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A rapid survey of the anuran diversity at Nandi Hills and Moodiganahalli village, Chikkaballapur District, Karnataka, India

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ABSTRACT. The current study conducted a comprehensive survey between July and August 2021 to assess the diversity of frogs in Nandi Hills (maximum elevation of 1478 m asl) and Moodiganahalli village, Bengaluru Rural, which is located approximately 13 km from Nandi Hills (965 m a.s.l.). The study employed opportunistic audio-visual surveys to identify anurans, with surveys conducted around natural and temporary water bodies. The preliminary survey revealed 12 species of anurans belonging to four families. The current inventory study of anuran species of Nandi hills opines that the anuran assemblages in these areas could be depauperate due to habitat loss and quality degradation in urban landscapes.

KEYWORDS. Anuran diversity, Habitat loss, Inventory, Nandi Hills, Peri-Urban

Introduction

The focal aim of ecology has always been to understand the patterns and processes that uphold biodiversity as critically important for the feasibility of any ecosystem (Tilman et al. 2014). Scientists argue that the various dimensions of biodiversity, such as genes, species, functional forms, adaptations, habitats, ecosystems, and variability within and between these factors are tightly interconnected. These factors affect the state, stability, and productivity of the ecosystem, as well as ecosystem services (Schneiders et al. 2012), thereby making biodiversity, an ecological, social, and economic issue. Ever-increasing land degradation, changing climate, fragmentation, deforestation, and urbanization owing to human pressure across the globe threaten biodiversity and associated ecosystem services (Foley et al. 2005; Ceballos et al. 2015; Jones et al. 2018). Measurements of species presence and absence alone are, thus, a paltry substitute for biodiversity value and biodiversity loss (Dorazio et al. 2011).

Patrick et al. (2014) notes that rapid biodiversity surveys have the potential to tackle the absence of baseline biodiversity data for conservation and management.

Anurans have been admirable site-specific bio-indicators (Pechmann and Wilbur 1994; Donnelly and Crump 1998) despite the negative effects of anthropogenic landscape change such as habitat loss, fragmentation, degradation, and isolation (Hamer and McDonnell 2008). Regardless of the species richness and abundance loss due to pollution-related causes (Collins and Storfer 2003; Hamer and McDonnell 2008), anurans have shown remarkable adaptations in urban habitats (Gibbs et al. 2005). In light of

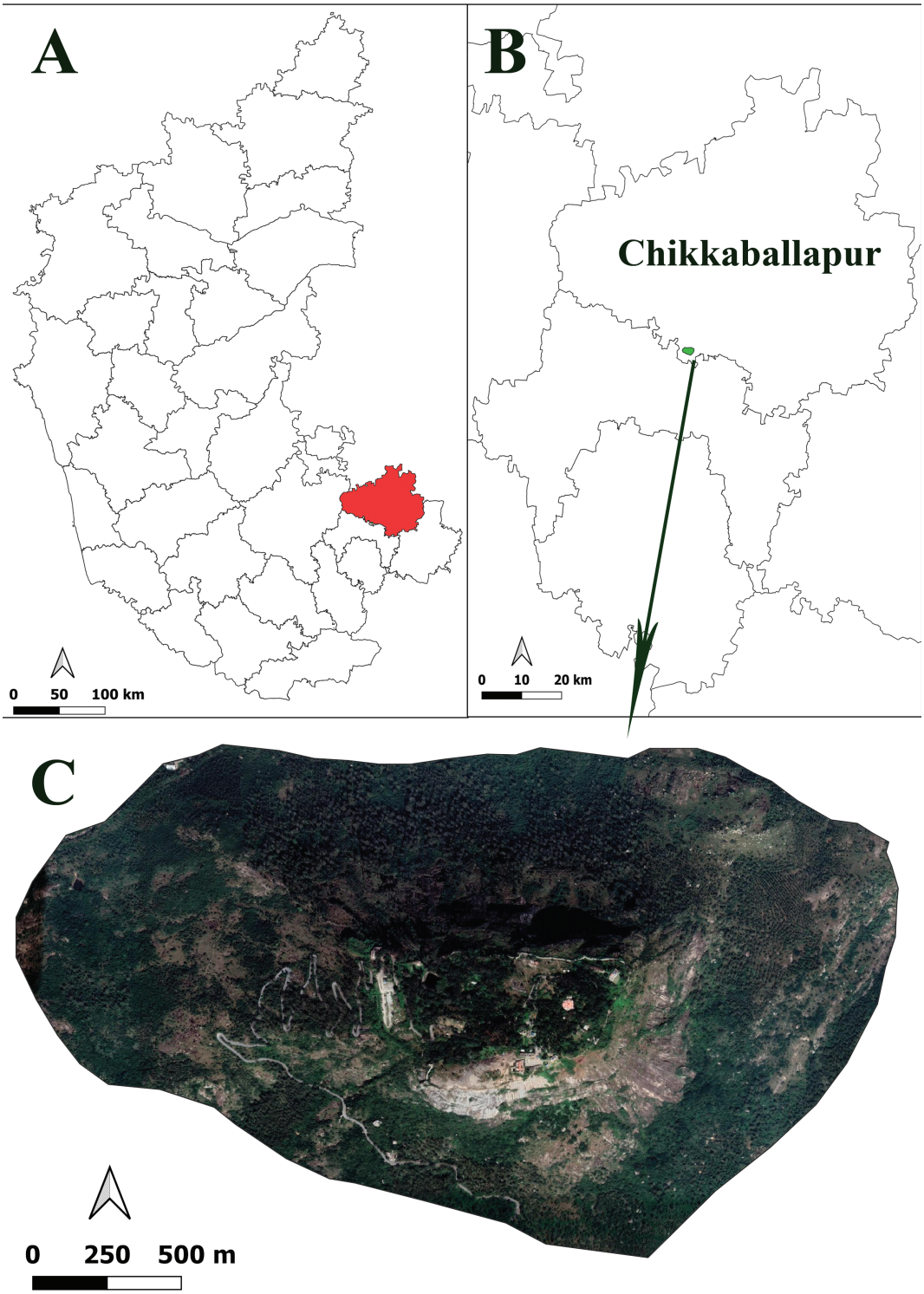

Figure 1. A. Political outline map of Karnataka (Red colour indicates Chikkaballapur district); **B.** Political boundaries of Chikkaballapur (Green colour indicates the study area); **C.** Topographical map representing the study area, Nandi Hills

the worldwide amphibian extinction catastrophe, Ceballos et al. (2020) contend that there is greater urgency than ever to identify anuran population decrease, highlighting the significance and need to document the presence of amphibian diversity.

Amphibian research in the state of Karnataka, India dates to 1876, when Günther described *Ansonia ornata* (now *Blaira ornata*) from the Western Ghats region. So far, a total of 100 species of amphibians have been reported from the state of Karnataka, out of which 26 are under the vulnerable list (Dinesh et al. 2021). Most of the amphibian studies in Karnataka were primarily focused on the Western Ghats region, which has been one of the global biodiversity hotspots and a habitat for unique lineages of anurans. Contrastingly, the Deccan plateau regions of Karnataka are understudied and neglected, needing detailed surveys to record the diversity in these ignored areas. The discovery of a new species of burrowing frog *Sphaerotheca bengaluru* (Deepak et al. 2020) from the peri-urban regions of Bengaluru provides evidence that anuran diversity needs to be further explored in the Deccan plateau regions of the state of Karnataka and elsewhere.

Since no satisfying baseline information was available in the literature so far, we aimed to assess the diversity and distribution of anurans from Nandi Hills, Bengaluru Rural, based on a rapid biodiversity assessment, and to strengthen future conservation strategies and policy-making initiatives in this region.

Materials and methods

Study area. A total of five visits were carried out between the months of July and August 2021, followed by a random opportunistic survey method using three-man hours between 18:00 hrs to 00:00 hrs at Nandi Hills and Moodiganahalli village to explore the anuran diversity of the regions. The Nandi hills (formerly known as Nandi Durga) is part of three rocky hills, located in the Chikkaballapur district of Karnataka, which is due north of Bengaluru at 60 km 13.366 N, 77.683 E with an elevation of 800 to 1480 m. Geologically, the Nandi Hills are a part of the Dharwad craton (Krabbendam and Palambakumbura 2018 and references therein) that is dated to be nearly 3.5 billion years old, and therefore, is an interesting landmass to study biodiversity. The hill range runs northwards to Gudibanda in Kolar district and extends to the state of Andhra Pradesh (Singh 1988). The hill range covers 2837 ha and comprises three main hillocks. Of the three hills, the Nandi Hills has an altitude of 1478 m a.s.l. The Arkavathi River originates at Nandi Hills, flows towards Ramanagara district, and joins the river Cauvery at Sangama, Kanakapura. The hills are known for its pleasant climate throughout the year. Most of the original forest covers on the hills have degraded and given way to secondary vegetation consisting of primary scrubs. The hill slopes and the valley are dominated by open scrub vegetation. *Eucalyptus globulus* (Australian Eucalyptus) and *Shorea roxburghii* (Taloora Lac Tree) have been introduced in some areas. However, some natural woodlands remain, particularly near the summit. Lantana weed has spread across the hills, displacing native flora. Scrub vegetation, interspersed with Eucalyptus, covers the hillsides (Praveen 2006; BirdLife International 2021).

Moodiganahalli is a small village close to Nandi hills in Devanahalli Taluk of the Bangalore Rural district in Karnataka, India. It is approximately 92.88 hectares in area. This village is mainly dominated by agricultural fields, where a majority of the water sources are wells, irrigation channels, and ponds. The area also includes scrub lands, plains, and grazing lands. Moodiganahalli comprises low-elevated lands in comparison to the Nandi Hills. The map (Figure 1) was generated using QGIS 3.12.2 and administrative map were obtained from gadm.org.

The study opportunistically conducted a thorough comprehensive survey during the monsoon season between the months of July and August 2021. The study employed (1) acoustic encounter surveys; and (2) visual encounter surveys (Rödel and Ernst 2004) to locate anurans with searches conducted around water bodies such as natural and temporary ponds. These methods rely on detecting all individuals seen and/or heard in a 25 m radius area for a 15 min period (Lips et al. 2001).

Surveys were carried out from the base of the hill and the surrounding regions, which include

Figure 2. Different habitats at Nandi Hills & Moodiganahalli village, which were surveyed during the present study.

secondary forests, open land, scrub jungles, agriculture lands, ponds, and artificial wetlands like water channels, and mud puddles. In the mid elevation (< 900 m) areas, the slopes and streams were sampled, while in the high elevation (> 900 m) regions, the artificial water tanks, canals, channel structures, ponds, wetlands, open lands, forests, and scrub forests were surveyed (Figure 2).

Frogs were acoustically located and identified up to the species level. Visual observations and morphological characters also aided in frog identification. All the breeding grounds and spawning sites were carefully examined for frogs and tadpoles. Other microhabitats in the forest patches, leaf litter, barks of trees, and shrubs were also inspected for frogs.

Specimens were collected and photographed under controlled conditions using Canon 6D Mark II camera and Tamron SP 180 mm F/3.5 Di 1:1 macro lens for further identification.

Results

Our study revealed 12 species of Anurans under four families (Table 1 & Figures 3, 4)

Discussion

Our rapid survey revealed 12 species of anurans belonging to four families (Table 1) giving us a coarse estimation of the distribution of these anurans found in the Nandi hills region and the surrounding areas. Among the 12 species reported here, members of the family Dicroglossidae and Microhylidae were found to be speciose (with five species each). In general, members of both these families are widespread due to their flexible environmental adaptability when compared to other habitat specialist frog species. Among the 10 species of both the families, nine species are distributed over a wide range, of which *S. bengaluru* described recently (Deepak et al. 2020) is known only from the surrounding regions of Bengaluru.

Interestingly, *S. bengaluru*, *S.* cf. *breviceps*, and *U. systoma* were located around the lower elevations around Moodiganahalli village, and not on of the higher elevations on Nandi hills, suggesting an elevational preference for these data deficient anurans.

Although the species list presented here is not exhaustive, chances of occurrence of the species

Table 1. Anuran species found in Nandi hills and surrounding areas along with altitude (in meters) and IUCN (International Union Conservation of Nature) status. *indicates the anuran species found in the low elevation areas surrounding Nandi hills. LC = least concern, DD = Data deficient, NE = Not evaluated.

Sl. No.	Family	Species	Altitude (m)	IUCN Status
1	Bufonidae	*Firouzophrynus peninsularis* (Rao, 1920)	800–1400	LC
2		*Euphlyctis cyanophlyctis* (Schneider 1799)	800–1400	LC
3		*Minervarya agricola* (Jerdon 1853)	800–1400	NE
4	Dicroglossidae	*Minervarya* cf. *syhadrensis* (Annandale 1919)	800–1400	LC
5		*Sphaerotheca bengaluru**	< 900	DD
6		*Sphaerotheca cf. breviceps**	< 900	LC
7		*Microhyla ornata* (Duméril and Bibron 1841)	800–1400	LC
8		*Microhyla rubra* (Jerdon 1853)	800–1400	LC
9	Microhylidae	*Uperodon systoma**	< 900	LC
10		*Uperodon taprobanicus* (Parker 1934)	800–1400	LC
11		*Uperodon variegatus* (Stoliczka 1872)	800–1400	LC
12	Rhacophoridae	*Polypedates maculatus* (Gray, 1830)	800–1400	LC

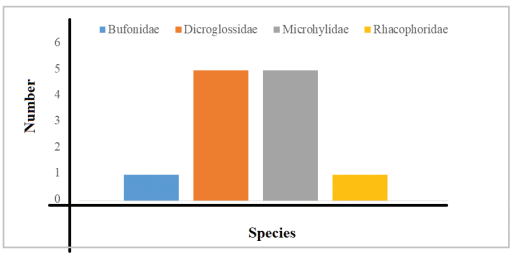

Figure 3. Bar graph depicting the diversity of anuran families from the study areas.

D. scaber, *Hoplobatrachus tigerinus*, *Phrynoderma hexadactylus*, and *Microhyla sholigari* along with rhacophorids from the study area cannot be ruled out at these elevations and habitats. The survey also focussed on finding the relict populations of *Minervarya kalinga* based on its records from two regions — the Eastern and Western Ghats (Hegde et al. 2020). However, perhaps because of limited time access, our search was futile, but we do not rule out the possibility of encountering *M. kalinga* in this habitat. Hence, more detailed surveys in this region are required to understand their habitat niche.

When compared to the biodiversity hotspots in the Indian subcontinent, other biogeographic regions such as the large Deccan range with hills, and plateaus, and the Eastern Ghats, which are discontinuous mountain ranges, have been hitherto neglected. Nandi Hills and other hills in the Deccan region are composed of characteristics of both the Eastern and the Western Ghats landscapes, and these might act as refugia to most of the primitive, rare, and endangered flora and fauna (Dinesh et al. 2018). They might also increase and support the diversity and density of flora and fauna in the surrounding plains.

Studies in the hills of the Deccan plateau regions of peninsular India are largely neglected because the majority of herpetofaunal studies are concentrated on the Western Ghat biodiversity hotspot. In the last two decades, numerous reptile species have been described from these landscapes, which also includes a shield tail species from Nandi Hills (Ganesh et al. 2021).

Nandi Hills, being a popular tourist destination, experiences a lot of vehicular movement, particularly during the weekends and the summer season. The traffic along these roads could be having a detrimental and possibly lethal effect on the anuran population. Given the fact that toads and frogs have short dispersal abilities in urbanized areas, (Hammer and Parris 2011) issues such as road accidents while crossing, exposure to runoff (oil), noise, vehicular exhaust/stone crushing emissions, and vibrations could be affecting the anuran assemblages in Nandi Hills and the surrounding areas either through direct or behavioural disturbances. Incidences such as landslides, forest fires, construction activities, car and bike race events, and illegal stone crushing at Nandi Hills (News Papers 2021) in recent times suggest that anuran assemblages in these areas could be depauperate due to habitat degradation and loss. Thus, the cur-

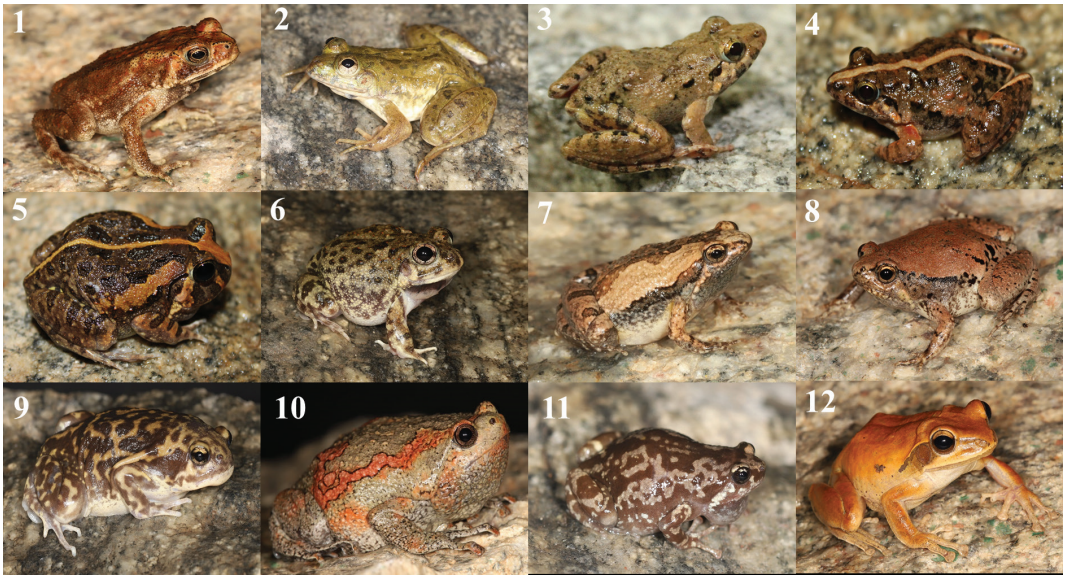

Figure 4. Anurans from the study areas **1.** *Firouzophrynus peninsularis*, **2.** *E. cyanophlyctis*, **3.** *Minervarya agricola*, **4.** *M.* cf. *syhadrensis*, **5.** *S. bengaluru**, **6.** *S.* cf. *breviceps**, **7.** *Microhyla ornata*, **8.** *M. rubra*, **9.** *Uperodon systoma**, **10.** *U. taprobanicus*, **11.** *U. variegatus*, **12.** *Polypedates maculatus* (*indicates the anuran species found in the surrounding low elevated areas of Nandi Hills)

rent preliminary inventory study suggests that conservation measures involving anurans in this region should consider the preservation of habitat mosaics and recommend future surveys with continuous monitoring to provide more accurate accounts of the current distributional and diversity patterns of anurans. Furthermore, future assessments should ensure continuous monitoring to provide more accurate accounts of the current distribution of organisms, and their causal explanations behind the differential success of taxa along ecological gradients in these critical and fragmented habitats.

Declaration of competing interest and funding

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