

Anurans of select green spaces of Davao City, Mindanao Island, Philippines

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Abstract. Delima-Baron EM, Ruales CAS, Tripole C, Tagoon MDT, Susulan TB. 2022. Anurans of select green spaces of Davao City, Mindanao Island, Philippines. *Biodiversitas* 23: 4810-4815. Data on anurans in green spaces, especially in highly urbanized cities, including Davao, is still very limited. We present for the first time a checklist of anuran species from six green spaces of Davao City previously not surveyed for anuran data. Anurans were documented from January to April 2019 using visual encounter techniques coupled with microhabitat searches on several nocturnal surveys. Eighteen species representing seven families were recorded. Three endemic species: *Pelophryne brevipes*, *Fejervarya moodiei*, and *F. vittigera*, were added to the current list of anurans known from green spaces of Davao City, bringing the total known species for Davao City to 23. Thirteen of the species recorded are endemic. Two species under the Near Threatened category of IUCN, *Limnonectes magnus* and *Sanguirana everetti*, were also documented. The study also accounted for four invasive species: *Rhinella marina*, *Eleutherodactylus planirostris*, *Hoplobatrachus rugulosus*, and *Kaloula pulchra*. However, these species were encountered only in sites with artificial structures nearby, prominent noise, and has less heterogeneous vegetation. Data adds to the limited account of anurans in Davao City's green spaces. Adding more species also implies that the list of anurans from Davao City's green spaces is far from complete. Exploration of other green spaces available in the city is necessary to fully understand anuran species composition and the value of green spaces to the persistence of this taxon even in highly urbanized areas.

Keywords: Ecology, frog inventory, invasive species, urban diversity, urban green landscape

INTRODUCTION

Green spaces are areas with vegetation, either artificial, secondary, or primary growth, including open spaces, urban parks, hedgerows, and gardens (Haaland and van den Bosch 2015). These areas are set aside for aesthetic, recreational, commercial, or conservation purposes (Irvine et al. 2010; Taylor and Hochuli 2017). Urban green spaces provide a continuum of remnant vegetation patches that could benefit different animal taxa, as revealed in studies (Milanovich et al. 2012; Lepczyk et al. 2017). These green spaces in urbanized areas can also serve as a refuge for native wildlife, including those species groups known to be globally declining (Goulson et al. 2002; Carrier and Beebe 2003; Irvine et al. 2010). The ecological value of interconnected green spaces in urban areas is prominent as it forms part of regional and national efforts on biodiversity conservation actions (Irvine et al. 2010) and thus promotes the persistence of wildlife species even in urban settings (Straka et al. 2016; Hamer et al. 2018).

A taxon that can benefit from the green spaces found in urban areas is anurans, as reported in several accounts. Data from the study of Hamer et al. (2011) revealed that

interconnected green spaces, even in highly urbanized areas, promote species richness of frogs as it prevents desiccation and direct exposure to predators. Puglis and Boone (2012) reported that Blanchard's cricket frogs (*Acris blanchardi*) and green frogs (*Rana clamitans*) populations from Oxford, Ohio benefitted from green spaces such as buffered golf courses by acting as habitat havens for these species. Simple habitat enhancements in urban settings help keep populations of amphibians in Vietnam intact, as Holzer et al. (2017) reported. Required habitat-associated features include the presence of non-concrete banks, the existence of plants in aquatic areas, vegetated uplands surrounding possible breeding sites, and the occurrence of shallow spots. Increased green spaces were considered influential to the body size of the European Common Frog, *Rana temporaria*, and can be used to measure the species' survivability (Niemeier et al. 2020). Populations of the Pacific chorus frog (*Pseudacris regilla*) persist in urbanized landscapes when terrestrial habitats are found adjacent to breeding sites (Green et al. 2020). Hutto and Barrett (2021) also reported that urban green spaces with a smaller network of roads may harbor reduced watertight surfaces, thus promoting anuran dispersal and sustainability.

Several reports on anurans inhabiting green spaces in urbanized cities are available (Dixon et al. 2011; Kruger et al. 2015; Li et al. 2018; Ijie et al. 2021). These reports reveal anuran assemblage composition within urban green spaces and also provide information on how conditions within these urban green spaces influence what anuran species thrive in these green spaces. In the Philippines, accounts of anurans in non-forested habitats are available, but these are direct comparisons to species found in forested areas close to surveyed non-forested areas (Aureo and Bande 2019; Cruz et al. 2019). Philippine data on anurans documented from urban green spaces in highly urbanized localities are limited to current writing (Apayor-Ynot et al. 2017; Jabon et al. 2019; Gersava et al. 2020; Duco et al. 2020).

Since information about anuran composition and distribution in green spaces of highly urbanized cities in the Philippines like Davao remains relatively meager, the results of this study provide a significant contribution to this topic. Moreover, the inclusion of six sites previously not visited for anuran surveys also augments the knowledge about anuran species found in Davao City. Data of the present study may also contribute to plans for creating green spaces in the city with appropriate management intervention strategies to support the persistence of anuran species and possibly other diverse wildlife taxa.

MATERIALS AND METHODS

Description of green spaces surveyed

Green spaces surveyed for this study were areas within Davao City, Davao del Sur, Mindanao Island, the southern part of the Philippines that have either man-made, secondary, or primary vegetation (Figure 1). These sites were chosen based on accessibility and the absence of previous data on anurans. Despite the onset of urbanization, several areas of the city still contain patches of vegetation that different species of animals, including anurans, inhabit. Sites were visited from January to April 2019. Descriptions of sites surveyed are provided below.

Site 1 - includes a patch of trees inside the compound of Davao City National High School (DCNHS), one of the largest public high schools in the city. The school grounds have a few stands of trees on the periphery, including Acacia, Mahogany (*Swietenia macrophylla*), and *Terminalia catappa*. The school also maintains a small garden where a few stands of trees and other cultivated plants are found. Weather was generally good at the time of sampling except for occasional drizzles in the early part of the evening.

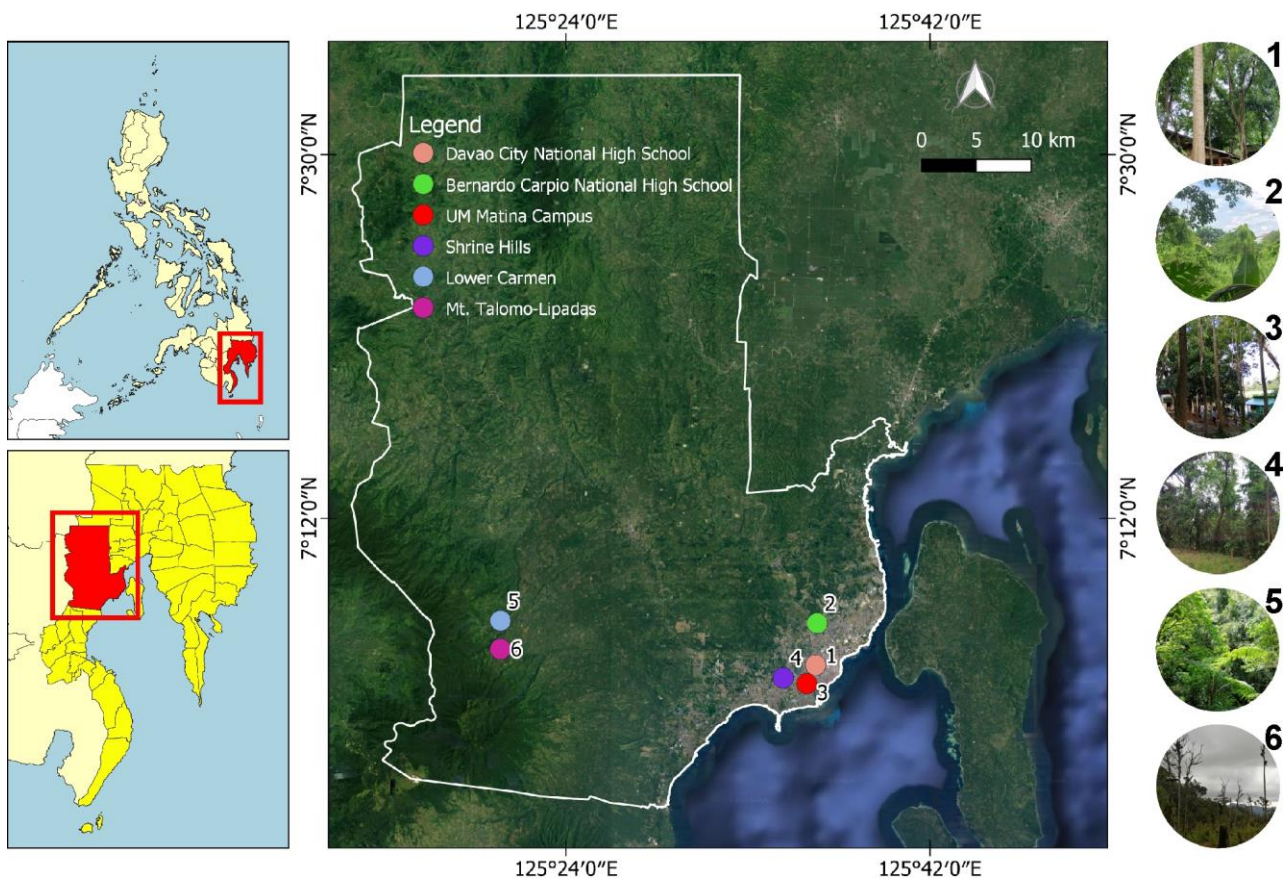


Figure 1. Location map showing the six green spaces surveyed in Davao City, Mindanao Island, Philippines. 1. DCNHS ($7^{\circ}4'44''$, $125^{\circ}36'21''$, 18 masl), 21-22 January 2019; 2. NCNHS ($7^{\circ}6'48''$, $125^{\circ}36'26''$, 49 masl), 23-24 January 2019; 3. UM Matina ($7^{\circ}03'49''$, $125^{\circ}35'55''$, 21 masl), 24-25 January 2019; 4. Shrine Hills ($7^{\circ}4'06''$, $125^{\circ}34'45''$, 154 masl), 28-29 January 2019; 5. Lower Carmen ($7^{\circ}6'55.5''$, $125^{\circ}20'46.3''$, 930 masl), 8-10 March 2019; 6. Talomo-Lipadas ($7^{\circ}05'31.36''$, $125^{\circ}20'45.89''$, 1260 masl), 26-29 April 2019.

The site is surrounded by city roads, with occasional to regular vehicle traffic. As it is situated within the school grounds, the area is teeming with human activities the entire daytime until the early hours of the night.

Site 2 - situated on the far northern side of the city inside the school grounds of Bernardo Carpio National High School (BCNHS). The school ground is smaller than DCNHS. The exterior periphery of the school is surrounded by a few stands of trees outside its boundaries, whereas the school ground interior maintains a few stands of *Terminalia catappa* and *Acacia*. Few water pools, possibly rainwater collected in a cemented structure, were also observed. Short downpours occurred in the early part of the night at the time of sampling but did not persist. Although the site is not close to the main road where vehicles pass through, it is heavily surrounded by human dwellings. Moreover, at the time of sampling, the construction of a school building was ongoing.

Site 3 - is a forest patch inside the University of Mindanao (UM) Matina campus that holds one of the last green spaces in Davao City. It is found within the 50-hectare campus of the university within barangay Maa and Matina. The vegetation patch harbors endemic tree species like Kamagong (*Diospyros blancoi*) and Antipolo (*Artocarpus blancoi*). A small remaining swamp is also found in its interior. Weather was generally good throughout the sampling period except for occasional drizzles at night time. Though situated inside the school campus, the site is located on the far end section of the school and thus a bit isolated from most human activities.

Site 4 - is a green space in the upper portion of Shrine Hills on Matina side. It is one of the important green spaces in Davao City that harbors the endemic tree Antipolo (*Artocarpus blancoi*) and the Southeast Asia native Narra (*Pterocarpus indicus*). The forest patch where sampling was done had a moderately thick leaf litter cover. Although the weather was generally fine for the first sampling night, heavy downpours, which lasted for about 2 hours, happened on the succeeding sampling days. The surveyed area was beside the road and was also surrounded by several scattered houses.

Site 5 - is one of the last relatively large green spaces in Davao City but is slowly converted into agricultural patches. It is marked with high moisture due to the presence of Lipadas river that runs from Mount Talomo. Several species of old-growth trees can be seen in the area. The site's forest litter is very thin, with a scanty forest canopy. Weather was generally good at the time of sampling. Site surveyed is beside a river tributary of Carmen River on one side but is bordered by a banana plantation on the opposite side.

Site 6 - entryway to Mount Talomo-Lipadas is also another relatively unexplored area in the Philippines for biodiversity data, except that it is known as one of the nesting sites of the Philippine Eagle (*Pithecophaga jefferyi*). It consists of the following ecosystem types: agroecosystem, montane, and mossy-pygmy forests. It is a headwater catchment area of several major river systems of Panigan, Tamugan, and Talomo River. Several species of endemic plants are found in the area. Sampling site has a

relatively thick forest leaf litter cover, tree stands are moderately covered with moss, and the moisture of the area is relatively high. At the time of sampling, drizzles were constant, but heavy downpours were experienced during the later hours of the night.

Sampling technique

Anurans were documented using visual encounter techniques and microhabitat searches (Heyer et al. 1994) in established transects. Each transect established in all sites was 100m long and 10m wide, stationed randomly in each site and was walked twice: morning (09:00 to 12:00 hours) and evening (18:00 to 21:00 hours). Three observers surveyed each transect stationed in each site. Diurnal transect walks mainly involved searches in tree holes, rotting logs, leaf litter shifting, while the nocturnal search was mostly focused on the search of frogs in leaf axils, leaves, petioles, and fronds. Searchers relied on sightings and frog calls to locate species. Samples were then hand-captured whenever possible. Species were identified based on diagnostic morphological characters of available past and recent publications (Diesmos et al. 2015; Baron et al. 2019; Pili et al. 2019; Delima-Baron et al. 2021). Species identification confirmation was done by the first author. Voucher specimens are currently housed at the Zoology Laboratory of San Pedro College in Davao City, Philippines. Voucher specimens were collected for some individuals following specifications of the Gratuitous Permit issued by the Department of the Environment and Natural Resources Region XI (WGP No. XI-2018-1). Field catalogue numbers of collected specimens are: *Pelophryne brevipes* (EMD 1165, EMD 1166, EMD 1173); *Philautus surdus* (EMD 1167, EMD1168, EMD1169, EMD1170, EMD1171, EMD1172; EMD 1174, EMD 1175, EMD 1176); *Philautus acutirostris* (EMD 1183); *Polypedates leucomystax* (EMD 1181); *Pulchrana grandocula* (EMD 1182).

RESULTS AND DISCUSSION

Eighteen species under seven families were accounted for from the six green spaces surveyed in Davao City (Table 1). Three of the species: *Pelophryne brevipes*, *Fejervarya moodiei*, and *F. vittigera*, were previously not accounted inaccessible published literature on anurans of Davao City, hence increasing the species count to 23. Out of the 18 species, six were exclusively encountered in the farthest green space surveyed (Site 6). Green spaces situated farther from the city center (Sites 5 and 6) show higher species richness than those situated near the city center (Sites 1-4). Except for Site 6, invasive species were documented: *Rhinella marina* (Site 1-5), *Kaloula pulchra* (Site 1,3-5), *Hoplobatrachus rugulosus* (Site 3-4), and *Eleutherodactylus planirostris* (Site 1,2,4). In terms of endemism, 72% (13 species) were accounted for, with nine species known to occur only within the Mindanao faunal region. The endemic species were recorded in four out of the six sites surveyed, two of these sites are located close to the city center. Five anurans were exclusively found in Site

6 (*Pelophryne brevipes*, *Leptobrachium lumadorum*, *Palaeobatrachus stejnegeri*, *Philautus surdus*, and *Philautus acutirostris*). In surveyed sites near city center, four endemic anurans were accounted: *Fejervarya moodiei* (Site 3), *Fejervarya vittigera* (Sites 3 and 4), *Limnonectes leytenensis* (Sites 4), *Kalophrynus sinensis* (Sites 3 and 4). Although 16 of the species are currently listed under the Least Concern category of the International Union for Conservation of Nature (IUCN 2022), two species: *Limnonectes magnus* and *Sanguirana everetti*, are classified under the Near Threatened category.

To date, published literature on anurans in green spaces of Davao City is still sparse. Although existing studies on

anurans of the city were already published (Ibañez et al. 2012; Apayor-Ynot et al. 2017; Dacalus et al. 2017; Baron et al. 2019; Jabon et al. 2019; Gersava et al. 2020), data from these accounts were from surveys conducted on a single location within Davao City. In contrast, the present study provides data on anurans in green spaces previously not surveyed and has included several locations. This resulted in a rise in the number of anuran species in Davao City from 20 to 23. Data attest to previous assumptions that the inclusion of more sampling sites in various locations may contribute to heterogeneity of species composition of that area (Brown and Stuart 2012; Diesmos et al. 2014).

Table 1. Species composition, endemism, and conservation status of anurans accounted from select green spaces of Davao City compared with previous reports

Family/species	Ibañez et al. (2012)	Dacalus et al. (2017)	Jabon et al. (2019)	Baron et al. (2019)	Gersava et al. (2020)	This study
Bufonidae						
<i>Pelophryne brevipes</i> MFRE, LC (4)						✓ (Site 6)
<i>Rhinella marina</i> NE, I, LC (79)	✓		✓		✓	✓ (Sites 1-5)
<i>Ansonia muelleri</i> MFRE, LC	✓					
Ceratobatrachidae						
<i>Platymantis</i> cf <i>guentheri</i> MFRE, LC	✓					
Dicroglossidae						
<i>Fejervarya moodiei</i> , PE, DD (3)						✓ (Site 3)
<i>Fejervarya vittigera</i> PE, LC (4)						✓ (Site 4)
<i>Hoplobatrachus rugulosus</i> NE, I, LC (12)			✓		✓	✓ (Sites 3, 4)
<i>Limnonectes leytenensis</i> PE, LC (8)					✓	✓ (Sites 4, 5, 6)
<i>Limnonectes magnus</i> MFRE, NT (4)	✓	✓				✓ (Site 6)
Eleutherodactylidae						
<i>Eleutherodactylus planirostris</i> * NE, I, LC (23)						✓ (Sites 1,2,4)
Megophryidae						
<i>Pelobatrachus stejnegeri</i> MFRE, LC (10)	✓					✓ (Site 6)
<i>Leptobrachium lumadorum</i> MFRE, LC (8)	✓	✓				✓ (Site 6)
Microhylidae						
<i>Kaloula pulchra</i> NE, I, LC (22)			✓		✓	✓ (Sites 1, 3, 4,5)
<i>Kalophrynus sinensis</i> MFRE, LC (8)		✓				✓ (Sites 3, 4, 5)
Ranidae						
<i>Pulchrana grandocula</i> MFRE, LC (5)	✓					✓ (Site 5)
<i>Sanguirana everetti</i> MFRE, NT (9)	✓					✓ (Site 5)
<i>Staurois natator</i> PE, LC	✓					
Rhacophoridae						
<i>Philautus surdus</i> PE, LC (15)	✓	✓		✓		✓ (Site 6)
<i>Philautus acutirostris</i> MFRE, LC	✓	✓		✓		✓ (Site 6)
<i>Philautus leitensis</i> MFRE, LC		✓		✓		
<i>Philautus worcesteri</i> MFRE, LC		✓		✓		
<i>Philautus</i> cf <i>poecilus</i> MFRE, LC		✓				
<i>Polypedates leucomystax</i> NE, LC	✓				✓	✓ (Sites 3, 4, 5)
<i>Nyctixalus spinosus</i> MFRE, LC	✓					✓ (Sites 5, 6)
<i>Rhacophorus pardalis</i> NE, LC	✓					

Note: Endemism: PE: Philippine endemic; MFRE: Mindanao Faunal Region endemic; NE: Non-endemic; Conservation status: NT: Near Threatened; LC: Least Concern; DD: Data Deficient; I: Introduced species; Sites 1: DCNHS; Site 2: NCNHS; Site 3: UM Matina; Site 4: Shrine Hills; Site 5: Lower Carmen; Site 6: Talomo-Lipadas; number in parenthesis- total number of individuals per species accounted in present study. *Previously accounted by Olson et al. (2014) though the account was focused solely on this species and not as part of an anuran survey in Davao City

The observation of higher species richness accounted for in sites farther from the city center adheres to the previous report of Zhang et al. (2016), who noted that richness declined with proximity of sampling locations to the city center. The group of Menin et al. (2016) also reported that rural sampling sites have higher species richness than survey areas near the urban area. Although the green spaces surveyed for this site support native anurans, invasive species were also documented from five out of the six sites. These sites either have vegetation fragments with very reduced plant heterogeneity, man-made structures, or anthropogenic noise. Previous reports of surveys of Jabon (2019) and Gersava (2020) also accounted for *R. marina*, *H. rugulosus*, and *K. pulchra* around the Mintal area near residential houses, commercial spaces, highways, and in land patches with ground vegetation. Olson et al. (2014) also reported hearing calls of *E. planirostris* within a subdivision of Davao City. These invasive species were also previously reported to have a wide distribution within the country but have not been observed to occur in densely forested areas (Diesmos et al. 2006; Diesmos et al. 2015; Pili et al. 2019).

No concrete pattern on endemism is deducible from the present inventory results, but endemic species were noted to be higher in green spaces that are considered forest patches. This observation may connote that endemic anurans have a greater affinity to forested habitats or those with thicker vegetation than with more open habitats (Solania and Fernandez-Gamalinda 2018; Delima-Baron et al. 2021). The presence of the endemic *F. vittigera*, *F. moodiei*, and *L. leytenis* in green spaces near city centers supports previous accounts of the habitat generalist nature of these species as they can thrive in low elevation, agricultural, and highly disturbed habitats (Delima et al. 2006; Brown et al. 2013; Gersava et al. 2020).

Output of the current surveys augmented the knowledge about anurans species found in Davao City. The addition of three endemic species increased the current total to 23 species. Data also imply that the anuran species list for the city is likely to increase as more areas are surveyed and sampling effort per area is magnified. Data also highlight green spaces as possible important habitats of different anuran species and thereby can be used for promoting anuran species diversity. This is based on the number of endemic species accounted for compared to non-endemic species. Future inventories should also consider the inclusion of variables that may influence anuran species richness and composition, including measurement of anthropogenic activities, green space size, vegetation composition and extent, and microclimatic conditions.

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