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# Anura diversity and distribution at the three anthropogenic habitat areas of the IPB Dramaga Campus, West Java, Indonesia

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## ABSTRAK

*Anura, kelompok amfibia yang tersebar luas di ekosistem air tawar dan terestrial, masih kurang diteliti mengenai keanekaragaman dan pola distribusinya di lingkungan perkotaan. Studi ini bertujuan untuk mengidentifikasi komposisi spesies, keanekaragaman, kemerataan, pola distribusi, dan variabel lingkungan penting yang menentukan keragaman Anura di tiga area dengan tingkat gangguan yang berbeda di kampus IPB Dramaga, Bogor. Data dikumpulkan menggunakan metode VES. Hasil menunjukkan bahwa distribusi Anura di ketiga habitat cenderung berkelompok, terdiri dari 199 individu dari enam jenis dan empat suku.* Duttaphrynus melanostictus *mendominasi habitat dengan tingkat gangguan tinggi, menunjukkan dia sebagai jenis toleran yang mampu bertahan hidup dan mendominasi komunitas amfibia di daerah yang terganggu. Sebaliknya, area dengan gangguan rendah menunjukkan keanekaragaman jenis dan kemerataan tertinggi (H' = 1,13, E = 0,63) dibandingkan dengan dua habitat lainnya. Hal ini didukung oleh pH tanah rata-rata 5,09 dan kelembaban tanah 59,8%. Faktor lingkungan dan aktivitas manusia kemungkinan memengaruhi perbedaan dalam struktur komunitas. Hasil penelitian ini menekankan pentingnya menjaga keanekaragaman mikrohabitat di daerah perkotaan untuk mendukung kelangsungan hidup spesies amfibi yang toleran terhadap gangguan maupun yang sensitif.*

***Kata Kunci: Amfibian,* indeks nearest neighbor*, antropogenik, area urban, indeks morisita***

## ABSTRACT

*Anura, a group of amphibians widely distributed in freshwater and terrestrial ecosystems, has been understudied regarding its diversity and distribution patterns in urban terrestrial settings. This study aims to identify the species composition, diversity, evenness distribution patterns and environmental correlates of Anura across three differing disturbance level areas within the IPB Dramaga campus in Bogor. Data was collected using the Visual Encounter Survey method. The results indicate that Anura distribution across the three habitats tends to be clustered, comprising 199 individuals from six species and four families.* Duttaphrynus melanostictus *dominated habitats with high disturbance levels, highlighting its ecological significance as a tolerant species capable of surviving and dominating amphibian communities in disturbed areas. Conversely, the low-disturbance area exhibited the highest species diversity (H' = 1.13) and evenness (E = 0.63) compared to the other two habitats, supported by an average soil pH of 5.09 and soil moisture of 59.8%. Environmental factors and human activities likely influenced differences in community structure. These findings emphasize the importance of maintaining diverse microhabitats in urban areas to support the persistence of both disturbance-tolerant and sensitive amphibian species.*

***Keywords: Amphibians, anthropogenic, morisita index, nearest neighbor index, urban area***

## INTRODUCTION

Anurans (frogs and toads) are widely distributed amphibians; their presence spans various climatic regions as one of the most ecologically diverse groups of amphibians (de Azevedo Calderon & Guerino, 2011), occupying broad range of habitats, from tropical forests to highly urbanized areas (Penhacek et al., 2024; Smallbone et al., 2011). However, anuran species differ in their tolerance to environmental change (Pereira et al., 2025). While some generalist species can persist in disturbed or urban habitats, many sensitive species are known to respond strongly to environmental changes, particularly in microhabitat conditions such as humidity, temperature, and water availability (Tong et al., 2023). Therefore, changes in environmental quality are indicated by shifts in anuran species composition, making anurans useful bioindicators of environmental change (Syazali et al., 2017)

Urban environments are characterized by intense anthropogenic pressures and have been known to affect anuran life. For example,  Artificial light at night (ALAN) influences male call-site selection in some anuran species, with males tending to avoid calling in areas illuminated by artificial light, a characteristic of urbanized areas (Kobisk & Kwiatkowski, 2023). Another pressure as traffic noise induces physiological stress in female frogs and masks male advertisement calls, thereby reducing their ability to locate potential mates (Tennessen et al., 2014; Intani et al., 2024). Another pressure is fragmentation of habitats in urban settings necessitates that frogs adapt to novel resources and challenges, often favoring generalist species like *Duttaphrynus melanostictus* over specialists, thereby altering community composition (Licata et al., 2019).

University campuses, akin to micro-urban environments, comprise green spaces and infrastructure, offering diverse habitats for wildlife. The IPB Dramaga campus, located near Bogor City, features a diverse range of ecological elements, including forest patches, artificial lakes, agricultural areas, and green spaces that are interspersed among buildings and roads. This setting provides an ideal context for examining anuran responses to anthropogenic disturbances. A study conducted at this site has documented the diversity and distribution of frog populations around the campus lake (Ribut et al., 2024). Previous studies on university campuses indicate their potential to sustain frog populations despite urban pressures, particularly when natural vegetation or green spaces are present (Yudha et al., 2023; Liando et al., 2019). These findings underscore the value of campuses as sites for investigating amphibian adaptation to human-induced environmental changes.

Although several studies have been conducted in urban and semi-urban campus environments in Indonesia (Liando et al., 2019; Yudha et al., 2023; Ribut et al., 2024), information on how anthropogenic disturbance influences anuran community structure across different disturbance levels remains limited. Most existing studies primarily focus on species diversity, with comparatively little attention given to spatial distribution patterns, particularly for terrestrial amphibians. In addition, previous studies at the IPB Dramaga Campus have primarily focused on aquatic habitats such as lakes (Ribut et al., 2024), while information on anuran distribution in terrestrial habitats remains very limited. This study aims to evaluate the spatial distribution and diversity of anurans in the terrestrial habitat of the IPB Dramaga Campus and identify the influence of environmental variables on these distribution patterns.

## METHODOLOGY

### Study Area

We conducted the study during the dry season in April 2025 at the IPB Dramaga Campus, Bogor, West Java. Three study areas were selected to represent a gradient of anthropogenic disturbance based on qualitative field observations of terrestrial habitat characteristics and surrounding environmental conditions. Site selection considered indicators such as surrounding land-use type, proximity to roads and buildings, intensity of pedestrian and vehicle activity,



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ambient noise exposure, proximity to water bodies (e.g., ponds and drainage channels), and the presence of shade-providing vegetation that may influence anuran occurrence.

The three study areas consisted of: (1) the IPB Dramaga Permanent Nursery (151 masl), (2) the vicinity of the Department of Chemistry (180 masl), and (3) the Main Gate of IPB Dramaga Campus (180 masl) **(FIGURE 1).** The Permanent Nursery was classified as a low-disturbance area, characterized by a cooler microclimate, dense vegetation cover, proximity to a water source, and minimal exposure to anthropogenic noise and human activity. The vicinity of the Department of Chemistry was categorized as a medium-disturbance area, with moderate pedestrian movement and intermittent academic-related noise. In contrast, the Main Gate was classified as a high-disturbance area due to its proximity to a major roadway, high pedestrian density, and continuous motorcycle and vehicular traffic throughout the day.

Each study area covered an observation plot of 12 m². The distances among the three sites ranged from approximately 600 to 1.200 m, indicating that the sites were spatially separated while remaining within the same campus landscape.

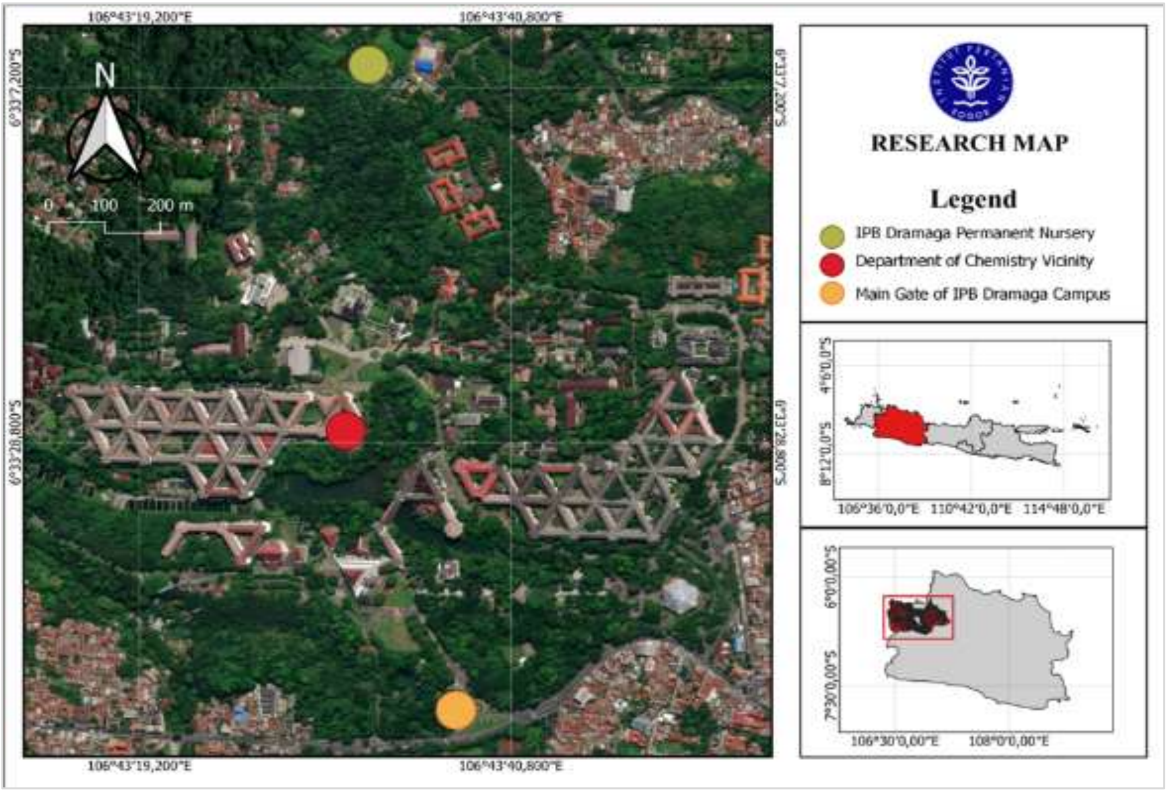


**FIGURE 1.** Three observed areas at the Dramaga Campus, IPB University (indicated by colored circles on the map). Green: The permanent nursery area, a low-disturbance site, characterized by limited pedestrian activity, minimal vehicle traffic, proximity to a water source, and dense vegetation. Red: The vicinity of the Department of Chemistry, a medium-disturbance site, with moderate pedestrian movement, occasional vehicle access, and moderate academic noise. Orange: The Main Gate of IPB Dramaga, a high-disturbance area, experiencing high pedestrian density, frequent motorcycle and car traffic, and proximity to a major road

## Data Collection

Data was collected nocturnally between 19:00 and 22:00 h using a Visual Encounter Survey (VES) method (Heyer et al., 1994), combined with acoustic observations to detect calling individuals. Surveys were conducted during this period because most anurans are



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nocturnal and exhibit higher activity and detectability at night than during daylight or crepuscular periods (Rocha et al., 2015).

Observations were carried out by slowly walking along predetermined survey paths within each study area using a cruising technique. All anuran individuals encountered were temporarily captured by hand and photographed for species identification. To prevent double counting on the same survey day, individuals were marked with a small amount of non-toxic acrylic paint applied externally to the body surface. This marking method was not only non-invasive that will not cause physical injury, but also temporary, fading naturally within a short period. After recording data, all individuals were immediately released at the point of capture.

Substrate characteristics were recorded for each encounter, including substrate type, distance to the nearest water source, and elevation. Distance to water sources and point locations were recorded using Google Earth. Environmental variables were measured in situ at each encounter point, including air temperature, air humidity, and light intensity using a 4-in-1 environmental meter, as well as soil pH and soil moisture using a portable 2-in-1 soil meter.

Species abundance data (number of individuals per species per location) were used to calculate ecological indices and to perform one-way ANOVA. GPS coordinate data from individual encounters were used to perform spatial analyses using the Nearest Neighbor Index (NNI) in QGIS. All environmental variables were recorded as continuous quantitative data and used as explanatory variables in the Canonical Correspondence Analysis (CCA). Data collection was repeated four times in each observed area.

**Species Identification**

We identified the anuran species using field guidebooks and amphibian identification keys (Frost, 2025), specifically "Amphibians of Java and Bali" (Iskandar, 1998) and *"Panduan Bergambar Identifikasi Amfibi Jawa Barat"* (Kusrini, 2013). For individuals that could not be captured or photographed, specifically *Limnonectes macrodon*, species identification was validated through direct consultation with herpetology experts. Additionally, identifications were cross-checked against recent taxonomic updates and regional references (Milto 2025) to account for recently split or rediscovered species. These measures minimized the underestimation of herpetodiversity.

**Data Analysis**

We calculated four ecological indices: Shannon-Wiener Diversity Index (H′), Simpson's Dominance Index (D), Margalef's Species Richness Index (Dmg), and Shannon's Evenness Index (E) (Magurran & McGill, 2011) using RStudio. 12.1 with "*vegan*" package (Borcard et al., 2011). Then we continued the analysis with a one-way ANOVA and post-hoc Tukey HSD tests to compare the three observed areas (significant differences at $p < 0.05$). Moreover, we analyzed data on individual encounters of each species found using the Morisita Dispersion Index (Id) to determine the distribution patterns of anuran populations across three observation areas. The index will fall into a random category if $Id = 1$, a clustered/grouped category if $Id > 1$, or a uniform category if $Id < 1$ (Morisita, 1962). We also examined the spatial distribution patterns of Anura individuals across each study area using the Nearest Neighbor Index (NNI) (Chiu et al., 2018), which was computed in Quantum GIS version 3.22.1 (Frontasyeva, 2011).



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Furthermore, we performed the Canonical Correspondence Analysis (CCA) (Ter Braak, 1987) to assess how species composition and abundance are associated with environmental gradients. In this study, the environmental gradients included air temperature, air humidity, light intensity, wind speed, soil pH, average rainfall, distance to the nearest water source, and elevation. These variables were used as environmental predictors to examine their influence on variation in species composition among study sites.

## RESULTS AND DISCUSSION

### Species composition and ecological index

In this study, we identified a total of 199 anuran individuals comprising six species from four families **(FIGURE 2; TABLE 1)**: Bufonidae (*Duttaphrynus melanostictus* and *Phrynoidis asper*), Dicroglossidae (*Limnonectes macrodon* and *Fejervarya cancrivora*), Rhacophoridae (*Polypedates leucomystax*), and Ranidae (*Hylarana megalonesa*).

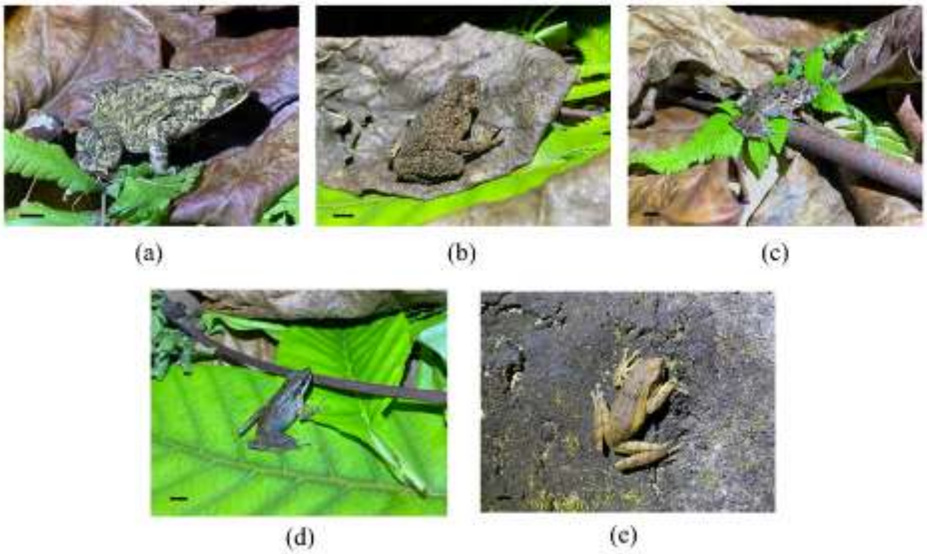


**FIGURE 2.** Anuran species observed in the three areas at Dramaga Campus, IPB University. (a) *Duttaphrynus melanostictus,* (b) *Phrynoidis asper,* (c) *Fejervarya cancrivora,* (d) *Hylarana megalonesa,* (e) *Polypedates leucamystax.* Black lines are 1 cm scale

**TABLE 1.** Species Composition of anurans in the three observed areas at Dramaga Campus

| Species | Chemistry | Main Gate | Permanent Nursery | ∑ |
|---|---|---|---|---|
| **Bufonidae** | | | | |
| *Duttaphrynus melanostictus* | 36 | 66 | 57 | 159 |
| *Pheryonides asper* | 0 | 0 | 2 | 2 |
| **Dicroglossidae** | | | | |
| *Limnonectes macrodon* | 0 | 0 | 3 | 3 |
| *Fejervarya cancrivora* | 0 | 0 | 6 | 6 |
| **Rhacophoridae** | | | | |
| *Polypedates leucomystax* | 4 | 5 | 15 | 24 |
| **Ranidae** | | | | |
| *Hylarana megalonesa* | 0 | 0 | 5 | 5 |
| **Totals (individual)** | **40** | **71** | **88** | **199** |



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The anuran species composition at IPB Dramaga Campus is dominated by *D. melanostictus* (82% of total individuals), particularly in areas with high human activity, such as the Main Gate. *D. melanostictus* is recognized as a generalist species with high tolerance to anthropogenic disturbances, including noise pollution and habitat fragmentation (Purkayastha et al. 2011). Its ability to adapt to artificial substrates (e.g., concrete and paving), coupled with physiological adaptations such as drought tolerance and reproductive flexibility (utilizing temporary water pools), supports its abundance in degraded habitats (Licata et al., 2019; Samitra & Rozi, 2020).

In contrast, the low species diversity observed at the Main Gate area (H′ = 0.25) is likely associated with high levels of anthropogenic disturbance typical of urban environments. Previous studies have shown that traffic noise and artificial lighting can affect acoustic communication and nocturnal activity in anurans (Lewis et al., 2021; Wells, 2007). Most anurans are nocturnal and usually call under low-light conditions. Artificial light at night can disrupt their natural activity, increase predation risk, and cause individuals to reduce or stop calling behavior. Consequently, acoustic communication, which is essential for reproduction, may be disrupted (Kobisk & Kwiatkowski, 2023). Although light intensity was not directly measured in this study, the low diversity observed at the Main Gate area is consistent with patterns reported in highly disturbed urban habitats (Lewis et al., 2021; Wells, 2007). Conversely, species such as *L. macrodon* and *H. megalonesa* were exclusively observed in the Nursery Area, characterized by dense vegetation and stable environmental conditions. Anuran species with specific habitat preferences tend to persist only in minimally disturbed areas (Miftakhurrohmah et al., 2019). The low abundance of *L. macrodon* (3 individuals) in the Nursery Area may be attributed to our observation of time limitations. This species is reported to be primarily active between 22:00 and 01:00 WIB (Kusrini, 2013), whereas our observation period falls outside this range (19:00–22:00 h). Nevertheless, our findings align with global trends where generalist species (e.g., *D. melanostictus*) dominate disturbed habitats, while sensitive species (e.g., *L. macrodon*) are displaced, highlighting the importance of conserving natural habitats such as permanent nurseries to provide breeding sites, support anthropogenically sensitive species, and prevent community homogenization as a biodiversity conservation effort (Murphy & Romanuk, 2014).

An ecological index analysis of the order Anura across three study areas at Dramaga Campus, IPB University, revealed evident variations in community parameters (**FIGURE 3)**. We found that the low-disturbance area (Permanent Nursery IPB Dramaga) showed moderate diversity (H′ = 1.13), dominant species (D = 0.54), species richness (Dmg = 1.12), and evenness (E = 0.63). Meanwhile, the high disturbance area (Main Gate of IPB Dramaga) had the lowest index among the four ecological indices. A one-way ANOVA revealed significant differences in diversity (p = 0.02), dominance (p = 0.02), and species richness (p = 0.01) among the three observed areas. In contrast, the evenness value (p = 0.50) did not differ significantly. These test results align with the dominance of *D. melanostictus* across all observed areas, which may mask the distributions of other species, resulting in similar evenness values (Maestre et al., 2012). The post-hoc Tukey HSD tests for indices with significant differences confirmed that the Permanent Nursery area differed significantly from the Main Gate area with p-values of 0.0271 for the diversity index, 0.0279 for the dominant index, and 0.019 for the species richness. Our



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findings indicate that the Permanent Nursery area harbors the healthiest ecosystem among the three observed areas. This superiority is supported by consistently higher values across all analyzed ecological indices. The Permanent Nursery area supports higher biodiversity, a more balanced species distribution, and greater species richness than other areas.

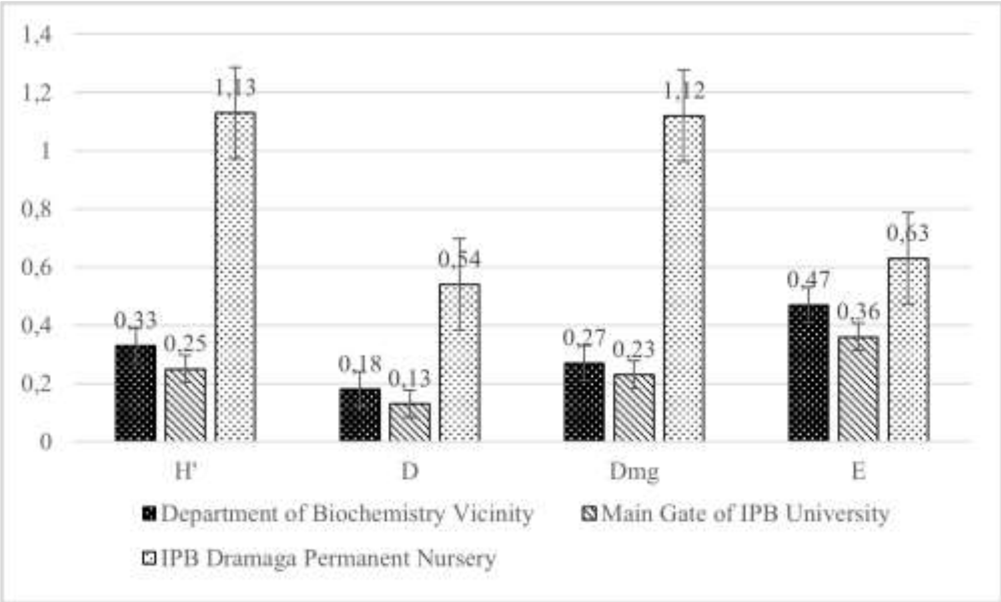


**FIGURE 3.** Ecological indices of amphibian communities at three locations in IPB Dramaga Campus: H′= Diversity index, D Dominance index, Dmg Species richness index, E Evenness index. Bars represent mean values; error bars indicate standard deviation. IPB Dramaga Permanent Nursery showed the highest mean values of diversity (H′), dominance (D), species richness (Dmg), and evenness (E) indices compared to the Department of Biochemistry Vicinity and the Main Gate of IPB University.

The favorable conditions at the Permanent Nursery likely result from more stable environmental factors such as optimal soil quality **(TABLE 4).** High diversity and dense vegetation in the nursery create a variety of microhabitats, facilitating niche partitioning among anurans (Gentry, 1982; Valencia et al., 2004). Moreover, fertile soil, adequate light exposure, and minimal human disturbance contribute to ecosystem stability. Conversely, lower index values observed near the Main Gate and the vicinity of the Department of Chemistry suggest reduced diversity and evenness, likely due to land-use changes and proximity to roads. Anthropogenic pressures, such as pollution, habitat fragmentation, and disruptive human activities, also contribute to resource depletion and environmental homogenization, thereby reducing species richness by up to 24.8% (Murphy & Romanuk, 2014). Our findings suggest that maintaining or replicating environmental conditions similar to those in the Permanent Nursery through natural vegetation management and limiting anthropogenic activities can effectively preserve Anura diversity.

**Distribution pattern**

The spatial distribution of anurans across three observed areas consistently exhibiting clustering patterns, as indicated by both the Morisita Index the Id and the Nearest Neighbor Index, the NNI (**TABLE 2** & **TABLE 3**). Species-level analysis showed clustering pattern across all species, with Id values ranging from 1.05 to 3.00. Notably, *P. asper, L. macrodon, F.*



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*cancrivora*, and *H. megalonesa* displayed the highest Id values (3.00), though these were likely inflated due to low sample sizes (n= 2–6). In contrast, *D. melanostictus,* the most abundant species (n= 118), had a lower Id value of 1.05, reflecting its ecological flexibility and generalist nature (Licata et al., 2019). At the area level, NNI analysis confirmed a clustered spatial pattern, with Average Nearest Neighbor Index (ANNI) values consistently below 1 (0.42–0.80). The most substantial clustering was recorded at the Permanent Nursery (Z= –10.29), likely driven by the availability of heterogeneous microhabitats, such as shaded, moist substrates near water sources, which are critical for amphibian hydration, thermoregulation, and reproduction (Iskandar, 1998; Chusman, 2006; Yanuarefa et al., 2012).

**TABLE 2.** Morisita index and spatial distribution patterns of anuran species in the study area

| Species | Morisita Index | Category |
|---|---|---|
| **Bufonidae** | | |
| *Duttaphrynus melanostictus* | 1.05 | Clustered |
| *Pheryonides asper* | 3.00 | Clustered |
| **Dicroglossidae** | | |
| *Limnonectes macrodon* | 3.00 | Clustered |
| *Fejervarya cancrivora* | 3.00 | Clustered |
| **Rhacophoridae** | | |
| *Polypedates leucomystax* | 1.32 | Clustered |
| **Ranidae** | | |
| *Hylarana megalonesa* | 3.00 | Clustered |

**TABLE 3.** Nearest Neighbor Index (NNI) Analysis of anuran spatial distribution at sampling sites

| Location | Sample | Observed Distance | Expected Distance | ANNI | Z-score | Pattern |
|---|---|---|---|---|---|---|
| Main Gate | 71 | 6.71 | 13.58 | 0.49 | -8.09 | Clustered |
| Biochemistry | 40 | 7.45 | 9.31 | 0.8 | -2.41 | Clustered |
| Permanent Nursery | 87 | 4.25 | 10.05 | 0.42 | -10.29 | Clustered |

**TABLE 4.** Environmental measurements were conducted at each Anura encounter at the observation site

| Parameters | Biochemistry | Main Gate | Permanent Nursery |
|---|---|---|---|
| Air Temperature (°C) | 28.07 ± 0.87 | 28.23 ± 1.28 | 28.85 ± 0.42 |
| Air Humidity (%) | 81.85 ± 6.81 | 79.51 ± 6.64 | 81.2 ± 5.81 |
| Soil Humidity (%) | 64.87 ± 8.72 | 64.14 ± 17.54 | 59.81 ± 9.48 |
| Soil pH | 4.49 ± 0.37 | 4.30 ± 0.47 | 5.09 ± 0.44 |

Notes: Data are expressed as mean ± standard deviation (SD), based on measurements taken at three sampling points at each site during nocturnal surveys. Biochemistry, Main Gate, and Permanent Nursery represent medium, high, and low-disturbance areas, respectively.

The restricted presence of *P. asper, L. macrodon, F. cancrivora*, and *H. megalonesa* at the Permanent Nursery area likely reflects their dependence on humid, vegetated environments near aquatic resources (Kwatrina et al., 2019). Meanwhile, the broad distribution of *P. leucomystax* across all areas can be attributed to its arboreal habits and high adaptability (Gunzburger & Travis, 2004; Kwatrina et al., 2019). Similarly, *D. melanostictus* maintained an clustering pattern across all habitats, consistent with its reputation as a disturbance-tolerant



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species frequently found in anthropogenically modified environments (Licata et al., 2019). These patterns highlight the importance of conserving high-quality microhabitats, such as those at the Permanent Nursery, which serve as refugia for sensitive amphibian taxa. Integrating green corridors and buffer zones into urban planning is crucial for maintaining amphibian diversity in disturbed landscapes, aligning with global conservation recommendations that emphasize the importance of habitat heterogeneity in urban ecosystems (Aronson et al., 2014).

Moreover, anuran individuals are predominantly found on five substrate types (paving, concrete, leaf litter, grass, and soil). They differ significantly across areas based on distance from water sources (100 to 500 meters). *F. cancrivora* and *P. leucomystax* were more frequently encountered at the Permanent Nursery area, which is relatively close to a water source (a small pond < 100 meters), indicating their preference for aquatic habitats. In contrast, at the drier and more distant Main Gate location (500 meters away), *D. melanostictus* was dominant, suggesting an adaptation to less humid environmental conditions (Mogali et al. 2017).

Furthermore, the Canonical Correspondence Analysis (CCA) showed that environmental variables (air temperature, air humidity, soil humidity, and soil pH; **TABLE 4)** collectively explained 47.36% of the total variation in anuran community distribution (*Constrained Inertia* = 0.2171; **FIGURE 4**). The first CCA axis (CCA1) contributed the most, with an eigenvalue of 0.1682, accounting for 36.69% of the variation explained by the environment. Although the permutation test (ANOVA by axis) revealed a non-significant association for CCA1 ($p = 0.370$ at $\alpha = 0.05$), the positive trend of soil pH ($p = 0.089$) in relation to *D. melanostictus* distribution suggests a weak influence. However, validation with a larger dataset is required to strengthen statistical significance. The diversity of anurans at the Permanent Nursery was driven by a combination of specific environmental conditions: neutral soil pH (5.09), high air humidity (81.2%), and proximity to water sources. These conditions likely facilitated niche partitioning among species such as *F. cancrivora* and *P. leucomystax.* In contrast, temperature variation across sites (28.07–28.85°C) was too minimal to significantly affect anuran distribution, as amphibians are more sensitive to humidity and water availability (Wells, 2007).

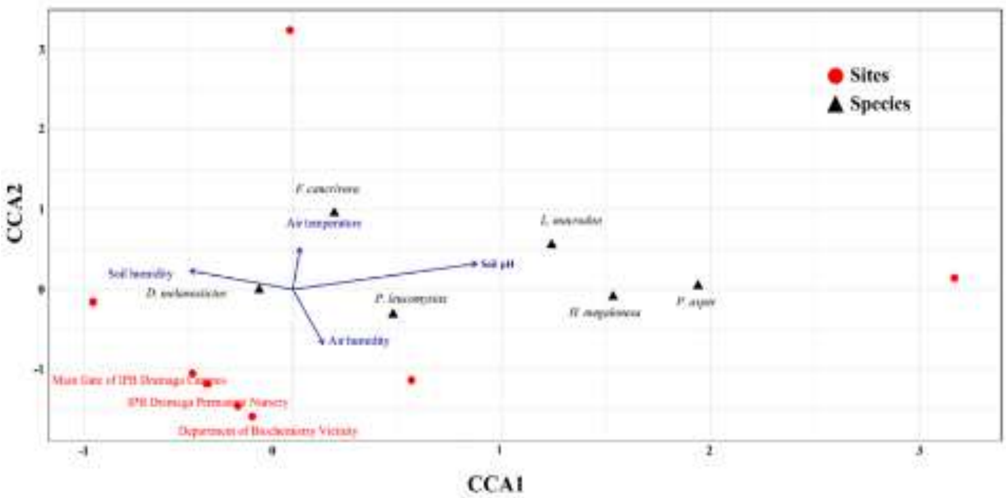


**FIGURE 4.** Canonical correspondence analysis (CCA) distribution of anuran species and environmental variables. The red color represents each observed area. Blue color shows each environmental parameter. The



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color black represents the sixth observed anuran species. The CCA1 axis reflects the gradient of soil pH and air humidity, while the CCA2 axis reflects variations in air temperature and soil moisture.

## CONCLUSIONS

This study identified six Anura species from four families. The Permanent Nursery , as the least disturbed area exhibited moderate species diversity and evenness attributed neutral soil pH, high air humidity, and proximity to water sources; while the Main Gate and Biochemistry sites, as more disturbed area showed lower diversity with the disturbance-tolerant *Duttaphrynus melanostictus*. All areas showed clustering distribution patterns, with the Permanent Nursery as the least disturbed area exhibits the most pronounced clustering. Environmental variables, particularly soil pH and humidity, accounted for 47.36% of the variation in Anura community structure, with *D. melanostictus* showing a weak association with higher soil pH. These findings emphasize the importance of preserving diverse, less-disturbed microhabitats in urban settings to support resilient and sensitive amphibian species. Thus, the concept of green corridors and buffer zones into urban planning may be important in enhancing habitat heterogeneity, thereby promoting the conservation of Anura communities and mitigating anthropogenic impacts on biodiversity.

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## CONFLICTS OF INTEREST STATEMENT

The authors declare that they have no competing interests.

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