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Comparative dynamics and area health model: miscellany of butterflies versus odonates of Dholka, Ahmedabad

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Abstract

Far beyond their dazzling colors, butterflies, dragonflies, and damselflies are living barometers of environmental health, whispering the stories of air, water, and habitat quality. In the rapidly growing urban sprawl of Ahmedabad, these delicate fliers serve as irreplaceable sentinels of ecological balance. This study offers a replicable blueprint for assessing “area health” through a fine-scale examination of urban biodiversity, green habitats, and supporting environmental parameters. Our 8 km² focus area, Dholka town, Ahmedabad, is crowned by three tranquil lakes and embraced by a lush pocket forest. Weather records of temperature, humidity, wind speed, visibility, and UV index paint Dholka as a rare refuge of biodiversity within a concrete-dominated landscape. Within its mosaic of habitats, we documented an impressive diversity: 30 butterfly species (Lepidoptera), 9 dragonfly species, and 8 damselfly species (Odonata). Remarkably, this richness flourished on wild plant species often dismissed as weeds, yet here, they proved to be ecological lifelines. *Prosopis juliflora* (Fabaceae), *Alternanthera ficoidea* (Amaranthaceae), *Lantana camara* (Verbenaceae), *Dicliptera paniculata* (Acanthaceae), and *Tephrosia purpurea* (Fabaceae) served as vital microhabitats, nurturing countless indicator species. Rigorous water quality analyses further reinforced our holistic health assessment model. This research underscores the hidden power of small green ecosystems, capable of sustaining biodiversity and stabilizing the broader metropolitan environment. We urgently advocate for the inclusion of select butterfly and odonate species in the IUCN conservation list, ensuring their protection before they slip unnoticed toward extinction. In safeguarding these sentinels, we safeguard the very heartbeat of our urban ecosystems.

Keywords: Butterfly diversity, Odonate diversity, Water analysis, Weather profile, Area health

Introduction

Biodiversity studies at the local landscape level offer critical insights into the ecological interplay between insect fauna and plant communities. Butterflies (Lepidoptera) and dragonflies (Odonata) are widely recognized as bioindicators due to their sensitivity to habitat quality, microclimatic changes, and floral availability (Chowdhury *et al*. 2023) [7]. Despite their ecological significance, integrated field-based studies that document both faunal groups alongside wild plant diversity remain sparse in semi-urban Indian landscapes.

The Dholka region of Ahmedabad, Gujarat, encompasses a unique blend of agro-patches, semi-wild vegetation, seasonal wetlands, and human-modified landscapes. This area, though relatively small, presents a mosaic of habitats that support a surprisingly rich assemblage of butterflies, dragonflies, and native wild flora. Through systematic season-round observation, this study aimed to document the triad interaction among Lepidoptera, Odonata, and plant species, offering ecological insights into species distribution, seasonal trends, and plant-insect associations. Such studies are crucial in the context of increasing habitat fragmentation and climate variability, which pose direct threats to insect biodiversity and associated ecosystem services such as pollination and pest regulation (Thomas 2005) [29]. By presenting a complete ecological profile from this defined area, the present research establishes the Dholka region as a model micro-habitat for insect-plant interaction studies.

This study also provided a replicable model of how a defined geographical area can exhibit specific and stable biodiversity patterns among flora, butterflies, and dragonflies (Delpon *et al*. 2019) [11]. It demonstrates the ecological value and conservation potential of habitats even within anthropogenically influenced zones. The strategic location of this area, bridging wild and modified landscapes, allowed for a comprehensive season-round assessment of insect diversity and plant associations.

In the Dholka region, the observed butterfly diversity serves as a proxy for floral richness and habitat heterogeneity, particularly in areas where wild and cultivated plant species coexist (Ehrlich and Raven 1964) [14]. Butterflies depend on specific host plants for larval development and diverse nectar sources for adult sustenance (Singh and Müller 2025) [27]. Thus, a stable or diverse butterfly population often implies a balanced plant-insect interaction network and minimal chemical disturbance (Lewinsohn *et al*. 2022) [22].

Dragonflies, on the other hand, rely on clean, slow-moving, or stagnant water bodies for breeding, making them strong indicators of freshwater ecosystem quality (Adnan *et al*. 2025) [1]. Their life cycle, which includes both aquatic and terrestrial phases, makes them highly sensitive to changes in water pollution, habitat fragmentation (Johansson and Suhling 2004) [19]. In the Dholka landscape, the presence of multiple species of dragonflies indicates the persistence of semi-natural water bodies and a relatively unpolluted aquatic environment, despite increasing agricultural and urban influence.

Together, the co-occurrence and seasonal dynamics of butterflies and dragonflies in this study provide valuable insights into the ecological well-being of the Dholka area. Their diversity patterns not only reflect the underlying habitat quality but also serve as early warning systems for environmental degradation. Monitoring these faunal groups thus offers a cost-effective and ecologically meaningful approach to assess, conserve, and manage biodiversity in transitional zones like Dholka that lie at the interface of human activity and natural ecosystems. This is the first integrated two-year-long biodiversity documentation from this region that combines Lepidoptera, Odonata, and wild plants, offering a baseline for future ecological and environmental impact assessments.

Materials and methods

Area of study

The study was conducted in Dholka, which is an ancient town located in the Ahmedabad district (metropolitan) of Gujarat. The town is located at a coordinate of 22.72° North latitude and 72.47° East longitude. It is 45 km by road via National Highway 8A southwest of the city of Ahmedabad. Dholka has flat terrain. The average altitude of the town is 17m (56 ft) above sea level. It has many water bodies scattered all over. The River Sabarmati flows almost 40 Km to its east. Dholka has a hot and semi-arid climate. Geographically, the studied site is located northeast of the Nal Sarovar Bird Sanctuary, a Ramsar wetland renowned for its avifaunal richness, and is part of the Bhal region, which features a mosaic of agricultural land and remnant patches of wild vegetation. The study zone includes urban peripheries, agricultural edges, and roadside vegetation along Lana gam Road, offering diverse microhabitats ideal for observing butterflies (Lepidoptera), dragonflies (Odonata), and associated wild plant species. The selected area has three major lakes and one jungle area surrounded by crop fields as described in Figure 2 with details.

Weather profile at the time of study of the selected area

The study was conducted over a full annual cycle, spanning from June 1, 2024, to May 31, 2025, thereby encompassing all three major seasons. Observations were systematically carried out six times per week, twice daily across three designated days, to ensure comprehensive temporal coverage. Detailed weather profiling of the last year of the selected site is presented in the Results section, along with information on the corresponding weather stations (Figure 1). Meteorological parameters, including temperature, humidity, windspeed, visibility, and UV index, were recorded (Table 1).

Diversity record and photography

The present study documents and photographs the dominant wild plant species of Dholka, alongside the associated diversity of butterflies and dragonflies that depend on them. Two primary objectives guided the research: first, to establish a triangular ecological model connecting two key indicator groups, butterflies and dragonflies, with wild plants in the Dholka region; and second, to emphasize the ecological significance of wild flora in supporting these species. While India is known for its rich biodiversity in forests, wetlands, and protected areas, vast landscapes, characterized by wild vegetation and local lakes, remain largely underexplored. These areas, though ecologically significant, differ subtly in climatic conditions and offer unique biodiversity, yet they receive far less scientific attention compared to sanctuaries, national parks, and forest reserves.

All the pictures were taken using either a mobile phone with an extra zoom macro lens or a Nikon Coolpix P900 (83X, 24-2000 mm), along with the location and date. The identification of the observed organism was conducted using standard field guides, research papers, and the expertise of experienced professionals.

Water analysis

The selected study site featured three serene water bodies, designated as Lake 1, Lake 2, and Lake 3 (Figure 2). To capture their physico-chemical character, we measured temperature (°C), total dissolved solids (TDS, ppm), salinity (ppm), conductivity (µS), and pH. Sampling was carried out at a uniform time, 11:00 AM, under calm daylight conditions to minimize environmental variation. Freshwater samples were collected in sterilized containers, ensuring pristine representation of each lake. Every parameter was recorded in triplicate for precision, and the data are presented as mean ± SD (Table 3).

Results

Weather profiling and monitoring of the studied area

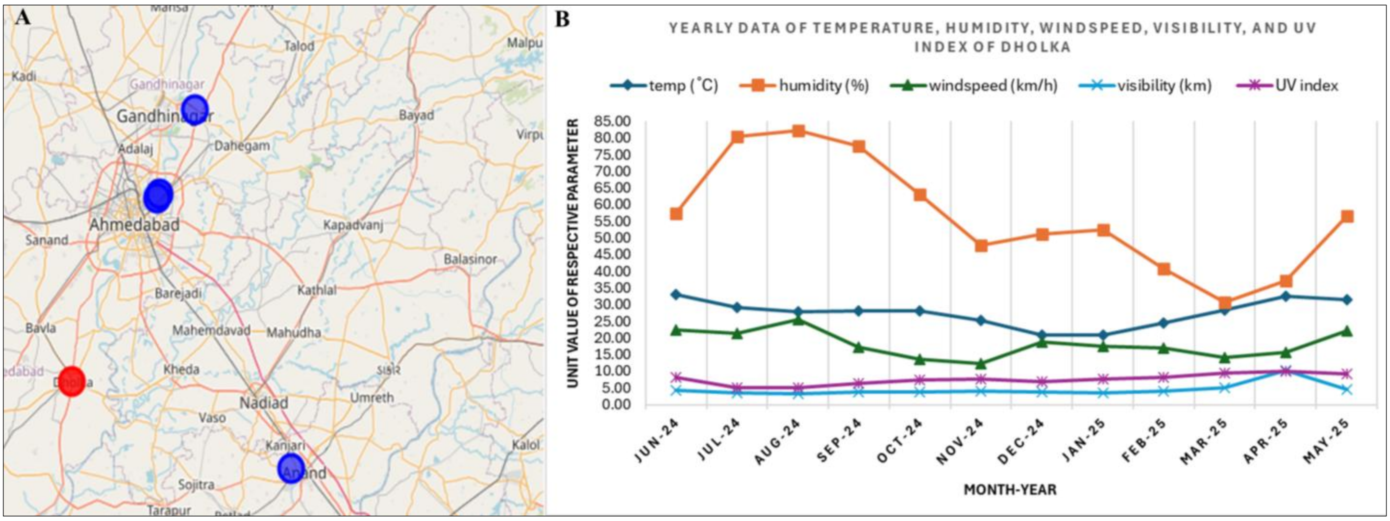

Fig 1: (A) Locations of weather stations used for the data build of Dholka region, (B) data of temperature, humidity, windspeed, visibility, and UV index of last year (2024-25)

Table 1: Yearly data of temperature, humidity, wind speed, visibility, and UV index of the selected area

Month	Temperature (°C)	Humidity (%)	Windspeed (km/h)	Visibility (km)	UV index
Jun-24	33.00	57.43	22.47	4.37	8.17
Jul-24	29.19	80.49	21.27	3.50	5.10
Aug-24	27.87	82.30	25.65	3.31	5.13
Sep-24	28.24	77.62	17.31	3.67	6.37
Oct-24	28.24	63.20	13.64	3.89	7.45
Nov-24	25.33	47.88	12.30	3.95	7.63
Dec-24	20.74	51.08	18.80	3.87	6.87
Jan-25	20.98	52.49	17.51	3.55	7.61
Feb-25	24.43	40.81	17.09	4.00	8.21
Mar-25	28.46	30.59	14.11	4.93	9.52
Apr-25	32.58	37.20	15.71	10.12	10.00
May-25	31.53	56.54	22.09	4.55	9.13
Yearly average	27.55	56.47	18.16	4.48	7.60

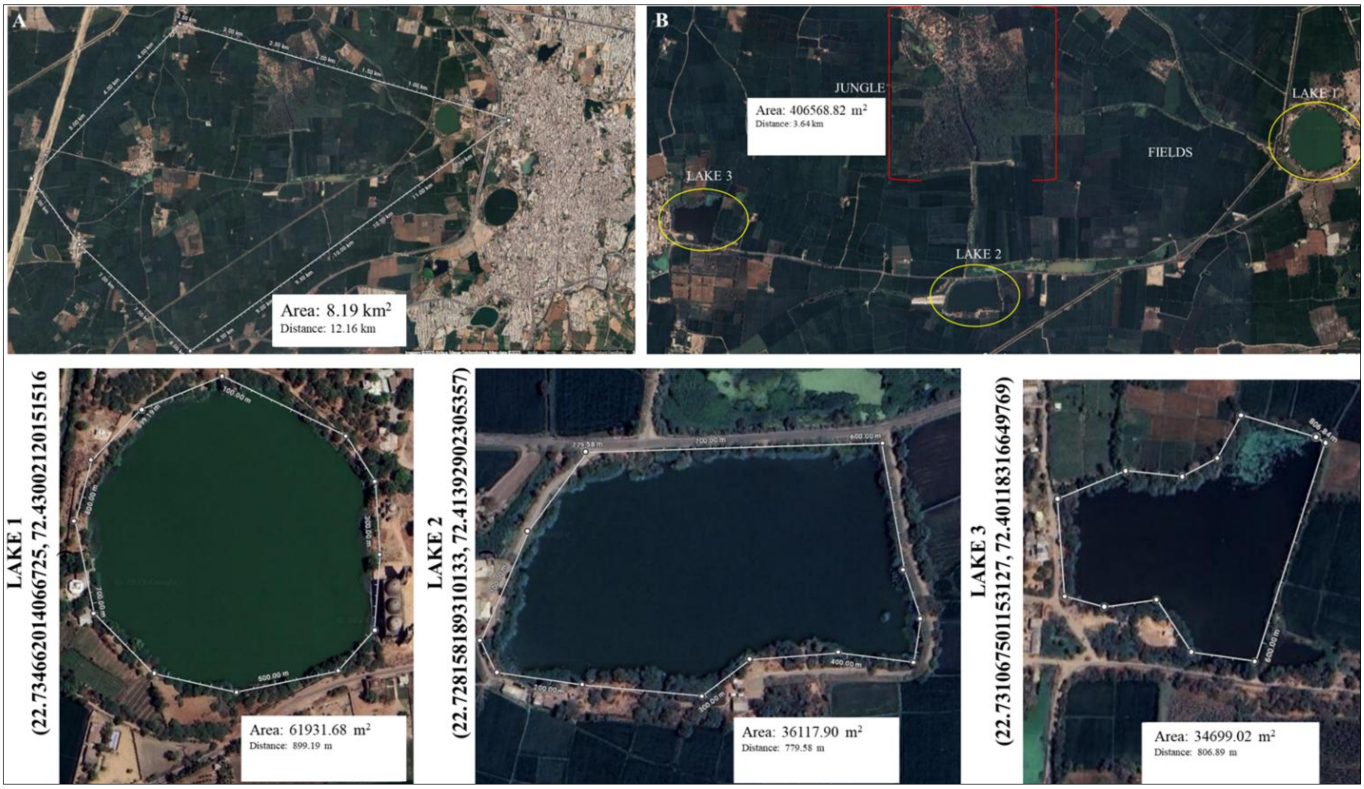

Fig 2: (A) Whole selected area of study (8.19 km^2), (B) Three lakes and one jungle in the selected area. Three lakes are also described below, with distance and area

As illustrated in Table 1 and Figure 1, the climatic conditions observed over the past year (2024-25) were notably conducive to the thriving life cycles of butterflies and dragonflies. The average annual temperature stood at a pleasant 27.55°C, ideal for the growth, mating, and migration activities of these delicate insects (Karlsson and Wiklund 2005) [20]. Humidity levels averaged 56.47%, and the wind speed hovered around 18.16 km/h, classified as a gentle breeze on the Beaufort scale, providing just the right conditions for sustained flight (Singleton 2008) [28]. Although the overall visibility averaged 4.48 km, it peaked at a clear 10 km during April. The UV index also reached its annual high in April 2025 (index 10), a reflection of the intense summer sunlight. With distinct summer, winter, and monsoon seasons marked across the year, the environmental rhythm was well-aligned with the biological needs of these insects. Month-wise variations in all climatic variables are detailed in Table 1.

The study area of Dholka is good for biodiversity, nestled amid three tranquil lakes, each equidistant and teeming with life. A lush forest with a dense canopy of wild vegetation stands nearby, offering shelter and sustenance to a variety of species. Surrounding this vibrant landscape are expansive fields growing rice, castor, cotton, wheat, and tomatoes, creating a mosaic of habitats that support rich ecological interactions. This serene location, largely untouched by dense human habitation and disturbances, provides an ideal environment for butterflies and dragonflies. Notably, colonies of *Belenois aurota*, with 30-40 individuals fluttering together, were frequently observed, an enchanting sight that speaks to the area's ecological balance. Although not part of this publication, over 120 species of birds and 5–6 mammalian species have been recorded by our team, further underscoring the extraordinary biodiversity of Dholka. Exact coordinates and area calculations are given in Figure 2.

Butterfly (Lepidoptera) diversity

A total of 30 butterfly species were recorded from the selected area (excluding 3 sightings without photographic proof). Among these, 7 species belonged to the Lycaenidae family, 10 to Pieridae, 8 to Nymphalidae, 2 to Papilionidae, and 2 to Hesperiidae (Figure 3). Three visually confirmed species, *Delias eucharis* (Pieridae), *Pachliopta aristolochiae* (Papilionidae), and *Ixias pyrene* (Pieridae), were not included in Figure 3 due to the absence of photographs. Most butterflies were observed fluttering around five wild plant species: *Prosopis juliflora* (Fabaceae), *Alternanthera ficoidea* (Amaranthaceae), *Lantana camara* (Verbenaceae), *Dicliptera culata* (Acanthaceae), and *Tephrosia purpurea* (Fabaceae). The full list is presented in Figure 3.

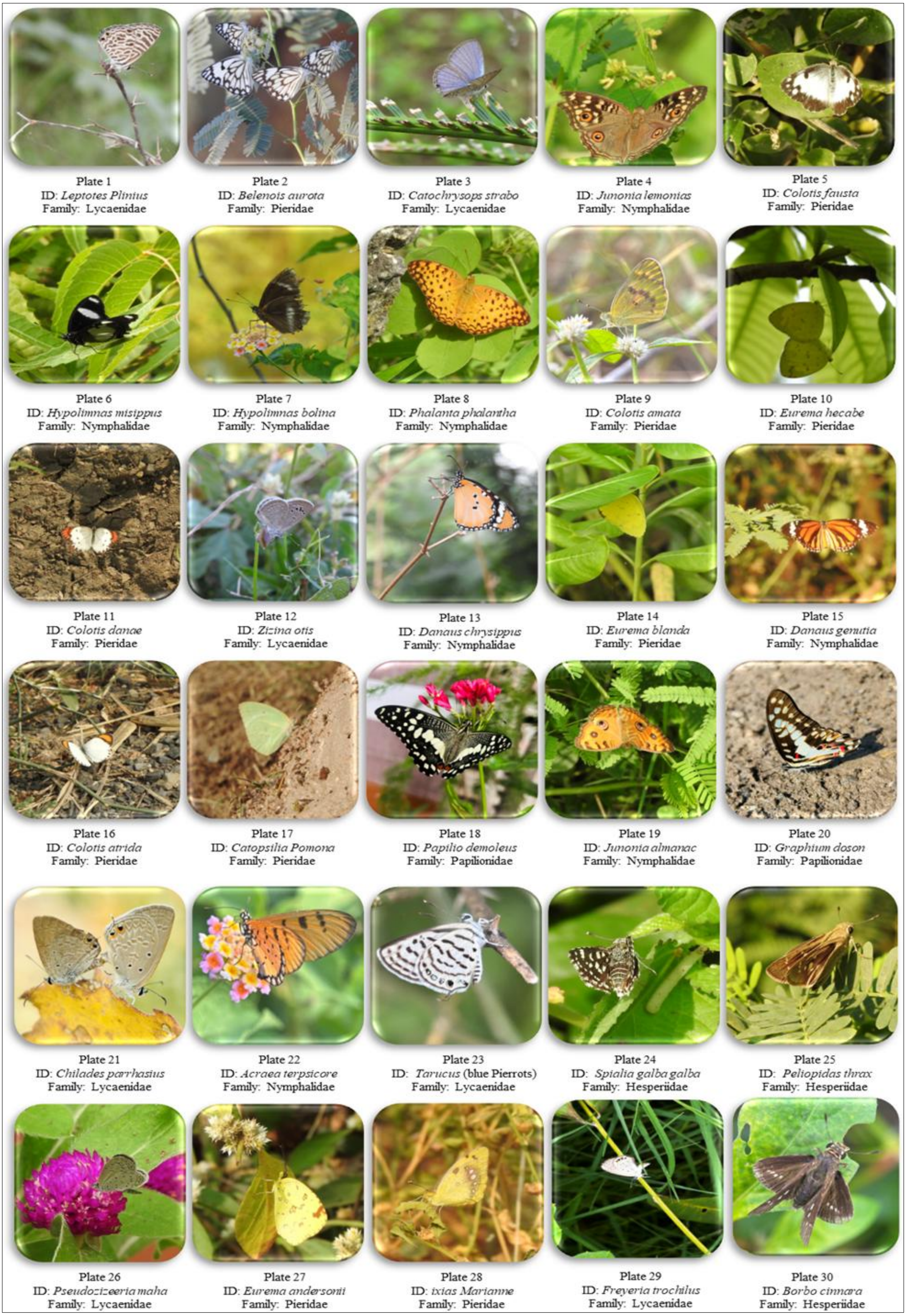

Fig 3: Species lists of butterflies observed in the Dholka, Ahmedabad

Dragonfly and Damselfly (Odonata) diversity

Fig 4: Diversity of Dragonfly and Damselfly of Dholka, Ahmedabad

The observation of 8 dragonfly and 5 damselfly species in the studied area of Dholka highlights its status as a healthy, ecologically rich, and relatively undisturbed environment (Figure 4). Such biodiversity is a strong indicator of environmental quality, reflecting the region's thriving natural balance. Like Dholka, many peri-urban areas surrounding major population centers possess similar hidden ecological treasures that deserve greater attention and systematic study. These areas can serve as valuable models for both current and future environmental research. The study site, with over >95% wild vegetation, offers a sanctuary for a wide variety of organisms by providing essential food sources, shelter, and breeding grounds. This abundance of wild flora supports a complex web of life and delivers vital ecosystem services. The presence of diverse Odonata species further underscores the area's ecological stability and functionality. Altogether, this makes Dholka an exemplary natural habitat, worthy of conservation, long-term monitoring, and deeper environmental exploration.

Table 2: Scientific names, common names with family, and IUCN categorization of observed species

Sc. Name of species	Common name	Family	IUCN category
Butterfly			
Leptotes Plinius	Zebra blue	Lycaenidae	Not specified
Catochrysops strabo	Forget-me-not	Lycaenidae	Not specified
Zizina otis	Lesser grass blue	Lycaenidae	Least concern
Chilades parrhasius	Small cupid	Lycaenidae	Not specified
Tarucus (blue Pierrots)	Blue pierrots	Lycaenidae	Not specified
Pseudozizeeria maha	Pale grass blue	Lycaenidae	Not specified
Freyeria trochilus	Grass jewel	Lycaenidae	Least concern
Ixias Marianne	White-orange tip	Pieridae	Not specified
Eurema andersonii	One-spot grass yellow	Pieridae	Least concern
Colotis atrida	Little orange tip	Pieridae	Not specified
Catopsilia Pomona	Common emigrant	Pieridae	Not specified
Eurema blanda	Three-spot grass yellow	Pieridae	Not specified
Colotis danae	Crimson tip	Pieridae	Not specified
Eurema hecabe	Common grass yellow	Pieridae	Least concern
Colotis amata	Small salmon Arab	Pieridae	Not specified
Colotis fausta	Large salmon Arab	Pieridae	Least concern
Belenois aurota	Indian pioneer	Pieridae	Least concern
Junonia lemonias	Lemon pansy	Nymphalidae	Least concern
Hypolimnas misippus	Danaid eggfly	Nymphalidae	Least concern
Hypolimnas bolina	The great eggfly	Nymphalidae	Not specified
Phalanta phalantha	Common leopard	Nymphalidae	Least concern
Danaus genutia	Striped tiger	Nymphalidae	Least concern
Danaus chrysippus	Plain tiger	Nymphalidae	Least concern
Junonia almanac	Peacock pansy	Nymphalidae	Least concern
Acraea terpsicore	Tawny coster	Nymphalidae	Not specified
Graphium doson	Common jay	Papilionidae	Not specified
Papilio demoleus	Lime butterfly	Papilionidae	Not specified
Pelopidas thrax	White branded swift	Hesperiidae	Not specified
Spialia galba galba	Grizzled skipper	Hesperiidae	Not specified
Borbo cinnara	Rice swift	Hesperiidae	Not specified
Dragonfly			
Crocothemis servilla	Scarlet skimmer	Libellulidae	Least concern
Brachythemis contaminata	Ditch jewel	Libellulidae	Least concern
Diplacodes trivialis	Chalky percher	Libellulidae	Least concern
Diplacodes haematodes	Scarlet percher	Libellulidae	Least concern
Rhyothemis variegata	Variegated flutterer	Libellulidae	Least concern
Orthetrum sabina	Green marsh hawk	Libellulidae	Least concern
Tholymis tillarga	Coral-tailed cloudwing	Libellulidae	Least concern
Tramea basilaris	Red marsh trotter/Keyhole glider/Wheeling glider	Libellulidae	Least concern
Urothemis signata	Greater crimson glider	Libellulidae	Least concern
Damselfly			
Ceriagrion coromandelianum	Yellow waxtail	Coenagrionidae	Least concern
Pseudagrion microcephalum	Blue sprite	Coenagrionidae	Least concern
Mortonagrion varralli	Brown dartlet	Coenagrionidae	Not specified

Ischnura nursei	Pixie dartlet	Coenagrionidae	Least concern
Pseudagrion rubriceps	Saffron-faced blue dart	Coenagrionidae	Least concern
Paracercion calamorum	Dusky lilly-squatter	Coenagrionidae	Least concern
Agriocnemis pygmaea	Pygmy dartlet	Coenagrionidae	Least concern
Pseudagrion rubriceps	Saffron-faced blue dart	Coenagrionidae	Least concern

In the present study, we documented several species of butterflies (Lepidoptera), dragonflies, and damselflies (Odonata) from the surveyed region. Each species was identified up to the scientific name and classified at the family level. Upon cross-referencing the observed species with the IUCN Red List, it was found that most of them do not currently appear under any specific conservation category. This absence suggests that these species have not yet been assessed or updated in the IUCN database, or they are currently considered to have stable populations without immediate threats at a global level.

However, the lack of conservation status should not be misinterpreted as a sign of security. The omission could highlight a gap in the existing knowledge or monitoring efforts for insect biodiversity, particularly in local or regional contexts. It is therefore recommended that future studies focus on long-term population monitoring and ecological assessments. Such data are crucial for timely evaluation and potential inclusion of these species in conservation frameworks. Our findings stress the importance of encouraging regional conservation databases and citizen science platforms to complement global initiatives like the IUCN.

Water analysis

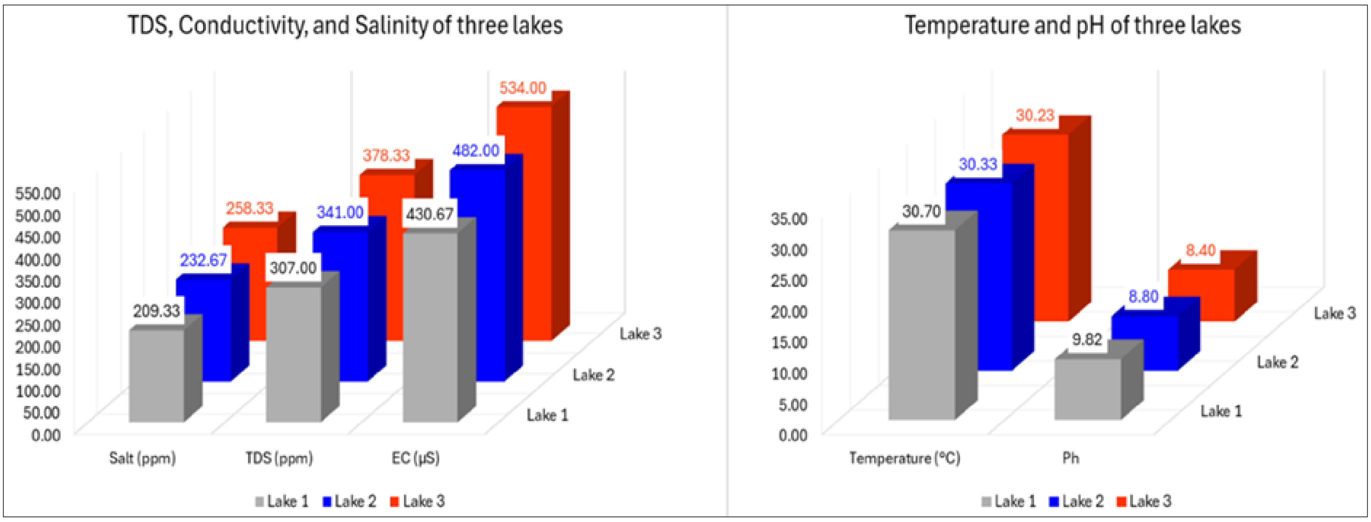

Fig 5: 3D graphical representation of comparative assessment of the water of the selected 3 lakes of Dholka

Table 3: Water analysis of the selected 3 lakes (mean±SD)

Parameter	Lake 1	Lake 2	Lake 3
Temperature (°C)	30.7±0.37	30.33±0.37	30.23±0.25
pH	9.82±0.14	8.80±0.05	8.40±0.03
Salinity (ppm)	209.33±2.05	232.67±2.87	258.33±6.02
TDS (ppm)	307±4.90	341±4.55	378.33±8.38
Conductivity (µS)	430.67±11.47	482±6.98	534±11.22

The physicochemical profile of the three lakes reveals subtle but ecologically significant variations. Lake 1, with a temperature of 30.7 °C and the highest pH (9.82), presents an alkaline-rich environment that could challenge the survival of many sensitive aquatic invertebrates, yet may favor certain algae and hardy species. Lake 2 (30.3 °C, pH 8.80) sits in a relatively moderate alkaline range, while Lake 3 (30.23 °C, pH 8.40) leans closer to a balanced condition, potentially offering a more stable habitat. Salinity exhibits an increasing gradient from Lake 1 (209.33 ppm) to Lake 3 (258.33 ppm), accompanied by similar rises in TDS (307 ppm to 378.33 ppm) and conductivity (430.67 µS to 534 µS), indicating a greater ionic load and mineralization in Lake 3.

Such parameters influence the lake's biodiversity profoundly: butterflies, dragonflies, and damselflies, being dependent on aquatic larval stages, thrive best in waters with balanced pH, moderate salinity, and lower TDS. Excess alkalinity and elevated dissolved solids, as observed in Lake 1 and particularly in Lake 3, may limit the diversity of sensitive odonate larvae, thereby indirectly reducing adult insect abundance. This, in turn, ripples through the ecosystem, diminishing pollination services provided by butterflies and the bioindicator role of dragonflies and damselflies, and signalling gradual shifts in overall habitat health.

Discussion

Vegetation patches and their biodiversity play a crucial role in maintaining ecological balance in India. Wetlands and ponds act as natural purifiers, regulate groundwater, and serve as carbon sinks, while also providing critical habitats for migratory birds, fish, amphibians, and insects. Vegetation patches, whether in rural or urban settings, sustain pollinators, improve soil fertility, reduce air pollution, and help regulate temperature, thereby supporting both ecological and human well-being. In fast-urbanizing regions of India, even small green spaces and roadside plantations serve as vital refuges for biodiversity, bridging the gap between natural and built environments (Bašić *et al*. 2020) [4]. Biodiversity indicators such as wild plants, butterflies, and odonates highlight the health of ecosystems in different dimensions. Wild plants form the foundation of habitats and offer essential ecosystem services like pollination, seed dispersal, and soil stabilization (Anwar *et al*. 2024) [3]. Butterflies, being sensitive to environmental changes, act as indicators of terrestrial ecosystem health, while odonates reflect the quality of aquatic ecosystems, as their larvae are highly responsive to water pollution (Dolai 2023) [13]. Together, these groups provide a comprehensive picture of ecosystem vitality and resilience.

In the context of urban biodiversity assessment, our findings resonate with and extend previous research conducted in other regions of India and beyond. For instance, a detailed investigation in Kalyani Lake Park, Nadia district, West Bengal, provided a comprehensive account of Odonata and Lepidoptera diversity, their distribution, and potential ecological interactions, thereby highlighting the value of such taxa as bioindicators of ecosystem health (Dolai 2023) [13]. Interestingly, contrasting results emerged from a study in the Balikpapan–Samarinda region of East Kalimantan, Indonesia, where no significant relationship was observed between butterfly and odonate species richness (Cleary *et al*. 2018) [8]. Such variability underscores the influence of local habitat characteristics and ecological dynamics on biodiversity patterns.

Comparative insights also emerge from more recent work in West Bengal State University Campus, which reported 26 species of Libellulidae, a number considerably higher than the 9 Libellulidae species recorded in our Ahmedabad study (Bengal and Ghorai 2025) [5]. However, our dataset adds further depth with the documentation of 8 species belonging to the Coenagrionidae family, thereby enriching the regional odonate checklist. Similarly, urban butterfly diversity reported from Durgapur city revealed 39 species across 5 families, whereas our survey identified 30 species spanning the same number of families in Ahmedabad (Sarkar *et al*. 2025) [25]. These comparisons highlight both the ecological richness and the regional variations in species representation, suggesting that urban landscapes support distinct assemblages shaped by local climatic, hydrological, and land-use factors. Our findings from Ahmedabad contribute a valuable data point to this growing body of literature, demonstrating how such assessments can inform conservation planning, urban landscape management, and the broader discourse on the relationship between biodiversity and human well-being.

In Gujarat, earlier investigations on odonate diversity focused primarily on riverine wetlands and specific campus ecosystems. For instance, a study carried out during 2014-15 in three riverine wetlands of the Vadodara district, where water parameters were also measured, documented eight species of odonates at one site and ten species at another, while our present study revealed a comparatively higher richness of 14 species at the surveyed site (Dholu *et al*. 2023) [12]. Similarly, butterfly diversity assessments across Gujarat have highlighted considerable variation: 32 species were reported from Bhakt Kavi Narsinh Mehta University (BKNMU), 23 species from Lalbaug, and 25 species from Junagadh Agriculture University (Vishakha H. Gohel, Jatin V. Raval 2019) [31]. Other significant contributions include the documentation of 55 butterfly species from Vadodara district in 2017, 58 species from Bharuch district in 2014, and a more recent record from Bhavnagar district in 2022 (Trivedi *et al*. 2022) [30] (Bhatt and Nagar 2017) [6] (Kumar 2014) [21].

However, it is noteworthy that most of these earlier surveys were undertaken in expansive forest tracts, designated parks, or institutional campuses, environments that naturally provide structured and resource-rich habitats. In contrast, the present study diverges from this trend by exploring the fragmented green spaces that are interspersed across the urban and rural landscapes of Gujarat. Such data, however, are crucial for understanding the broader ecological context in which species persist.

Parameters including temperature, visibility, humidity, UV index, and wind speed contribute significantly to shaping the microclimatic conditions of habitats and directly influence the activity, behaviour, and survivorship of insects (Corcos *et al*. 2018) [9] (Yu 2020) [33] (Amalero *et al*. 2003) [2]. The study indicated that the abundance of butterflies is more sensitive to the above factors than any other insect (Horák *et al*. 2021) [18]. Temperature exhibited a consistent and strong positive correlation with insect diversity across all land use types, highlighting its critical role in shaping insect communities. Similarly, wind speed showed a positive association with insect diversity, specifically in garden habitats, suggesting that moderate airflow may enhance insect activity or dispersal in such environments. Humidity was also found to significantly influence diversity in other land uses, reinforcing the importance of microclimatic conditions in supporting insect populations (Withaningsih *et al*. 2025) [32].

In the present study, most environmental parameters appeared favourable for sustaining high diversity of butterflies, dragonflies, and damselflies. However, an exceptionally high UV index (7.60) was recorded, which may exert stress on sensitive insect groups and potentially limit their abundance or diversity (Holford *et al*. 2024) [17].

Water quality analysis plays a crucial role in biodiversity assessments of odonates, as their larval stages are fully aquatic and highly sensitive to the physicochemical properties of their environment (da Silva *et al*. 2025) [10]. Parameters such as pH, dissolved oxygen, conductivity, hardness, and salinity influence the suitability of habitats for larval development and successful adult emergence. Regarding pH, acidic waters have been associated with higher abundances of several odonate species, while butterflies appear less affected by pH variations (Schell and Kerekes 1989) [26]. In our study, all three lakes exhibited slightly basic pH levels, yet supported nine species of dragonflies and eight species of damselflies. Water and air temperature also significantly impact larval survival;

temperatures between 15–30℃ are optimal, whereas extreme heat, as seen in thermal springs, often correlates with reduced odonate abundance and diversity (Fulan *et al*. 2011) [15]. Our observations of a 30℃ water temperature fall within this favourable range. Salinity and conductivity further shape species distribution, with dragonflies being more vulnerable to salinity changes than damselflies. Consistent with previous findings, we recorded a higher number of dragonfly species than damselflies (Zia *et al*. 2018) [34]. Studies show that conductivity >1200 µS severely limits species development, and values > 700 µS result in rare occurrences (Rychła *et al*. 2011) [24]. Our measured conductivity between 430-530 µS offers ideal conditions for larval growth and population stability. Additionally, total dissolved solids (TDS) values between 150–300 ppm are considered optimal for arthropods, and with levels near 300 ppm in our study, the water quality further supports a diverse insect community (Payra *et al*. 2025) [23].

In the selected area, butterflies were observed to have a higher species richness than odonates, which can be attributed to the presence of five major plant species, *Prosopis juliflora*, *Alternanthera ficoidea*, *Lantana camara*, *Dicliptera culata*, and *Tephrosia purpurea*. Among these, the first three are exotic species, while the latter two are endemic, reflecting a pattern similar to that observed in our study. A parallel example is seen in a Californian study where *Centaurea solstitialis*, once regarded as one of the state's worst invasive weeds, now plays a crucial role as a nectar source for numerous butterfly species (Graves and Shapiro 2003) [16]. These findings highlight how exotic plants, despite their invasive nature, can function as host or nectar resources, thereby contributing to the richness of lepidopteran diversity.

This study shines a spotlight on the overlooked green patches of Gujarat, small forests, lakes, fields, and wild vegetation scattered across urban and rural landscapes. Spanning areas as compact as 5–10 km, these pockets of nature harbour an extraordinary diversity and intricate life cycles that often go unnoticed. Unlike well-studied wetlands, national parks, butterfly gardens, or institutional campuses, these modest green spaces form the true backbone of regional biodiversity. By focusing on such areas, this study offers a practical and replicable model for biodiversity enthusiasts and researchers alike, encouraging them to explore and conserve the greenery right in their neighbourhoods. Every city in Gujarat holds lakes, fields, and forests teeming with life, yet research on odonates and lepidoptera remains scarce compared to studies on birds, mammals, and reptiles. Our work invites the scientific community and nature lovers to look beyond the conventional and embrace the hidden natural treasures that quietly sustain ecological balance.

Conclusion

This is the first biodiversity study conducted in Dholka, Ahmedabad. The findings highlight that green patches in both urban and rural settings hold significant potential for conserving butterflies and odonates, including dragonflies and damselflies. Such areas deserve attention alongside national parks, butterfly parks, campuses, and gardens. Future conservation policies should prioritize these wild patches to support insect diversity. Exotic plants like *Prosopis juliflora*, *Alternanthera ficoidea*, and *Lantana camara* were found to provide valuable habitats. Furthermore, environmental factors such as UV index and water quality play a key role in sustaining diversity, and efforts to improve these parameters can further enhance conservation outcomes.

References

1. Adnan NAA, Rahman AA, Kassim NFA, Seri NA. Distribution and population abundance of odonates in relation to abiotic factors in an urbanized freshwater ecosystem: a case study from Universiti Sains Malaysia. Pertanika J Sci Technol. 2025;33:1923–42. DOI:10.47836/pjst.33.4.12
2. Amalero EG, Ingua GL, Erta GB, Emanceau PL. Review article: Methods for studying root colonization by introduced. Agronomie. 2003;23:407–18.
3. Anwar T, Qureshi H, Shahzadi S, *et al*. Exploring the benefits of wild plants in dietary nutrition: investigating perspectives, choices, health impacts and sustainable practices. BMC Complement Med Ther. 2024;24:1–26. doi:10.1186/s12906-024-04379-4
4. Bašić N, Kutnar K, Marušič D, Pisanski T. ORCID iD. Ars Math Contemp. 2020;19:13.
5. Bengal W, Ghorai N. Seasonal dynamics of odonate (Insecta: Odonata) species diversity and abundance in. Cuad Biodivers. 2025;68:18–29. doi:10.14198/cdbio.27683
6. Bhatt UM, Nagar PS. Diversity of butterflies in an arboretum of Vadodara, Gujarat, India. Check List, 2017, 13. doi:10.15560/13.2.2073
7. Chowdhury S, Jennions MD, Zalucki MP, *et al*. Protected areas and the future of insect conservation. Trends Ecol Evol. 2023;38:85–95. doi:10.1016/j.tree.2022.09.004
8. Cleary DFR, Mooers AØ, Eichhorn KAO, *et al*. Diversity and community composition of butterflies and odonates in an ENSO-induced fire affected habitat mosaic: a case study from East Kalimantan, Indonesia, 2018, 2.
9. Corcos D, Cerretti P, Mei M, *et al*. Predator and parasitoid insects along elevational gradients: role of temperature and habitat diversity. Oecologia. 2018;188:193–202. doi:10.1007/s00442-018-4169-4
10. da Silva EC, de Azevedo K de FS, de Carvalho FG, *et al*. Impacts of oil palm monocultures on freshwater ecosystems in the Amazon: a case study of dragonflies and damselflies (Insecta: Odonata). Aquat Sci, 2025, 87. doi:10.1007/s00027-024-01126-2
11. Delpon G, Vogt-Schilb H, Munoz F, *et al*. Diachronic variations in the distribution of butterflies and dragonflies linked to recent habitat changes in Western Europe. Insect Conserv Divers. 2019;12:49–68. doi:10.1111/icad.12309
12. Dholu S, Rathod DM, Parasharya BM. Odonate diversity reflected by wetland quality in Gujarat, India. J Biol Control. 2023;37:123–30. doi:10.18311/jbc/2023/34797

13. Dolai S. Diversity and abundance of odonates (dragonflies and damselflies) and lepidopteran (butterflies) fauna of Kalyani Lake Park, Nadia district, West, 2023.
14. Ehrlich PR, Raven PH. Butterflies and plants: a study in coevolution. Evolution. 1964;18:586–608.
15. Fulan JÂ, Henry R, Davanso RCS. Efeitos das mudanças diárias dos fatores ambientais sobre a abundância e a riqueza de Odonata. Acta Limnol Bras. 2011;23:23–9. doi:10.4322/actalb.2011.015
16. Graves SD, Shapiro AM. Exotics as host plants of the California butterfly fauna. Biol Conserv. 2003;110:413–33. doi:10.1016/S0006-3207(02)00233-1
17. Holford P, Parajuli S, Beattie GAC, Cen Y. Arthropods and ultraviolet radiation: survival, growth and development. Ecol Entomol. 2024;49:451–62.
18. Horák J, Rada P, Lettenmaier L, *et al*. Importance of meteorological and land use parameters for insect diversity in agricultural landscapes. Sci Total Environ. 2021;791:148159. doi:10.1016/j.scitotenv.2021.148159
19. Johansson F, Suhling F. Behaviour and growth of dragonfly larvae along a permanent to temporary water habitat gradient. Ecol Entomol. 2004;29:196–202. doi:10.1111/j.0307-6946.2004.00592.x
20. Karlsson B, Wiklund C. Butterfly life history and temperature adaptations; dry open habitats select for increased fecundity and longevity. J Anim Ecol. 2005;74:99–104. doi:10.1111/j.1365-2656.2004.00902.x
21. Kumar A. Butterfly (Lepidoptera: Insecta) diversity from different sites of Jhagadia, Ankleshwar, District-Bharuch, Gujarat. Octa J Environ Res. 2014;1:9–18.
22. Lewinsohn TM, Neto MA, Almeida A, *et al*. From insect-plant interactions to ecological networks. Biota Neotrop. 2022;22:1–15. doi:10.1590/1676-0611-BN-2022-1399
23. Payra P, Bhanja A, Kandar P. Diversity and composition of aquatic insects in three perennial rural ponds of Ramnagar-I Block, East Midnapore, West Bengal, India. Int J Ecol Environ Sci. 2025;51:297–309. doi:10.55863/ijees.2025.0619
24. Rychła A, Benndorf J, Buczyński P. Impact of pH and conductivity on species richness and community structure of dragonflies (Odonata) in small mining lakes. Fundam Appl Limnol. 2011;179:41–50. doi:10.1127/1863-9135/2011/0179-0041
25. Sarkar S, Shaw R, Chakrabarty M. Comparative assessment of butterfly species in Durgapur City: a case study. Holist Approach to Environ. 2025;15:104–13. doi:10.33765/thate.15.3.2
26. Schell VA, Kerekes JJ. Distribution, abundance and biomass of benthic macroinvertebrates relative to pH and nutrients in eight lakes of Nova Scotia, Canada. Water Air Soil Pollut. 1989;46:359–74. doi:10.1007/BF00192870
27. Singh P, Müller C. Pharmacophagy in insects: ecological and evolutionary perspectives on the non-nutritional use of plant specialized metabolites. Entomol Exp Appl. 2025;173:661–73. doi:10.1111/eea.13586
28. Singleton F. The Beaufort scale of winds: its relevance, and its use by sailors. Weather. 2008;63:37–41. doi:10.1002/wea.153
29. Thomas JA. Monitoring change in the abundance and distribution of insects using butterflies and other indicator groups. Philos Trans R Soc Lond B Biol Sci. 2005;360:339–57. doi:10.1098/rstb.2004.1585
30. Trivedi D, Makwana VM, Shukla AH, Dodia PP. Diversity of butterflies in Victoria Park Reserve Forest, Bhavnagar, Gujarat, India. Not Sci Biol. 2022;14:1–13. doi:10.55779/nsb14311293
31. Gohel VH, Raval JV. Butterfly diversity, seasonality and status at Junagadh, Gujarat, India. Int J Environ Ecol Fam Urban Stud. 2019;9:15–28. doi:10.24247/ijeefusapr20192
32. Withaningsih S, Ilmi BF, Parikesit P. Correlation between flying insect diversity and environmental factors in various land use types in Paseh District, Sumedang Regency, West Java. Diversity, 2025, 17. doi:10.3390/d17010002
33. Yu H-S. Effects of environmental factors on the endocrine system. In: Handbook of Endocrinology, 2020, 43–68. doi:10.1201/9780367811440-2
34. Zia A, Azam I, Munir A, Afsheen S. Effect of salinity gradients on species composition of Odonata naiads. 2018;7:11–25.