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Diversity and distribution of dragonflies and damselflies (*Odonata*) in India: A comprehensive review

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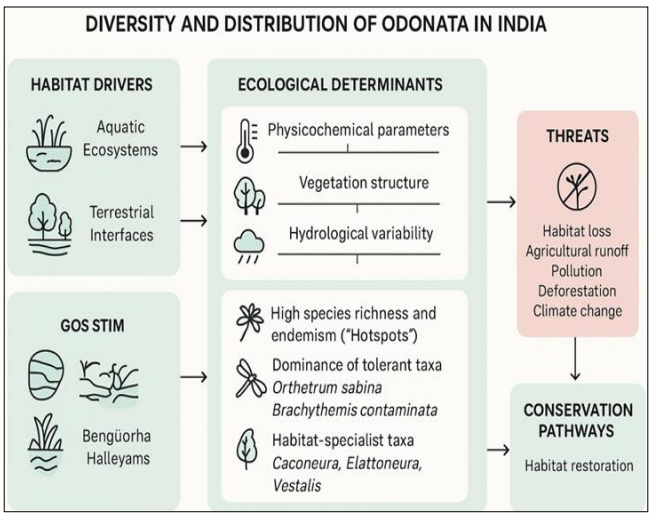
Abstract
Dragonflies and damselflies (Order *Odonata*) constitute one of the most ancient and ecologically significant groups of insects, acting as vital indicators of freshwater ecosystem integrity. This comprehensive review synthesizes existing literature on the diversity, distribution, and ecological roles of Indian *Odonata*, integrating data from regional surveys across the Western Ghats, Eastern Himalayas, northeastern India, central plains, and coastal ecosystems. India harbors approximately 498 species across 18 families and 154 genera, reflecting exceptional biogeographical heterogeneity and high levels of endemism, particularly within the families *Libellulidae* and Coenagrionidae. Regional assessments reveal that odonate diversity is closely governed by habitat heterogeneity, vegetation structure, water quality, and climatic gradients. Studies from biodiversity hotspots such as the Western Ghats and the Eastern Himalayas highlight the persistence of both endemic and threatened taxa, whereas surveys in semi-urban and agricultural landscapes demonstrate the adaptability of generalist species to moderate anthropogenic pressures. Despite progress in taxonomic revisions and faunistic inventories, significant ecological and geographical data gaps remain, particularly in the north eastern and trans-Himalayan regions. Major threats to odonate diversity include habitat degradation, pollution, deforestation, and climate change, all of which have led to localized declines in sensitive taxa. The review emphasizes the need for integrative conservation approaches combining habitat restoration, ecological monitoring, molecular taxonomy, and citizen science initiatives. Ultimately, sustaining the diversity of India's dragonflies and damselflies is essential for maintaining freshwater ecosystem health and ensuring the long-term resilience of the country's aquatic biodiversity.

Keywords: *Odonata*, dragonflies, damselflies, biodiversity, India, freshwater ecosystems, distribution, conservation

Introduction

Odonata, encompassing dragonflies and damselflies, represent one of the most ancient and ecologically significant orders of insects, serving as bioindicators of freshwater ecosystem health due to their sensitivity to environmental changes (Dawn & Chandra, 2014) [1]. Globally, more than 6,000 species have been identified, of which India harbors approximately 488 species distributed across 152 genera and 18 families, reflecting its vast biogeographical diversity (Payra *et al*., 2019) [2]. The Indian subcontinent, with its varied topography and climatic gradients, supports a rich odonate fauna spanning from the Western Ghats and Eastern Himalayas to central and peninsular regions.



Regional assessments have significantly contributed to understanding the distribution and habitat preferences of Indian *Odonata*. For instance, Payra *et al*. (2019) [2] documented 38 species in Sunabeda Wildlife Sanctuary, Odisha, highlighting the dominance of the family *Libellulidae* and the occurrence of species with restricted ranges such as *Elattoneura nigerrima* and *Agriocnemiskalinga*. Similarly, Dawn and Chandra (2014) [1] reported 85 species from Chhattisgarh, including 13 new state records, underscoring the ecological richness of central India's forested and wetland ecosystems. Urban and peri-urban ecosystems have also shown considerable odonate diversity, as evidenced by Munirathinam and Deva (2023) [4] who recorded 12 species of *Odonata* in the Challaghatta region of Bengaluru, despite anthropogenic disturbances.

Short-term faunistic surveys, such as the one conducted in and around Asirvanam Monastery, Bengaluru, further emphasize the persistence of odonates even within fragmented landscapes (Vijay Kumar, Deva, &Jayashankar, 2023) [3]. These findings indicate the adaptive potential of *Odonata* and their role as ecological sentinels in both natural and human-modified environments. However, many regions in India remain underexplored, and there is a pressing need for long-term, standardized monitoring to elucidate patterns of species richness, endemism, and distribution in response to climatic and land-use dynamics.

This review aims to synthesize the existing literature on the diversity and distribution of *Odonata* across India, integrating findings from various ecological regions and highlighting conservation implications in light of rapid environmental change.

Dragonflies and damselflies (Order *Odonata*) are among the oldest extant lineages of winged insects, tracing their evolutionary history to over 300 million years (Bybee *et al*., 2016). They are globally recognized for their ecological importance as both predators and bioindicators of freshwater ecosystem integrity (Kalkman *et al*., 2018). The Indian subcontinent, owing to its climatic heterogeneity and biogeographical complexity, harbors a remarkably rich odonate fauna. Subramanian and Babu (2020) [8] estimated the presence of approximately 498 species across 18 families and 154 genera in India, distributed across varied ecosystems ranging from coastal mangroves to Himalayan streams.

Recent studies have expanded our understanding of the spatial distribution and ecological preferences of Indian *Odonata*. De *et al*. (2021) [6] compiled a checklist of 97 species from the Doon Valley in Uttarakhand, representing 13 families, of which five were endemic, underscoring the significance of Himalayan wetlands as odonate habitats. Similarly, Tiple, Sharma, and Padwad (2022) [9] documented 75 species from Jabalpur, Madhya Pradesh, revealing high species richness within urban and semi-urban landscapes, with *Libellulidae* and *Coenagrionidae* emerging as dominant families. These findings align with Bharathi and Koparde (2022) [5], who reported 35 species from Gondia district in Maharashtra, highlighting the Vidarbha region's potential as an odonate diversity hotspot requiring systematic long-term monitoring.

Coastal and deltaic ecosystems also play a pivotal role in sustaining odonate diversity. Dolai, Samanta, and Mallick (2025) [7] identified 39 species from Namkhana, West Bengal, across mangrove and brackish habitats, emphasizing the influence of habitat heterogeneity on odonate assemblages. Their study demonstrated strong correlations between species richness, seasonal fluctuations, and habitat quality. Such studies reinforce the understanding that *Odonata* diversity is intricately linked to habitat stability, vegetation complexity, and water quality.

Across peninsular India, rapid urbanization and agricultural intensification pose significant threats to odonate populations. Munirathinam and Deva (2023) [4] observed 12 *Odonata* species in the peri-urban landscape of Challaghatta, Bengaluru, demonstrating resilience among generalist species despite anthropogenic disturbances. Similarly, Vijay Kumar, Deva, and Jayashankar (2023) [3] reported a diverse assemblage from Asirvanam Monastery in southern India, suggesting that even fragmented landscapes can support substantial insect biodiversity when basic hydrological and vegetative conditions persist.

The biogeographic distribution of *Odonata* in India reveals distinct ecological gradients, with species assemblages varying from the moist evergreen forests of the Western Ghats—one of the most critical centers of endemism—to the semi-arid plains of central India (Payra *et al*., 2019) [2]. This ecological adaptability is not only a reflection of evolutionary resilience but also a key indicator of environmental transformations under changing climatic regimes. However, significant knowledge gaps persist, particularly in the northeastern and trans-Himalayan regions, where limited surveys have constrained the accurate mapping of odonate distribution patterns.

Description of Order *Odonata*

The order *Odonata*, encompassing dragonflies and damselflies, represents one of the most ancient and ecologically significant groups of aquatic and terrestrial insects. Characterized by their amphibious life cycle, odonates exhibit aquatic larval stages (naiads) and aerial adult stages, thereby functioning as critical biotic links between aquatic and terrestrial ecosystems (Sawarkar, 2013). Members of *Odonata* are primarily predatory throughout their life history, playing an essential role in regulating populations of mosquitoes and other pest insects, thus contributing to natural biological control (Mitra, 2002, as cited in Sawarkar, 2013).

Globally, the order comprises more than 5,000 species distributed across two primary suborders—*Zygoptera* (damselflies) and *Anisoptera* (dragonflies)—that exhibit notable morphological and ecological divergence (Sawarkar, 2013; Singh, Singh, &Hermans, 2017). Damselflies, typically slender and weak fliers, are often associated with shaded and vegetated habitats, while dragonflies, with robust bodies and strong flight capabilities, dominate open and sunlit freshwater environments (Singh *et al*., 2017). In India, approximately 474 species of odonates under 140 genera and 19 families have been reported, reflecting the country's diverse climatic and hydrological conditions that support extensive odonate assemblages (Subramanian, 2014, as cited in Singh *et al*., 2017).

Ecologically, odonates serve as reliable bioindicators of freshwater ecosystem integrity due to their sensitivity to hydrological fluctuations, vegetation structure, and pollution levels. Their distribution patterns and species richness often mirror the ecological quality of wetlands and riparian habitats (Singh *et al*., 2017). The larval stages contribute significantly to aquatic food webs as both predators and prey, whereas adults are vital components of terrestrial food chains, enhancing energy transfer between ecosystems (Sawarkar, 2013). Thus, *Odonata* embodies both taxonomic diversity and ecological functionality, making it an indispensable subject in biodiversity and conservation research across India.

Review of Literature

Studies on the diversity and distribution of *Odonata* in India have significantly expanded in the past two decades, reflecting growing taxonomic, ecological, and conservation-oriented interest in this insect order. *Odonata*, comprising dragonflies and damselflies, have been extensively studied for their biogeographical patterns, habitat preferences, and ecological importance as freshwater bioindicators. The Indian odonate fauna, part of the Indo-Burma and Western Ghats biodiversity hotspots, continues to reveal new species and distributional records through recent surveys.

In Central India, Dawn and Chandra (2014) [1] conducted an extensive faunal survey of Chhattisgarh, reporting 85 species across 49 genera and 10 families, with 13 new state records. The dominance of *Libellulidae* and *Coenagrionidae* mirrored findings from other regions, yet the discovery of *Cyclogomphusheterostylus*, *Macrogomphusseductus*, and *Zygonyx iris iris* marked the first records of these taxa from Central India. Their study revealed significant habitat-wise diversity, with flooded paddy fields, forest streams, and swamps hosting rich odonate assemblages. The research underscored that Chhattisgarh, with 44% forest cover and

diverse forest types, serves as a crucial refuge for Central Indian *Odonata* (Dawn & Chandra, 2014) [1].

The Western Ghats, a globally recognized biodiversity hotspot, continue to yield new insights into odonate endemism. Varghese *et al*. (2014) [17] conducted a comprehensive inventory at the Salim Ali Bird Sanctuary in Kerala, recording 82 species belonging to 55 genera and 13 families, including 21 endemics to the Western Ghats. Notably, *Burmagomphuslaidlawi*, *Onychogomphusstriatus*, *Idionyxsaffronata*, and *Platystictadeccanensis* were among the species with highly restricted distributions. The family *Libellulidae* exhibited the highest diversity, while endemic taxa within *Gomphidae* and *Platycnemididae* were largely confined to forested streams. Their work demonstrated the intricate link between microhabitat specificity and endemism, reaffirming that the Western Ghats remain a core center of odonate radiation in peninsular India (Varghese *et al*., 2014) [17].

Nayak and Roy (2016) [14] assessed odonate diversity in the Asansol–Durgapur industrial region of West Bengal and recorded 57 species, with *Libellulidae* and *Coenagrionidae* being the most speciose families. Despite the anthropogenic pressures, their findings revealed considerable species richness, attributing this to habitat heterogeneity and the persistence of water bodies such as ponds, wetlands, and rivers. Their research also reaffirmed the ecological role of odonates as indicators of freshwater quality and their potential as natural pest control agents.

In western India, Rathod, Parasharya, and Talmale (2016) [22] explored southern Gujarat, reporting 55 species under 37 genera and eight families, with *Lesteselatus*, *Paracercionmalayanum*, and *Burmagomphuslaidlawi* recorded for the first time in the state. Their study extended the known range of several Western Ghats endemics into northern habitats, illustrating the ecological continuity of the Western Ghats biodiversity corridor. The presence of *Hylaeothemisindica* and *Microgomphustorquatus*—typically forest-associated taxa—indicated that the southern Gujarat landscape forms an important northern limit for Western Ghats odonates. The study further emphasized the role of riparian vegetation, rainfall patterns, and microhabitat variation in shaping local odonate assemblages (Rathod *et al*., 2016) [22, 29].

Debata and Swain (2018) [18] conducted a systematic assessment of the *Odonata* fauna in Kuldiha Wildlife Sanctuary, Odisha, recording 53 species belonging to 31 genera and nine families, including *Gynacanthabayadera* and *Onychothemistestacea* as first records for the state. Their research highlighted the presence of several forest-dependent taxa within the families *Gomphidae* and *Chlorocyphidae*, underlining the sanctuary's ecological significance as a refuge for both widespread and range-restricted species. The study emphasized that the diverse freshwater systems—rivers, hill streams, and wetlands—within the Eastern Ghats region sustain a rich odonate assemblage, warranting long-term monitoring for biodiversity conservation (Debata & Swain, 2018) [18].

Similarly, Dwari and Mondal (2018) [19] examined odonate composition in the Howrah District of West Bengal, documenting 54 species, including four newly recorded taxa: *Macrogomphusannulatus*, *Orthetrumluzonicum*, *Mortonagrionaborense*, and *Lestesviridulus*. The dominance of *Libellulidae* and *Coenagrionidae* reflected the prevalence of lentic habitats in semi-urban and rural landscapes. Their work provided one of the earliest comprehensive faunal baselines for the district and suggested that even densely populated regions can maintain substantial odonate diversity when aquatic habitats are preserved.

Similarly, Joshi and Sawant (2020) [11] described *Bradinopygakonkanensis* sp. nov. from the lateritic coastal habitats of Maharashtra, marking the only Western Ghats-endemic *Bradinopyga* species known to inhabit coastal ecosystems. Their work underscored the taxonomic richness of the Western Ghats and the importance of microhabitat-specific surveys in revealing cryptic species diversity. In another contribution, Joshi and Sawant (2019) [12] provided a detailed redescription of *Ceriagrionchromothorax* and discussed its restricted distribution in peninsular India, reaffirming the necessity of fine-scale taxonomic revisions in Indian odonatology.

A macro-regional perspective was provided by Kalkman *et al*. (2020) [20], who published a comprehensive *Checklist of the Dragonflies and Damselflies of South Asia*, encompassing Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka. The checklist enumerated 588 taxa (including 559 full species), with 251 species and subspecies being single-country endemics, 176 of which are found in India. This monumental synthesis integrated multiple taxonomic revisions, established new synonyms, and clarified larval descriptions, thereby standardizing *Odonata* taxonomy across the subcontinent. The authors emphasized the urgent need for larval descriptions and morphological keys to support conservation monitoring and freshwater ecosystem assessments in South Asia (Kalkman *et al*., 2020) [20].

Joshi, Gassah, and Ismavel (2021) [10] conducted an intensive long-term study in Karimganj District, Assam, documenting 97 species, including *Ceriagrioncalamineum*, *Nannophyopsisclara*, *Phyllothemiseltoni*, and *Zyxommabreviventre*—four species newly recorded for India. Their study emphasized the biodiversity significance of the northeastern region and highlighted the underexplored nature of Assam's odonate fauna. The authors called for systematic documentation and conservation assessments to address existing data gaps in northeastern India.

Thampuran*et al.;* (2021) [24] conducted a preliminary assessment of odonate diversity at the College of Forestry, Sirsi, located in the Uttara Kannada district of Karnataka, which forms part of the Western Ghats. Their survey recorded 32 species representing 7 families, with *Libellulidae* and *Coenagrionidae* emerging as the most dominant families. The high representation of these families indicated the presence of generalist taxa, likely resulting from moderate anthropogenic disturbance and habitat fragmentation within the campus landscape. The authors interpreted the high *Libellulidae /Coenagrionidae* ratio as a potential indicator of ecosystem disturbance, a phenomenon well-supported in tropical odonatology. Their study provided a valuable baseline for future biodiversity monitoring and emphasized the necessity of long-term temporal studies to understand habitat-driven population dynamics in the Western Ghats (Thampuran, Kumar, Shastri, & Bharath, 2021) [24].

Joshi *et al*. (2022) [13] expanded the known Indian odonate diversity by describing *Burmagomphuschaukulensis* sp. nov. from the Western Ghats, further contributing to the genus-level revision of *Burmagomphus* Kirby, 1900. Their discovery highlighted the evolutionary uniqueness and

endemism of the Western Ghats odonates. Collectively, these studies demonstrate that both the northeastern and peninsular regions of India are vital reservoirs of odonate diversity, yet remain incompletely documented.

Complementing these distributional surveys, Joshi *et al*. (2023) [16] rediscovered *Lestesnigriceps* Fraser, 1924 in Maharashtra after nearly a century, with new records from the Aarey Milk Colony, Mumbai, and the Sindhudurg District. Their morphological and taxonomic revision also synonymized *Lestespatriciataamrpatti* with *L. patricia* Fraser, 1924 and provided an updated identification key for *Lestes* species in the Western Ghats. This rediscovery not only expands the known range of *L. nigriceps* but also demonstrates the persistence of rare taxa in fragmented urban-forest interfaces, highlighting the value of both morphological and molecular reassessments in *Odonata* taxonomy (Joshi *et al*., 2023) [16].

Recent studies from the Himalayan regions have expanded this framework. Rafi *et al*. (2023) [21] compiled an updated faunal account for the Kashmir Himalaya, recording a diverse assemblage of high-altitude odonates, including *Aeshna*, *Somatochlora*, and *Sympetrum* species, which indicate the adaptation of *Odonata* to cold montane ecosystems. Their findings revealed the vulnerability of Himalayan odonate fauna to climate-induced hydrological shifts and glacier retreat, urging integrated conservation across mountain freshwater systems.

Recent research has greatly expanded the spatial and ecological scope of *Odonata* studies in India, particularly across underexplored biogeographic regions. Dey and Das (2025) [15] examined odonate diversity in a semi-urban habitat within Tripura University campus, Northeast India, emphasizing the ecological indicator role of *Odonata* in urban landscapes. Their study documented 33 species from 25 genera and five families—comprising 23 species of *Anisoptera* and 10 of Zygoptera—representing 44% of Tripura's known odonate fauna. The dominance of the family *Libellulidae* and the presence of both pollution-tolerant and sensitive taxa underscored habitat heterogeneity and moderate anthropogenic influence. Their findings highlighted the significance of urban green spaces in sustaining odonate diversity and reinforced the use of *Odonata* as sensitive bioindicators of environmental quality (Dey & Das, 2025) [15].

Complementing these findings, Gain and Kulkarni (2024) [23, 26] examined odonate assemblages in and around Lohara Lake, Chandrapur, Maharashtra, focusing on the influence of temperature on species diversity. They identified 12 species belonging to 11 genera and two families—*Libellulidae (*8 species) and *Coenagrionidae* (4 species)—revealing dominance of *Anisoptera* over *Zygoptera*. The study highlighted the physiological sensitivity of odonates to thermal variation, reporting a temperature range of 16°C–44°C and correlating it with changes in species composition. The authors concluded that increasing urbanization and climatic warming are key drivers affecting the diversity and distribution of odonates, underscoring the utility of these taxa as indicators of freshwater ecosystem health. Their findings contribute significantly to understanding how temperature gradients and anthropogenic stressors shape community assemblages in semi-urban freshwater habitats (Gain &Kulkarni, 2024) [23, 26].

In Central India, Tiwari, Nandanwar, Goswami, and Agase (2025) [25] performed a comprehensive diversity assessment in the Wainganga River Basin, Balaghat District, Madhya Pradesh. Their study recorded 18 species from two families—*Libellulidae* and Coenagrionidae—across 1,198 individuals, analyzed through ecological indices such as the Simpson's Index (0.933), Shannon-Wiener Index (2.784), and Pielou's Evenness Index (0.968). These metrics revealed a stable, evenly distributed odonate community indicative of a balanced ecosystem. *Diplacodestrivialis* and *Ceriagrion coromandelianum* were the most abundant taxa, suggesting adaptation to the heterogeneous freshwater habitats of the Wainganga basin. The authors emphasized that high evenness and moderate species dominance reflect ecological stability, making odonates effective biotic indicators for long-term wetland health monitoring. Their approach, which integrated quantitative diversity indices with behavioral field observations, represents a methodological advancement in Indian odonate ecology (Tiwari, Nandanwar, Goswami, &Agase, 2025) [25].

Ecological Roles and Habitat Associations

Odonates, comprising dragonflies and damselflies, are integral components of freshwater ecosystems and serve as robust ecological indicators due to their dual aquatic–terrestrial life cycle. Their ecological significance is multifaceted—spanning trophic interactions, ecosystem regulation, and habitat integrity assessment. Both larvae and adults' function as voracious predators, controlling mosquito populations and contributing to the stabilization of aquatic food webs (Aghade *et al*., 2022). The larval stages inhabit diverse lentic and lotic systems—ponds, lakes, rivers, and marshlands—where they serve as mid-level predators, preying upon aquatic invertebrates, small fish, and tadpoles, thereby maintaining ecological balance (Masih & Pathak, 2022).

Habitat preference and assemblage structure of odonates are influenced by hydrological and physicochemical characteristics, vegetation density, and climatic factors. Studies conducted in the mid-Western Ghats and central India demonstrate that species richness is often correlated with water quality, canopy cover, and the presence of emergent macrophytes, which provide perching and breeding sites (Harisha & Hosetti, 2017). The dominance of families such as *Libellulidae* and Coenagrionidae in open and semi-open freshwater systems reflects their adaptability and resilience to moderate anthropogenic pressure (Harisha, 2016) [27].

In agricultural landscapes and wetlands, odonates act as bioindicators of environmental health, with certain species, such as *Brachythemiscontaminata* and *Orthetrumsabina*, signifying eutrophic or polluted water conditions (Dwari & Mondal, 2017). Seasonal variations significantly affect odonate diversity, with monsoon months exhibiting peak abundance and reproductive activity due to increased water availability and vegetation cover (Aghade *et al*., 2022). Furthermore, odonate distribution exhibits spatial heterogeneity across India—from the tropical Western Ghats to the sub-Himalayan regions—underscoring their ecological plasticity and sensitivity to microhabitat alterations (Masih & Pathak, 2022).

Dragonflies and damselflies (*Odonata*) play pivotal ecological roles in both aquatic and terrestrial ecosystems due to their dual life stages. The larval stages inhabit freshwater systems—ranging from stagnant ponds to fast-flowing streams—while adults are aerial predators, forming

essential trophic links across ecological gradients. As predatory insects, both larvae and adults regulate populations of smaller aquatic organisms and flying insects, including mosquitoes, thereby maintaining ecological equilibrium and contributing to biocontrol functions (Harisha, 2016; Palei, Debata, & Mohapatra, 2017) [27, 28].

Odonates are highly sensitive to environmental alterations, such as water quality degradation, vegetation loss, and hydrological changes, making them reliable bioindicators of ecosystem integrity (Tuhin& Khan, 2018; Kalkman *et al*., 2020) [20]. Species distribution is intricately linked to habitat heterogeneity—rheophilic species, for instance, dominate fast-flowing streams, whereas lentic habitats like lakes and marshes host a greater diversity of *Libellulidae* and Coenagrionidae (Rathod, Patel, Mistry, & Parasharya, 2016; Dawn & Chandra, 2014) [1, 22, 29]. In southern and central India, studies have reported significant variations in species richness along gradients of altitude and vegetation density, demonstrating how microhabitat complexity and canopy cover influence community assemblages (Rathod, Parasharya, & Talmale, 2016; Palei *et al*., 2017) [22, 28].

Furthermore, odonates serve as ecological sentinels of freshwater health. Their larval stages are particularly responsive to physicochemical parameters such as dissolved oxygen, temperature, and pH, which govern larval development and survival (Dawn & Chandra, 2014) [1]. Habitat degradation through anthropogenic pressures—like agricultural runoff, deforestation, and urbanization—has led to declining odonate diversity in several Indian regions, underscoring their vulnerability and the need for habitat conservation (Rathod *et al*., 2015; Harisha, 2016) [27, 30]. Thus, the habitat associations and ecological functions of odonates position them as crucial indicators for assessing freshwater ecosystem stability and biodiversity conservation priorities across India.

Threats and Conservation Status of *Odonata* in India

Odonates, as sensitive inhabitants of freshwater ecosystems, are increasingly threatened by anthropogenic disturbances and environmental degradation across India. Habitat destruction, water pollution, agricultural runoff, deforestation, and urbanization represent the most pressing threats affecting the diversity and survival of dragonflies and damselflies (Harisha, 2016; Gain &Kulkarni, 2024) [23, 26, 27]. The loss and alteration of wetlands, streams, and riparian habitats due to unsustainable developmental activities have significantly disrupted odonate breeding and foraging habitats, leading to localized extinctions and range contractions (Rathod *et al*., 2016; Palei, Debata, & Mohapatra, 2017) [22, 28, 29].

Climate change compounds these threats through shifts in temperature, precipitation, and hydrological cycles, directly influencing larval development, adult emergence patterns, and overall community composition (Gain &Kulkarni, 2024) [23, 26]. Several studies from central and western India indicate a marked decline in odonate abundance in areas subjected to rising water temperatures and pollution from industrial effluents (Rathod, Patel, & Parasharya, 2015) [30]. Similarly, agricultural landscapes exposed to pesticides and fertilizers experience reduced larval survivorship, altering trophic interactions within aquatic ecosystems (Harisha, 2016) [27].

The conservation status of *Odonata* in India remains inadequately assessed, despite the country's hosting of approximately 474 species across 18 families (Kalkman *et al*., 2020) [20]. Only a limited number of species have been evaluated by the International Union for Conservation of Nature (IUCN), with many categorized as "Data Deficient" due to the scarcity of long-term monitoring and distributional data (Dawn & Chandra, 2014) [1]. Endemic taxa in biodiversity hotspots such as the Western Ghats and the Eastern Himalayas are particularly vulnerable, with several species facing threats from habitat fragmentation and invasive vegetation (Rathod *et al*., 2016; Kalkman *et al*., 2020) [20, 22, 29].

Recent initiatives, including regional surveys and conservation-focused inventories, have contributed valuable baseline data essential for species protection and policy formulation (Palei *et al*., 2017) [28]. However, systematic habitat restoration, pollution control, and inclusion of odonates in freshwater biodiversity monitoring frameworks are urgently required. Strengthening public awareness and integrating citizen science approaches may further enhance conservation outcomes for these ecologically vital taxa. Thus, safeguarding odonate diversity in India necessitates a multidimensional approach encompassing habitat preservation, ecological research, and adaptive management in the context of rapid environmental change.

Threats and Conservation Status of *Odonata* in India

The *Odonata* of India, encompassing both dragonflies (*Anisoptera*) and damselflies (Zygoptera), face escalating threats from anthropogenic and climatic pressures that compromise their habitats and ecological functions. Although India harbors approximately 488 species under 18 families, representing nearly 8% of global odonate diversity (Subramanian & Babu, 2017), habitat degradation and hydrological alterations have rendered several populations locally vulnerable or near threatened (Sahu, 2022).

Freshwater ecosystem modifications—such as dam construction, river channelization, siltation, and pollution—are primary stressors affecting odonate breeding and larval development. Agricultural runoff and pesticide accumulation in wetlands have also been reported to reduce larval survivorship and adult abundance (Payra *et al*., 2020). Similarly, rapid urbanization and deforestation in biodiversity hotspots like the Western Ghats and northeastern India have fragmented habitats, leading to a decline in species richness and local extirpations (Rathod, 2020).

Among the recorded Indian odonates, several species, including *Indothemiscarnatica* and *Macrogomphusrobustus*, are categorized as Near Threatened in the IUCN Red List (Tiple & Chandra, 2013). Many endemic taxa, particularly stream-associated damselflies such as *Elattoneura nigerrima* and *Pseudagrionspencei*, exhibit restricted distribution and heightened sensitivity to habitat changes (Payra *et al*., 2020). Studies from Odisha and Chhattisgarh further reveal that these species are confined to pristine forest streams and are rapidly declining in disturbed regions (Sahu, 2022; Payra *et al*., 2020).

Conservation of odonates thus requires an integrated approach encompassing habitat restoration, water quality management, and ecological monitoring. Odonates are increasingly recognized as bioindicators of wetland health, yet national-level conservation frameworks remain limited. Periodic biodiversity assessments and citizen-science initiatives, such as the Indian *Odonata* Database

(Subramanian, 2014), are crucial for mapping species distributions and identifying priority sites for protection. Strengthening wetland conservation policies under the Wildlife Protection Act and promoting odonate-based eco-education could ensure the persistence of these ecologically vital insects across India's freshwater landscapes.

India's *Odonata* fauna, encompassing an impressive diversity of dragonflies and damselflies, represents a vital component of the country's freshwater biodiversity and ecological stability. The comprehensive review of existing literature underscores that odonate diversity and distribution are intricately governed by habitat heterogeneity, water quality, vegetation complexity, and climatic gradients across the subcontinent. From the endemic-rich Western Ghats and Eastern Himalayas to the semi-arid zones of central and western India, regional surveys reveal both exceptional species richness and alarming signs of habitat loss. Despite considerable progress in taxonomic documentation and faunistic inventories, vast geographical and ecological gaps persist, particularly in the northeastern and central Indian landscapes.

The review highlights that *Odonata* serve not only as bioindicators of freshwater ecosystem health but also as efficient biological control agents that maintain ecological equilibrium. However, anthropogenic pressures—deforestation, urbanization, agricultural pollution, and hydrological modifications—continue to erode odonate habitats, leading to localized declines and potential species extinctions. The lack of long-term ecological datasets and limited inclusion of *Odonata* in national conservation frameworks further constrain effective management efforts.

Future conservation priorities must integrate habitat restoration, water resource management, and community-based monitoring within a unified biodiversity policy framework. Strengthening research through molecular taxonomy, ecological modeling, and geospatial mapping will enhance understanding of species dynamics under climate change scenarios. Furthermore, fostering citizen science initiatives and incorporating odonates into wetland and riverine ecosystem assessments can significantly expand monitoring capacity.

In essence, safeguarding the diversity of India's dragonflies and damselflies demands a multidimensional conservation strategy that bridges taxonomy, ecology, and policy. As ecological sentinels of freshwater health, the persistence of *Odonata* will serve as a measure of the nation's commitment to sustaining its aquatic biodiversity heritage.

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