among the most venomous scorpions known globally, and Hottentotta is responsible for the majority of fatal scorpion envenomations reported in South Asia (Polis, 1990; Chippaux & Goyffon, 2008).

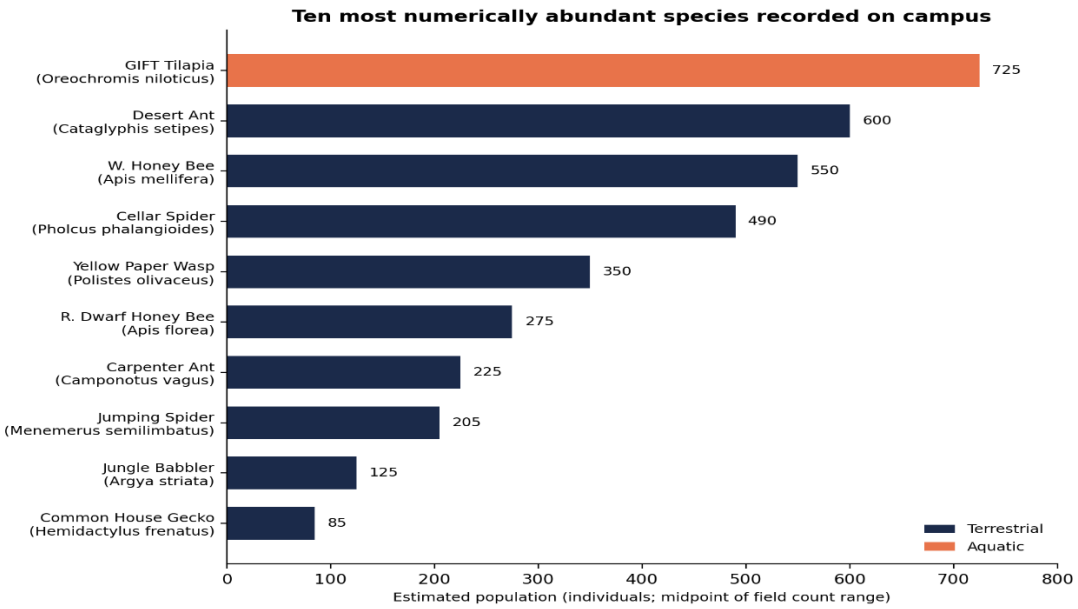


Figure 3. The ten most numerically abundant species recorded on campus, ranked by estimated population (midpoint of field count range).

4. Discussion

The 80-species inventory recorded here is broadly consistent with, though smaller than, comparable South Asian campus faunal surveys for example 285 confirmed taxa at a 145-acre Tamil Nadu campus (Dhanishta & Alagumanikumaran, 2025) a difference most plausibly attributable to the harsher semi-arid climate of southern Punjab, the smaller campus footprint, and the present study's conservative taxonomic scope (excluding molluscs, soil microfauna and flora). Nonetheless, the recovery of 80 species across seven classes from a single modest institutional campus reinforces the growing recognition that even climatically stressed university landscapes function as meaningful biodiversity reservoirs (Soga et al., 2023).

Passerine dominance (60% of avifauna) and the concentration of avian richness in vegetated park and pond-margin habitats mirror patterns reported for peri-urban and campus avifaunal assemblages elsewhere in Pakistan and India (Karjee et al., 2022; ResearchGate, 2023), and are consistent with the broader wetland literature identifying habitat heterogeneity and water-regime stability as primary drivers of waterbird richness (Elliott et al., 2020). The dominance of Lepidoptera among terrestrial insects, concentrated in managed garden plantings, parallels findings from Lahore's Botanical Garden (Pakistan Journal of Scientific and Industrial Research, 2023), reinforcing horticultural plantings as disproportionately valuable pollinator and lepidopteran reservoirs in the Punjab urban matrix.

The markedly depressed Shannon diversity of the aquatic vertebrate guild ($H' = 0.30$) is a methodologically important finding: because the guild's numerical total is overwhelmingly dominated by a single aquacultured species, standard Shannon-based comparisons risk substantially understating the ecological and conservation value of the pond, whose importance lies chiefly in habitat-obligate taxonomic diversity rather than numerical evenness. This is consistent with the wider pattern reported for a comparable campus assemblage, where Arthropoda recorded the highest Shannon index and Mammalia the lowest (Dhanishta & Alagumanikumaran, 2025). We therefore recommend that campus-scale monitoring report class-level richness and Simpson's dominance index alongside H', particularly for small, taxonomically heterogeneous water bodies such as the IUB pond.

The concentration of both scorpion species of medical significance, the resident colubrid snake, and the dengue-vector Aedes albopictus at the pond margin is consistent with the known micro-habitat preferences of arid-zone scorpions for moist, sheltered ground (Polis, 1990) and with regional evidence that Ae. albopictus abundance peaks in vegetated, humid outdoor micro-habitats during the warmer months (Gratz, 2004). Given the continuing clinical burden of dengue in Pakistani urban centres (Scientific Reports, 2024), this co-occurrence at a single, well-defined, easily monitored 10-metre ecotone represents an unusually tractable target for integrated public-health and biodiversity management, rather than a campus-wide intervention. Conversely, the confirmed presence of three reproductively dependent amphibian species provides direct, positive evidence of functional aquatic habitat integrity (Collins & Storfer, 2003; Blaustein & Wake, 1990), and should be weighed explicitly against any proposed larvicide-based vector control, favoring selective, non-target-safe agents (e.g., Bacillus thuringiensis israelensis) over broad-spectrum alternatives.

Several taxa recorded here explicitly bridge the terrestrial and aquatic compartments aquatic-larval, aerial-adult odonates; a pond-margin snake sustained by amphibian prey; a kingfisher foraging exclusively on pond fish; and a mosquito that breeds in standing water but creates terrestrial public-health risk collectively illustrating the reciprocal-subsidy model of terrestrial–aquatic food-web coupling (Polis et al., 1997; Nakano & Murakami, 2001; Odum, 1971). These linkages indicate that the two compartments cannot be managed as independent units: protecting the pond margin sustains species and ecological functions (predation, pollination, insectivory) that extend well beyond the water's edge.

5. Conclusion and Recommendations

This study provides the first systematic, multi-taxon, habitat-comparative faunal baseline for a university campus in the Rahim Yar Khan district, documenting 80 species across 7 classes. Terrestrial habitats chiefly the botanical garden, nursery and Sheikh Khalifa Park account for the bulk of campus species richness, while the spatially minor pond–riparian ecotone contributes disproportionate, non-substitutable taxonomic diversity, including all obligate aquatic vertebrates and several taxa of direct conservation and public-health concern. We recommend that campus management: (1) designate a protective buffer around

the pond margin restricting construction and chemical application; (2) expand native flowering plantings in the botanical garden and nursery to support the documented pollinator community; (3) implement source-reduction-based Aedes surveillance at the pond margin using non-target-safe larvicides; (4) install signage and first-aid training addressing the two medically significant scorpion species; and (5) establish a recurring, multi-season biodiversity monitoring programme, extending sampling beyond the summer season to capture migratory avifauna and monsoon-associated invertebrate turnover.

Acknowledgements

The authors thank the administration and technical staff of the Islamia University of Bahawalpur, Rahim Yar Khan Campus, for facilitating field access, and colleagues who assisted with field sampling and specimen identification.

References

Ali, S., & Ripley, S. D. (2012). Handbook of the birds of India and Pakistan (2nd ed.). Oxford University Press.

Bhattarai, S., Bhatta, B., Gautam, J., & Shrestha, B. B. (2026). Diversity and distribution patterns of invasive alien plant species along dispersal corridors in Parsa National Park, central Nepal. Ecology and Evolution, 16(2), e73046.

Bibi, S., Noreen, S., Jadoon, W. A., Imdad, K., Jameel, M. A., & Ali, A. (2026). Earthworm diversity and spatial distribution across the Hazara Division. BMC Ecology and Evolution.

Blaustein, A. R., & Wake, D. B. (1990). Declining amphibian populations: A global phenomenon. Trends in Ecology & Evolution, 5(7), 203–204.

Cardinale, B. J., Duffy, J. E., Gonzalez, A., Hooper, D. U., Perrings, C., Venail, P., Narwani, A., Mace, G. M., Tilman, D., Wardle, D. A., Kinzig, A. P., Daily, G. C., Loreau, M., Grace, J. B., Larigauderie, A., Srivastava, D. S., & Naeem, S. (2012). Biodiversity loss and its impact on humanity. Nature, 486(7401), 59–67.

Ceballos, G., Ehrlich, P. R., & Raven, P. H. (2022). Vertebrates on the brink as indicators of biological annihilation and the sixth mass extinction. Proceedings of the National Academy of Sciences, 117(24), 13596–13602.

Chippaux, J. P., & Goyffon, M. (2008). Epidemiology of scorpionism: A global appraisal. Acta Tropica, 107(2), 71–79.

Collins, J. P., & Storfer, A. (2003). Global amphibian declines: Sorting the hypotheses. Diversity and Distributions, 9(2), 89–98.

Dhanishta, N., & Alagumanikumaran, N. (2025). Biodiversity unveiled: A study of faunal diversity and student conservation mindset at V.H.N.S.N. College. Research Square (preprint).

Dirzo, R., Young, H. S., Galetti, M., Ceballos, G., Isaac, N. J. B., & Collen, B. (2014). Defaunation in the Anthropocene. Science, 345(6195), 401–406.

Elliott, L. H., Igl, L. D., & Johnson, D. H. (2020). The relative importance of wetland area versus habitat heterogeneity for promoting species richness and abundance of wetland birds in the Prairie Pothole Region, USA. The Condor, 122(1), duz060.

Gratz, N. G. (2004). Critical review of the vector status of Aedes albopictus. Medical and Veterinary Entomology, 18(3), 215–227.

Hallmann, C. A., Sorg, M., Jongejans, E., Siepel, H., Hofland, N., Schwan, H., Stenmans, W., Müller, A., Sumser, H., Hörren, T., Goulson, D., & de Kroon, H. (2017). More than 75 percent decline over 27 years in total flying insect biomass in protected areas. PLOS ONE, 12(10), e0185809.

IPBES. (2019). Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. IPBES Secretariat.

Karjee, R., Palei, H. S., Konwar, A., Gogoi, A., & Mishra, R. K. (2022). Bird assemblages in a peri-urban landscape in eastern India. Birds, 3(4), 383–401.

Khan, A. A., Ahmad, I., & Khalid, S. (2015). Assessment of biodiversity in institutional green spaces of Lahore, Pakistan. Pakistan Journal of Zoology, 47(2), 501–509.

Khan, M. S. (2006). Amphibians and reptiles of Pakistan. Krieger Publishing Company.

Little, D. C., Newton, R. W., & Beveridge, M. C. M. (2021). Aquaculture: A rapidly growing and significant source of sustainable food? Status, transitions, and potential. Proceedings of the Nutrition Society, 75(3), 274–286.

Nakano, S., & Murakami, M. (2001). Reciprocal subsidies: Dynamic interdependence between terrestrial and aquatic food webs. Proceedings of the National Academy of Sciences, 98(1), 166–170.

Odum, E. P. (1971). Fundamentals of ecology (3rd ed.). W. B. Saunders.

Pakistan Journal of Scientific and Industrial Research. (2023). Checklist of butterflies from the Botanical Garden, Lahore, Punjab, Pakistan.

Polis, G. A. (1990). The biology of scorpions. Stanford University Press.

Polis, G. A., Anderson, W. B., & Holt, R. D. (1997). Toward an integration of landscape and food web ecology: The dynamics of spatially subsidized food webs. Annual Review of Ecology and Systematics, 28, 289–316.

Ralph, C. J., Sauer, J. R., & Droege, S. (Eds.). (1995). Monitoring bird populations by point counts. USDA Forest Service General Technical Report PSW-GTR-149.

ResearchGate. (2023). Avian diversity, abundance and habitat suitability index for threatened species in selected areas of Northern Pakistan. ResearchGate Publication 363212934.

Roberts, T. J. (2005). The birds of Pakistan (Vols. 1–2). Oxford University Press.

Scientific Reports. (2024). Clinical characteristics of dengue virus infections in Karachi from 2019 to 2023: A cross-sectional study. PMID: 39738341.

Soga, M., Aronson, M. F. J., Yamaura, Y., Nagata, S., & Fukushima, M. (2023). Urban biodiversity: Research and management for greener cities. Biological Conservation, 279, 109946.

Tickner, D., Opperman, J. J., Abell, R., Acreman, M., Arthington, A. H., Bunn, S. E., Cooke, S. J., Dalton, J., Darwall, W., Edwards, G., Harrison, I., Hughes, K., Jones, T., Leclère, D., Lynch, A. J., Leonard, P., McClain, M. E., Muruven, D., Olden, J. D., Ormerod, S. J., … Young, L. (2020). Bending the curve of global freshwater biodiversity loss: An emergency recovery plan. BioScience, 70(4), 330–342.

Ullah, I., You, D. W., Wu, Q. M., Ying, S. X., Rajpar, M. N., Khan, T. U., & Rehman, F. U. (2024). Population dynamics and habitat preferences of waterbirds across six wetlands at different geographical scales.