Occurrence of burrowing water beetle (*Neohydrocoptus subvittulus*) in the small pond from Lucknow city

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Abstract

Neohydrocoptus subvittulus (Motschulsky, 1859), a burrowing water beetle (family Noteridae), plays a vital role in freshwater ecosystems, yet its presence and ecological significance remain poorly explored in urban environments. The present study investigates the occurrence of the *Neohydrocoptus subvittulus* within a small urban pond located in Lucknow city. *Neohydrocoptus subvittulus*, known for its adaptability to diverse aquatic environments, was documented in this isolated pond, expanding its known distribution in the northern plains of India. The beetle was found in association with dense aquatic vegetation and stable water conditions, suggesting suitable microhabitat availability. The occurrence of burrowing water beetles in Lucknow highlights their ecological adaptability and the crucial role of small urban water bodies in conserving aquatic biodiversity, water quality, and pond vegetation, which significantly influence the occurrence of *Neohydrocoptus subvittulus*.

Keywords: Urban pond, Lucknow, *Neohydrocoptus subvittulus*, Freshwater biodiversity

Introduction

Aquatic insects are key components of freshwater ecosystems, contributing to nutrient cycling, predation, and maintaining ecological balance. Among them, burrowing water beetles (Coleoptera: Noteridae) occupy a unique niche, living in sediments and among submerged vegetation, often serving as indicators of water quality and habitat health. *Neohydrocoptus subvittulus* (Motschulsky, 1859) [17] is a small burrowing water beetle widely distributed across Asia, but its occurrence in urban freshwater habitats of northern India remains poorly documented. Small ponds in cities like Lucknow provide microhabitats that support diverse aquatic fauna.

Current studies offer valuable information on the wider distribution of *Neohydrocoptus subvittulus*. Additionally, a checklist of aquatic beetles from Manipur lists *Neohydrocoptus subvittulus* among the species present in that region (Bhubaneshwari *et al.*, 2017) [4]. The species is found in several Asian countries, including India, China, and Sri Lanka (Nilsson, 2011) [19]. These records underscore the species' presence in diverse freshwater habitats across India. *Neohydrocoptus subvittulus* shows specific habitat preferences that influence its distribution and abundance. Studies indicate that this species favours freshwater bodies with cooler water temperatures ranging approximately from 21 to 32°C, conditions that are typical of tropical freshwater systems in India. Key physicochemical factors affecting its occurrence include water temperature, pH, and dissolved oxygen levels, with the beetle showing positive correlations with moderate to high dissolved oxygen and slightly acidic to neutral pH conditions. *Neohydrocoptus subvittulus* is often associated with aquatic vegetation, particularly dense emergent macrophytes such as water hyacinth, which provide shelter and feeding grounds. The species thrives in lentic habitats like ponds, lakes, and wetlands where organic matter and nutrients are adequately available to support its life processes. Seasonal variations, particularly post-monsoon stabilisation of water parameters, also play a role in its local abundance. These habitat preferences highlight the beetle's dependency on stable, nutrient-rich, and oxygenated freshwater ecosystems within Indian wetlands (Barman and Deka, 2017; Bhubaneshwari *et al.*, 2014; Bhubaneshwari *et al.*, 2015) [2, 5, 6].

The burrowing water beetles are integral to nutrient cycling, food web stability, and environmental monitoring, collectively sustaining healthy and resilient pond ecosystems. Burrowing water beetles, *Neohydrocoptus subvittulus*, play a vital role in maintaining pond health and supporting aquatic ecosystems by facilitating nutrient cycling, serving as bioindicators, and influencing food web dynamics. These beetles feed on detritus, algae, and microorganisms in pond substrates, helping to decompose organic matter (Siddiky *et al.*, 2024; Bharti and Yeole, 2025) [23, 3]. Their burrowing behaviour oxygenates sediments, speeds up nutrient turnover, and ensures the recycling of nutrients vital for the growth of other aquatic organisms. Water beetles are prey for fish, amphibians, and birds, thus connecting lower trophic levels to higher ones and supporting biodiversity (Macadam and Stockan, 2015) [14]. They regulate populations of smaller invertebrates and help balance aquatic insect communities, which in turn impacts overall pond health (Anamika *et al.*, 2021) [1]. Aquatic beetles are sensitive to changes in water quality, pollution, and habitat disturbance, serving as useful bioindicators for monitoring pond ecosystem health (Martínez-Román *et al.*, 2023) [15].

Changes in beetle populations can signal shifts in the ecological status of the pond, prompting early conservation or restoration efforts (Paul and Datta, 2022) [20]. Diverse beetle assemblages increase pond resilience to environmental fluctuations, supporting stable ecosystem functions under varied conditions (Martínez-Román *et al.,* 2023) [15]. Their adaptability to a range of physicochemical water conditions helps maintain ecosystem functioning in both natural and urban ponds (Liao, 2024; Siddiky *et al.,* 2024) [13, 23]. Small ponds play a crucial role in supporting aquatic insect diversity by providing stable, nutrient-rich habitats that serve as refuges and breeding grounds for a wide variety of species. These ponds often harbour diverse assemblages of aquatic insects, reflecting relatively healthy and balanced ecosystems with good water quality. The availability of varied microhabitats and aquatic vegetation supports different life stages of insects, promoting high species richness and abundance. Small ponds also contribute to ecological functions such as nutrient cycling, food web support, and biodiversity conservation, especially in urban or agricultural landscapes where larger water bodies may be scarce. Additionally, they can buffer environmental fluctuations, serving as important hotspots for insect colonisation, survival, and dispersal. Thus, small ponds are essential for maintaining regional aquatic insect biodiversity and ecosystem resilience (Hill *et al.,* 2021; Keinath *et al.,* 2023; Payra *et al.,* 2025; Bharti and Yeole, 2025) [10, 11, 21, 3].

Urbanisation significantly impacts the distribution of burrowing water beetles by altering their natural habitats. Increased urban development leads to habitat loss, fragmentation, and degradation, reducing the availability of suitable aquatic environments for these beetles. Urban areas often experience changes in water quality, such as increased pollution, altered physicochemical parameters, and decreased dissolved oxygen, which negatively affect beetle populations. Additionally, the reduction in vegetation cover and habitat heterogeneity limits shelter and breeding sites essential for their survival. Studies show that beetle diversity, abundance, and species richness tend to decline in highly urbanised sites compared to natural or less disturbed habitats. However, areas with lower urban intensity or higher green spaces may still support relatively diverse beetle communities by maintaining habitat quality. Therefore, urbanisation poses a major threat to burrowing water beetle distribution through multifaceted environmental changes that compromise their ecological niches and persistence in urban freshwater ecosystems (Eman *et al.,* 2012; Michael *et al.,* 2022; Ferzoco *et al.,* 2023; Keinath *et al.,* 2023) [7, 16, 8, 11].

Seasonal variation governs the population density, species composition, and ecological roles of aquatic insects through complex interactions between temperature, water availability, and habitat quality, ultimately shaping wetland ecosystem health year-round. Seasonal changes impact aquatic insect populations by influencing their abundance, diversity, and life cycle dynamics throughout the year. In many wetlands, insect populations peak in spring when water temperature, dissolved oxygen, and food availability reach optimal levels for growth and reproduction. As temperatures increase in late spring and summer, water levels may drop, and evaporation rises, which can limit suitable habitats and lead to declines in insect abundance. In contrast, during autumn and winter, lower temperatures and reduced resources often trigger dormancy, migration, or reduced activity, resulting in decreased diversity and shifts in community composition. Rainfall and humidity also play a significant role. Rainy seasons typically support surges in insect populations due to higher water availability and habitat complexity, whereas dry seasons may restrict growth and cause local declines or extinctions. The timing and intensity of these seasonal environmental changes drive cyclic patterns in populations and contribute to the turnover of dominant species between seasons. Additionally, seasonal fluctuations alter the prevalence of insect families that indicate water quality, with cleaner water indicators peaking in spring and more pollution-tolerant species becoming dominant during harsher periods (Nasirian and Salehzadeh, 2019; Van Dijk *et al.,* 2024; Haas and Pánik, 2025) [18, 25, 9].

Materials and Methods

The present investigation was conducted in a selected small urban pond (Figure 1A-1F) situated within Isabella Thoburn College, Lucknow, Uttar Pradesh (location coordinate-Lat. 26.8721450 and Long. 80.9445130). Random field sampling (Figure 1E) took place monthly, once a week, from March to May 2025. A total of 15 samples were collected, out of which 7 sample collections contained aquatic beetle. Aquatic beetles, *Neohydrocoptus subvittulus*, were collected using standard hand-netting and dip-net techniques, focusing on areas with dense aquatic vegetation and muddy substrates. Each specimen was preserved in 70% ethyl alcohol for general killing and long-term preservation of aquatic beetles and later identified in the laboratory using established taxonomic keys (Toledo, 2010) [24]. A collection of beetles required aquatic nets from the water and submerged vegetation. Petri dish for sorting and observing specimens after capture. Forceps for precise handling of collected beetles. Hand lens or portable field microscope for field identification. Store beetles in tightly sealed glass vials with screw tops to minimize evaporation and ensure sample integrity (Schauff, 1986; Lars Krogmann and Joachim Holstein, 2010) [22, 12].

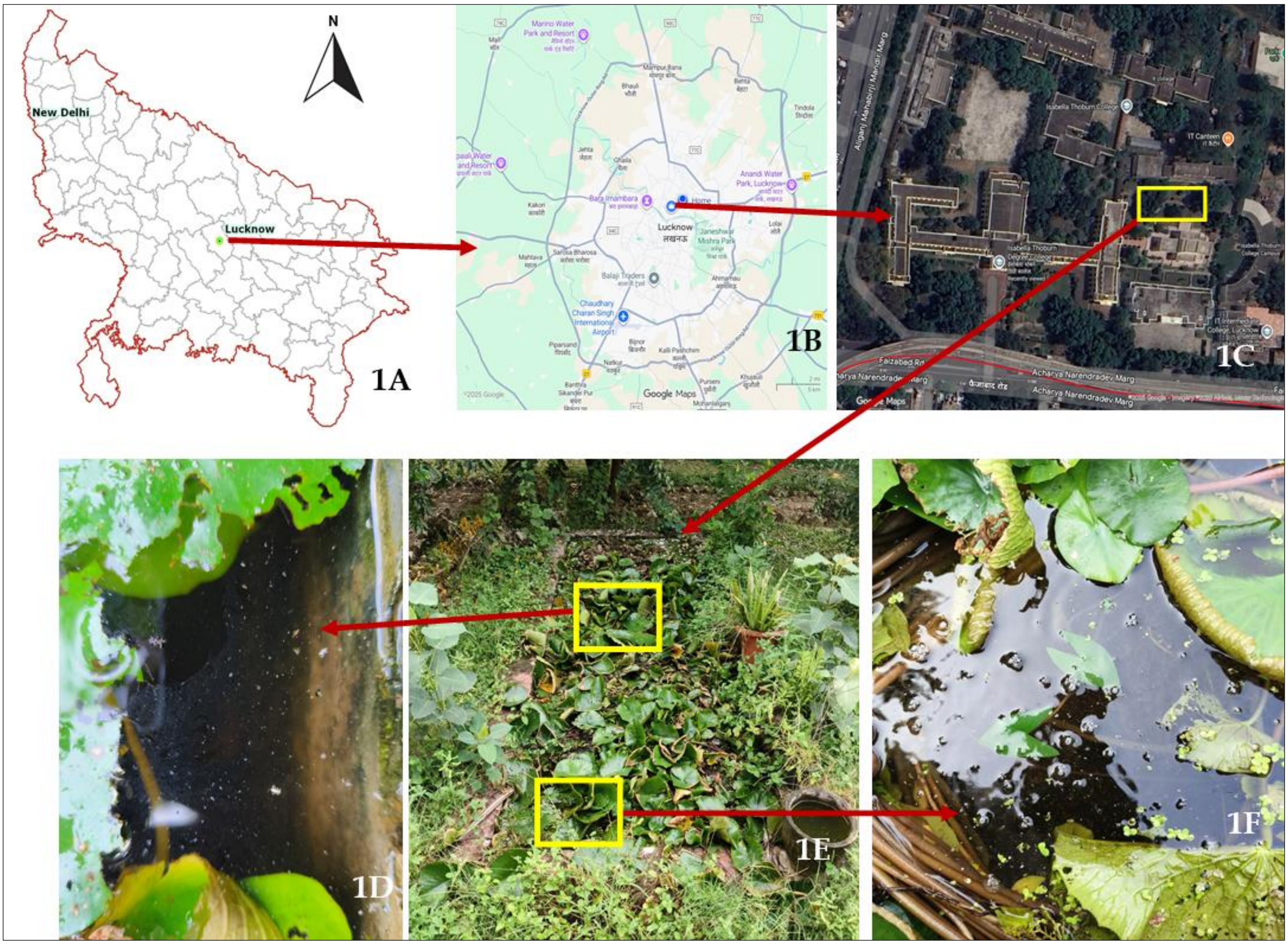

Fig 1: A. Map of Uttar Pradesh, B. Areal Map of Lucknow city, C. Sampling site, Isabella Thoburn College, Lucknow (Yellow rectangle), D. Enlarge view of water body showing submerged vegetation and sediment at the bottom, E. Sampling small water pond (Yellow rectangle), F. Rich flora of pond showing lotus and other aquatic plants

Results and Discussion

In the survey, seven samples of the same water body were positive and contained water beetles, out of 15 total samples. The identification key for *Neohydrocoptus subvittulus* focuses on its distinctive morphological characters within the Noteridae family. Body length was 2.2–3.0 mm, elongate and streamlined (Figure 2A-2F). Dorsal surface with micro reticulation of polygonal, rounded cells, often forming fine wrinkles (Figure 2B). Elytra typically light chestnut-brown, sometimes with pale patterns; longitudinal series of impressed dots present (Figure 2A,2E). Pronotum and head are reddish-yellow to testaceous, head slightly darkened frontally, legs and antennae uniformly testaceous (Figure 2A). Scutellum concealed, not externally visible (Figure 2B). The prosternal process is lanceolate, narrow between the coxae, bordered, and flat toward the rear. Metacoxal process with straight, subparallel sides and smooth surface, sometimes with weak setal punctation. Male, Last abdominal ventrite ending with a shallow "U"-shaped emargination; inner claw of hind tarsi slightly shorter than outer claw. Maxillary and labial palps conical, truncate distally (Toledo, 2010) [24].

The present study highlights the occurrence of *Neohydrocoptus subvittulus* in a small pond of Lucknow city and underscores its ecological significance within urban freshwater ecosystems. Aquatic insects, particularly burrowing water beetles, are widely recognized as essential contributors to nutrient cycling, food web regulation, and ecosystem health (Macadam & Stockan, 2015; Martínez-Román *et al.,* 2023) [14, 15]. The detection of *N. subvittulus* in this urban pond expands its known distribution in northern India and aligns with earlier records of the species from other parts of Asia, including India, China, and Sri Lanka (Nilsson, 2011; Bhubaneshwari *et al.,* 2017) [19, 4].

The findings correspond with previous reports that *N. subvittulus* exhibits strong habitat specificity, favouring lentic environments with submerged macrophytes and organic-rich sediments (Bhubaneshwari *et al.,* 2014; Barman & Deka, 2017) [5, 2]. The pond examined in Lucknow contained dense patches of aquatic vegetation (lotus and other aquatic vegetation), which likely provided suitable shelter, feeding opportunities, and oviposition sites (Figure 1E,1F). The association of *N. subvittulus* with moderate dissolved oxygen and neutral to slightly acidic pH observed in this study further supports earlier research emphasizing the role of key physicochemical parameters in structuring aquatic beetle assemblages (Bhubaneshwari *et al.,* 2015) [6]. Beyond habitat preferences, the ecological role of *N. subvittulus* warrants attention. Its burrowing activity in sediments enhances oxygen penetration, accelerates nutrient turnover, and supports microbial decomposition processes (Siddiky *et al.,* 2024) [23]. These functions not only sustain benthic productivity but also contribute to the availability of resources for higher trophic levels such as fish, amphibians, and water birds (Bharti & Yeole, 2025) [3]. Consequently, *N. subvittulus* acts as both a functional organism in nutrient cycling and as a prey species maintaining food web stability.

Urbanization, however, poses a critical challenge to the persistence of aquatic beetles. Habitat loss, water pollution, reduced vegetation cover, and altered hydrological regimes frequently diminish beetle diversity and abundance in urban environments (Michael *et al.,* 2022; Eman *et al.,* 2012; Ferzoco *et al.,* 2023) [16, 7, 8]. While the presence of *N. subvittulus* in the studied pond demonstrates resilience to urban pressures, continued monitoring is vital, as fluctuations in its population may serve as early warning indicators of ecological degradation (Paul & Datta, 2022) [20].

The role of small urban ponds as biodiversity refuges cannot be overstated. Such habitats often harbour diverse insect assemblages, provide breeding grounds, and maintain ecological functions even within heavily modified landscapes (Hill *et al.,* 2021; Keinath *et al.,* 2023; Payra *et al.,* 2025) [10, 11, 21]. Seasonal dynamics further influence beetle occurrence; post-monsoon stabilization of water parameters is particularly favourable for *N. subvittulus* and other aquatic insect taxa (Nasirian & Salehzadeh 2019; Haas & Pánik, 2025) [18, 9]. Thus, small ponds serve as critical reservoirs for maintaining regional aquatic insect biodiversity and sustaining ecosystem resilience in the face of urban expansion.

Fig 2: Aquatic burrowing water beetle, *Neohydrocoptus subvittulus*. 2A-2B. Morphology of water beetle, 2C. Ventral view, 2D-2E. Lateral view, 2F. Dorsal view of *Neohydrocoptus subvittulus*.
Mn- Mandible; Pa-Palp; An- Antennae; H- Head; Ey- Eye; El- Elytra; Sc- Scutellum; Ab-Abdomen; FL-Front leg; ML- Middle leg; HL- Hind leg; Fe-Femur; Ti- Tibia; Ta-Tarsus

Conclusion

The occurrence of *Neohydrocoptus subvittulus* in a small pond of Lucknow city adds valuable locality-level data to its known distribution in northern India. The findings emphasize the beetle's preference for lentic habitats with dense aquatic vegetation, organic-rich sediments, and stable physicochemical conditions, consistent with earlier reports across Asia. Its ecological role in nutrient cycling, sediment aeration, and as prey within aquatic food webs highlights its significance for maintaining ecosystem balance. The presence of *N. subvittulus* in an urban pond demonstrates the capacity of small freshwater habitats to support specialized beetle assemblages, even under increasing anthropogenic pressures. However, threats from urbanization, such as pollution, habitat loss, and reduced vegetation cover, pose challenges to the persistence of such species. Its sensitivity to environmental changes, *N. subvittulus*, serves as a useful bioindicator. Conservation and regular monitoring of small urban ponds are therefore essential to sustain freshwater biodiversity and ecosystem resilience.

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