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Unusual use of water-filled tires by *Nyctixalus spinosus* (Taylor, 1920) in an agroforestry farm in eastern Mindanao, Philippines

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Nyctixalus spinosus (Taylor, 1920) is a member of the family Rhacophoridae, a group of predominantly arboreal frogs. It is the only *Nyctixalus* species in the Philippines, and is endemic to the Mindanao faunal region where it occurs on the islands of Mindanao, Leyte, Bohol, Samar, and Basilan (Ates and Delima, 2008; Nuñeza et al., 2010; Sanguila et al., 2016; IUCN SSC Amphibian Specialist Group, 2020). This nocturnal, oviparous species deposits approximately 30–40 eggs per clutch in tree holes, where eggs adhere to cavity walls and tadpoles develop within the accumulated water until metamorphosis (Alcala and Brown, 1998). While the species is largely arboreal, it can also utilise either the forest floor among deep leaf litter or atop low-lying vegetation of primary and mature secondary forests between 300–1100 meters elevation, including montane, lowland, and submontane dipterocarp forests (Brown and Alcala, 1994; Alcala and Brown, 1998; Nuñeza et al., 2010; Sanguila et al., 2016). Reports from heavily degraded areas are scarce, with one documented observation from semi-urban green spaces in Davao City (Delima-Baron et al., 2022), suggesting its possible tolerance of some disturbances. However, to the best of our knowledge, there are still no known records of its use of artificial water-holding structures such as discarded car tires.

The observations happened on the grounds of the Nabunturan Balik Kinaiyahan (NBK) Farm, Nabunturan, Davao de Oro, Philippines (7.6155°N, 125.9601°E; 280–290 m elevation), a 50-ha agroforestry farm located about 2 km from the Nabunturan municipal centre (Fig. 1). Fieldwork took place between 17–21 June 2025, followed by a subsequent visit on 24 August 2025. The agroforestry site contains a mosaic of fruit trees and crops (*Mangifera indica*, *Theobroma cacao*, *Durio zibethinus*, *Nephelium lappaceum*, *Garcinia mangostana*, *Hevea brasiliensis*) alongside secondary growth vegetation, including *Piper aduncum*, *Cananga odorata*, and several *Neonauclea* and *Ficus* species. It is surrounded by degraded plantations of mixed corn, coconut, and other crops, as well as residential zones, making it the largest remaining block of dense vegetation in the area.

We recorded a total of 12 brightly coloured frogs, which were identified as *Nyctixalus spinosus* based on published morphological descriptions (Alcala and Brown, 1998). All individuals were observed in stagnant rainwater pools accumulated in abandoned vehicle tires distributed within the agroforest near the forest edge (Fig. 2). These tires, either partially embedded in the soil or lying on the surface, contained decomposing leaf litter, soil, and organic debris. During the initial survey, we recorded ten individuals across several days. On the first day, we observed a frog swimming in a tire pool between 18:00–23:00 h, along with several *Kalophrynus sinensis*. A second frog was found during the same time window on the following day in a neighbouring tire, less than 1 m from the first tire. On the third day, we observed four frogs between 05:00–06:00 h, each occupying separate tires located 3–4 m from the first location. The final four individuals were documented on the last day, all within the same general vicinity. A follow-up visit (between 16:32–20:25 h) resulted in the observation of two additional frogs within the same habitat. All individuals were visually detected; no vocalisations or amplexus were observed. Although

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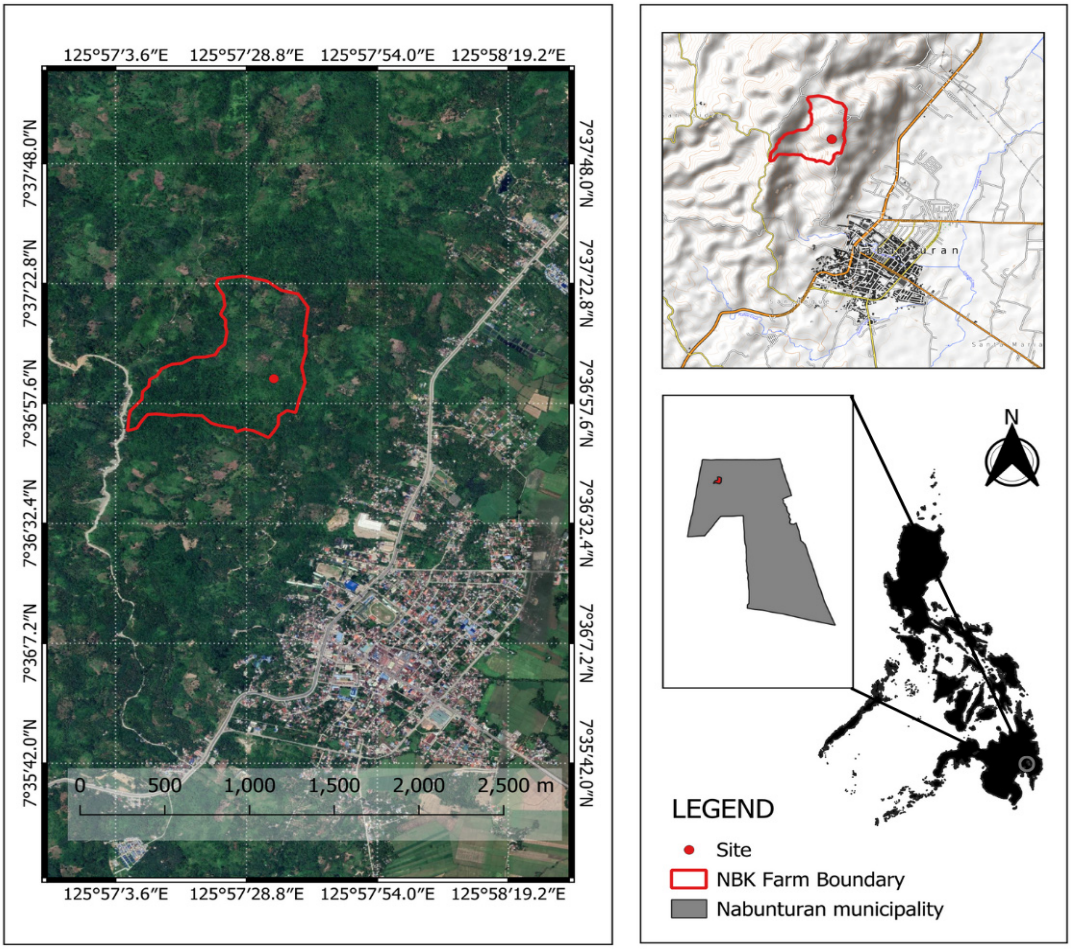

Figure 1. Map of the study site at Nabunturan Balik Kinaiyahan (NBK) Farm, Nabunturan, Davao de Oro, Philippines.

eggs and larvae were present in some tires, their species could not be definitively identified. Notably, we did not find frogs in expected microhabitats such as tree holes during the survey, suggesting that the species at this site may be primarily associated with tires. This observation may indicate a potential shift in microhabitat use in response to habitat modification.

We report on the presence of *N. spinosus* in an agroforestry system and the first potential record of the species using artificial water-holding structures, specifically discarded vehicle tires. The NBK farm, located adjacent to the municipal centre, contains water-filled tires that create microhabitats analogous to natural phytotelmata (e.g., tree holes, bamboo internodes, bromeliads). The water pooled inside the tires likely provided the lentic microhabitat necessary for *N. spinosus*, which undergoes indirect development and depends on such habitats for reproduction. Moreover, these structures offer standing water, decomposing plant matter, and shelter from predators, conditions known to support aquatic and semi-aquatic organisms (Thorp, 2015). At the NBK farm, we exclusively found *N. spinosus* individuals within water-filled discarded automobile tires located approximately 50 m from an unpaved roadside leading to the municipal centre. The surrounding habitat is heavily fragmented, consisting largely of dry leaf litter, rocky pathways, grass, and scattered shrubs, with a marked reduction in natural microhabitats such as tree holes and phytotelmata.

Comparable use of artificial microhabitats has been reported in other species. For example, the critically endangered Andamanese Charles Darwin's Frog

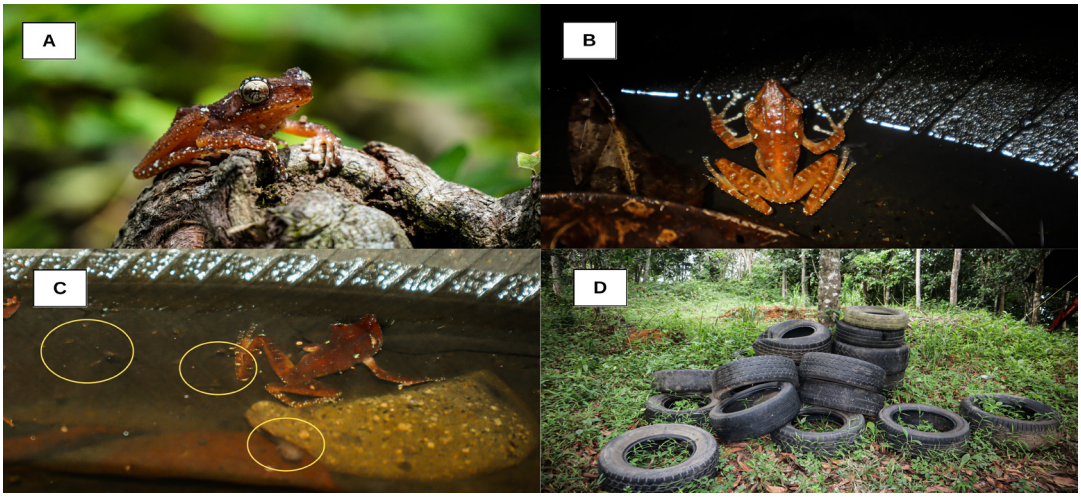

Figure 2. (A) *Nyctixalus spinosus* individual; (B) *N. spinosus* inside an abandoned tire, submerged in water; (C) Larvae (marked in yellow) observed in the tire pool with the *N. spinosus*; (D) tire microhabitats showing the immediate environment and surrounding vegetation in the agroforest. Photos by Lief E. D. Gamalo (A) and Frankie B. M. Juanitas (B–D).

(*Minervarya charlesdarwini*), an obligate phytotelm breeder, has been observed using various artificial water-holding structures such as plastic sapling bags, discarded bottles, automobile tires, and metal containers at forest edges—likely a behavioural response to habitat loss and fragmentation (Garg et al., 2022; Biju et al., 2024). Similar observations have been reported from other Southeast Asian anurans. Larvae of *Nyctixalus pictus* were documented inhabiting a rusty, water-filled oil drum in Singapore (Leong and Chou, 1999), while *Metaphrynella pollicaris*, *Philautus vermiculatus*, and *Theloderma asperum* in Malaysia have been recorded using artificial hollows such as wood–plastic composite posts, cement posts, and plastic bollards for shelter and breeding (Quah et al., 2025).

Habitat loss and fragmentation, primarily from agriculture and urban expansion, are among the most significant drivers of amphibian declines worldwide (Nolan et al., 2023). These environmental pressures may have contributed to behavioural shifts in *N. spinosus,* enabling them to exploit artificial microhabitats such as water-filled tires. Such structures may serve multiple functions, including temporary predator refuges, maintaining hydration and body temperature in moist retreats, or possibly oviposition. Although these water-filled tires share structural and ecological features with natural phytotelmata, and eggs and larvae were present in some pools, their taxonomic identity could not be confirmed. Combinedly with the absence of observed amplexus, this provides no direct evidence of reproductive use by *N. spinosus*. Further studies are needed to determine whether such artificial microhabitats serve as breeding sites. Moreover, reliance on artificial microhabitats near human settlements may heighten susceptibility to anthropogenic threats, including chemical contamination (Cheong et al., 2023) and habitat degradation typical of urbanising landscapes (Hamer et al., 2008).

The occurrence of *N. spinosus* in this setting can be interpreted in two ways. First, it may indicate a broader habitat tolerance than previously reported, potentially facilitated by the farm's structurally complex vegetation. Second, these individuals may represent remnants of a once larger population that has persisted in this small forest patch following habitat loss and fragmentation, rather than demonstrating true disturbance tolerance. Regardless of the mechanism, this record highlights the ecological value of agroforestry areas as potential refuges for native amphibians within human-modified environments.

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