



Butterfly Diversity of Navsari Agricultural University (NAU), Navsari, Gujarat, India

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Authors' contributions

This work was carried out in collaboration among all authors. Author SM designed and conducted the study, performed the statistical analysis, wrote the first draft of the manuscript. Author MP conducted study and survey and author BD proof read the manuscript and finalized the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The first systematic attempt to assess and document the butterfly richness on the lush green campus of Navsari Agricultural University (NAU) campus.

Place and Duration of Study: The study was conducted at the Navsari Agricultural University (NAU) and was performed from September 2020 to December 2022.

Methodology: The opportunistic surveys were conducted on a monthly basis in the different pre-determined existing paths on the campus. Butterflies were sited, identified, and photographed during the surveys. The Identification of the species was carried out using field books and later

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confirmed by photographs taken during each survey referencing different available literature and online databases. The species identified were listed and classified into respective families.

Results: A total of 83 butterfly species belonging to 5 families were recorded at Navsari Agricultural University (NAU), Navsari, Gujarat between September 2020 to December 2022. 13 butterfly species recorded are protected under scheduled categories of Wildlife protection act, 1972, while 4 species listed under the IUCN red list viz. *Euploea core* under the Least concerned category, *Hypolimnas misippus* under the Least concerned category, *Junonia almana* under the Least concerned category, and *Castalius rosimon* under the vulnerable category were recorded. The Navsari Agricultural University campus hosts a wide variety of plant species, providing essential food and egg-laying sites for butterflies, which in turn plays a crucial role in determining the diversity and abundance of butterfly species found in the area.

Conclusion: From this study, it is evident that Navsari Agricultural University (NAU), Navsari, Gujarat has a diverse butterfly fauna.

Keywords: *Lepidoptera*; red list; host plant; Campus; urban landscapes; Butterfly's diversity; Papilionidae.

1. INTRODUCTION

Butterflies are scaly winged insect of order Lepidoptera along with skippers and moths [1]. India harbors 1,501 butterfly species, out of which 334 species are distributed in Western Ghats [2,3]. Rich local flora influences the butterfly larval host relationship [4].

Urban green spaces play a crucial role in combating the negative influence of urbanization on local biodiversity. They are often found in small, fragmented patches like urban parks, Gardens and educational institutes, Agricultural universities, etc., that may be somehow isolated [5] and [6]. Navsari districts of the southern Gujarat region falls under the northern tip of the Western Ghats with few studied on butterflies.

Recently quite a few studies were conducted in urban and semi-urban landscapes of India and Gujarat [7-19], including in gardens, universities campuses, and urban parks. In the southern Gujarat region, butterfly diversity has been recorded in Ankleshwar [20] and Vansda [21]. However, there was no specific work reported in urban landscapes of Navsari district. This is the first systematic attempt to assess and document the butterfly richness on the lush green campus of Navsari Agricultural University (NAU) campus.

This study represents the first systematic effort to assess and document butterfly species richness on the Navsari Agricultural University (NAU) campus. By providing a detailed inventory of butterfly diversity in this green urban space, the research not only contributes to the broader understanding of Lepidoptera in the Western Ghats but also highlights the significance of

conserving such habitats. The findings could have important implications for local biodiversity conservation efforts, especially in urbanized regions where natural habitats are increasingly fragmented. Understanding the diversity and distribution of butterflies in these areas is crucial for developing conservation strategies that ensure the sustainability of these species and their habitats.

2. MATERIALS AND METHODS

2.1 Study Area

The Butterfly's diversity at the Navsari Agricultural University (NAU) was assessed from September 2020 to December 2022. The university (Lat-20.924660°, Long-72.907953°) sprawls over 3.45 km² in the Navsari district in Gujarat. The area's climate is generally humid and warm, receiving about 1500 mm of rainfall during the monsoon season (June-September). Winters (November-February) are moderately cold, while summers (March-May) are fairly hot and humid [22]. The general habitat of Navsari Agricultural University in South Gujarat is represented by a notable presence of dry and moist deciduous forests within the region [23]. This area comes under a heavy rainfall zone northernmost part of the Western Ghats. The unique location of the university allows the diversity of the different species to thrive well.

2.2 Survey Methods

The opportunistic surveys were conducted on a monthly basis using different pre-determined and existing paths on the campus [24]. Butterflies

were sighted, identified, and photographed during the surveys using the digital cameras (Canon EOS 3000D and Nikon D7200). The Identification of the species was carried out using field books and later confirmed by photographs taken during the surveys referencing different available literature traditional and online [25-29] and Evans, [2]. The species identified were listed and classified into respective families. Occasional rare sightings were also considered while preparing the final checklist. Their status was determined according to the number of sightings during the surveys (Priyamvada and Mohapatra, [16]). Butterflies were also classified under the schedule list of India's Wildlife Protection Act, 1972 (Anon., 2006) for a better understanding of conservation strategies.

3. RESULTS AND DISCUSSION

A total of 83 butterfly species belonging to 5 families, namely, Hesperidae (6 species), Papilionidae (6 species), Peiridae (20 species), Lycaenidae (23 species), and Nymphalidae (28

species) were documented during the study period (Table 1, Plates 1, 2, 3 and 4). A total of 12 butterfly species are protected under scheduled categories of The Wild Life (Protection) Amendment act, 2022, i.e. *Castalius rosimon rosimon* (fabricius, 1775) and *Danaus genutia genutia* (cramer, [1779]) are under schedule-i, *Hypolimnas misippus* (linnaeus, 1764) under schedule i as well as ii, *Anthene lycaenina lycaenina* (r. Felder, 1868), *Cepora nerissa phryne* (fabricius, 1775), *Charaxes solon solon* (fabricius, 1793), *Euchrysops cnejus cnejus* (fabricius, 1798), *Euthalia aconthea meridionalis* (fruhstorfer, 1906), *Kallima horsfieldii* (kollar, 1844), *Prosotas nora ardates* (moore, 1875), *Spindasis elima elima* (moore, 1877), under schedule ii and *Appias libythea* (fabricius, 1775) is under schedule iv of WPA 1972 (anon., 2006). Ecological inventories are important to maintain baseline data for future research to evaluate the shifts in species composition due to urbanization or other anthropogenic pressure [30-34].

Table 1. List of butterfly species of Navsari Agricultural University, Navsari, Gujarat

No.#	Zoological Name	Common Name	WPA Status	Status*
Family: Nymphalidae				
1	<i>Symphaedra nais</i> (Forster, 1771)	Baronet	NA	UC
2	<i>Junonia lemonias lemonias</i> (Linnaeus, 1758)	Chinese Lemon Pansy	NA	VC
3	<i>Ypthima huebneri</i> (Kirby, 1871)	Common Four-ring	NA	C
4	<i>Parantica aglea aglea</i> (Stoll, 1782)	Coromandel Glassy Tiger	NA	UC
5	<i>Euthalia aconthea meridionalis</i> (Fruhstorfer, 1906)	Dakhan Common Baron	Sched II	R
6	<i>Mycalesis perseus tabitha</i> (Fabricius, 1793)	Dakhan Common Bush brown	NA	C
7	<i>Ariadne merione merione</i> (Cramer, 1777)	Dakhan Common Castor	NA	R
8	<i>Hypolimnas misippus</i> (Linnaeus, 1764)	Danaid Eggfly	Sched I & II	VC
9	<i>Elymnias hypermnestra undularis</i> (Drury, 1773)	Himalayan Common Palmfly	NA	R
10	<i>Euploea core core</i> (Cramer, 1780)	Indian Common Crow	NA	VC
11	<i>Neptis hylas varmona</i> (Moore, 1872)	Indian Common Sailer	NA	C
12	<i>Tirumala limniace exoticus</i> (Gmelin, 1790)	Oriental Blue Tiger	NA	R
13	<i>Junonia iphita iphita</i> (Cramer, 1779)	Oriental Chocolate Pansy	NA	VC
14	<i>Moduza procris procris</i> (Cramer, 1777)	Oriental Commander	NA	UC
15	<i>Melanitis leda leda</i> (Linnaeus, 1758)	Oriental Common Evening Brown	NA	C
16	<i>Phalanta phalantha phalantha</i> (Drury, 1773)	Oriental Common Leopard	NA	C
17	<i>Hypolimnas bolina jacintha</i> (Drury, 1773)	Oriental Great Eggfly	NA	VC
18	<i>Junonia atlites atlites</i> (Linnaeus, 1763)	Oriental Grey Pansy	NA	VC
19	<i>Junonia almana almana</i> (Linnaeus, 1758)	Oriental Peacock Pansy	NA	VC
20	<i>Danaus chrysippus chrysippus</i> (Linnaeus, 1758)	Oriental Plain Tiger	NA	VC
21	<i>Danaus genutia genutia</i> (Cramer, [1779])	Oriental Striped Tiger	Sched I	VC
22	<i>Junonia hierta hierta</i> (Fabricius, 1798)	Oriental Yellow Pansy	NA	R
23	<i>Vanessa cardui</i> (Linnaeus, 1758)	Painted Lady	NA	R
24	<i>Charaxes solon solon</i> (Fabricius, 1793)	Pale Black Rajah	Sched II	R
25	<i>Junonia orithya</i> (Linnaeus, 1758)	Pale Blue Pansy	NA	UC
26	<i>Kallima horsfieldii</i> (Kollar, 1844)	Sahyadri Blue Oakleaf	Sched II	R
27	<i>Libythea myrrha rama</i> (Moore, 1872)	Sri Lankan Club Beak	NA	R
28	<i>Acraea terpsicore</i> (Linnaeus, 1758)	Tawny Coster	NA	VC
Family: Lycaenidae				
29	<i>Leptotes plinius plinius</i> (Fabricius, 1793)	Asian Zebra Blue	NA	VC
30	<i>Nacaduba beroe gythion</i> (Fruhstorfer, 1916)	Assam Opaque Six-Lineblue	NA	UC
31	<i>Castalius rosimon rosimon</i> (Fabricius, 1775)	Continental Common Pierrot	Sched I	VC
32	<i>Everes lacturnus syntala</i> (Cantlie, 1963)	Dakhan Orange-crowned Cupid	NA	VC
33	<i>Anthene lycaenina lycaenina</i> (R. Felder, 1868)	Dakhan Pointed Ciliate Blue	Sched II	VC
34	<i>Prosotas nora ardates</i> (Moore, 1875)	Indian Common Lineblue	Sched II	VC

No.#	Zoological Name	Common Name	WPA Status	Status*
35	<i>Spindasis ictis ictis</i> (Hewitson, 1865)	Indian Common Shot Silverline	NA	R
36	<i>Spindasis vulcanus vulcanus</i> (Fabricius, 1775)	Indian Common Silverline	NA	R
37	<i>Jamides bochus bochus</i> (Stoll, 1782)	Indian Dark Cerulean	NA	R
38	<i>Zizina otis indica</i> (Murray, 1874)	Indian lesser grass blue	NA	VC
39	<i>Chilades lajus lajus</i> (Stoll, 1780)	Indian Lime Blue	NA	C
40	<i>Talicauda nyseus nyseus</i> (Guérin-Méneville, 1843)	Indian Red Pierrot	NA	UC
41	<i>Spindasis elima elima</i> (Moore, 1877)	Indian Scarce Shot Silverline	Sched II	R
42	<i>Curetis thetis</i> (Drury, 1773)	Indian Sunbeam	NA	R
43	<i>Zizula hylax hylax</i> (Fabricius, 1775)	Indian Tiny Grass Blue	NA	UC
44	<i>Arhopala amantes amantes</i> (Hewitson, 1862)	Lankan Large Oakblue	NA	R
45	<i>Jamides celeno celeno</i> (Cramer, 1775)	Oriental Common cerulean	NA	C
46	<i>Catochrysops strabo strabo</i> (Fabricius, 1793)	Oriental Forget-me-not	NA	VC
47	<i>Euchrysops cnejus cnejus</i> (Fabricius, 1798)	Oriental Gram Blue	Sched II	VC
48	<i>Zizina otis otis</i> (Fabricius, 1787)	Oriental Lesser Grass Blue	NA	UC
49	<i>Chilades pandava pandava</i> (Horsfield, 1829)	Oriental Plains Cupid	NA	VC
50	<i>Lampides boeticus</i> (Linnaeus, 1767)	Pea Blue	NA	VC
51	<i>Virachola perse ghela</i> (Fruhstorfer, 1912)	Tamil Large Guava Blue	NA	UC
Family: Peiridae				
52	<i>Cepora nerissa phryne</i> (Fabricius, 1775)	Dakhan Common Gull	Sched II	UC
53	<i>Colotis fausta fulvia</i> (Wallace, 1867)	Dakhan Large Salmon Arab	NA	UC
54	<i>Ixias pyrene sesia</i> (Fabricius, 1777)	Dakhan Yellow Orange-tip	NA	VC
55	<i>Colotis amata amata</i> (Fabricius, 1775)	Desert Small Salmon Arab	NA	UC
56	<i>Colotis danae danae</i> (Fabricius, 1775)	Indian Crimson-tip	NA	R
57	<i>Delias eucharis</i> (Drury, 1773)	Indian Jezebel	NA	VC
58	<i>Colotis etrida etrida</i> (Boisduval, 1836)	Indian Little Orange-tip	NA	VC
59	<i>Belenois aurota aurota</i> (Fabricius, 1793)	Indian Pioneer	NA	VC
60	<i>Eurema laeta laeta</i> (Boisduval, 1836)	Indian Spotless Grass Yellow	NA	VC
61	<i>Paretonia hippia</i> (Fabricius, 1787)	Indian Wanderer	NA	VC
62	<i>Eurema hecabe hecabe</i> (Linnaeus, 1758)	Oriental Common Grass Yellow	NA	VC
63	<i>Catopsilia pomona pomona</i> (Fabricius, 1775)	Oriental Lemon Emigrant	NA	VC
64	<i>Catopsilia pyranthe pyranthe</i> (Linnaeus, 1758)	Oriental Mottled Emigrant	NA	VC
65	<i>Leptosia nina nina</i> (Fabricius, 1793)	Oriental Psyche	NA	C
66	<i>Colotis aurora</i> (Cramer, 1780)	Plain Orange Tip	NA	VC
67	<i>Eurema brigitta rubella</i> (Wallace, 1867)	Red-line Small Grass Yellow	NA	C
68	<i>Eurema andersonii shimai</i> (Yata & Gaonkar, 1999)	Sahyadri One-spot Grass Yellow	NA	C
69	<i>Eurema blanda silhetana</i> (Wallace, 1867)	Sylhet Three-spot Grass Yellow	NA	C
70	<i>Appias libythea</i> (Fabricius, 1775)	Western Striped Albatross	Sched IV	C
71	<i>Ixias marianne</i> (Cramer, 1779)	White Orange-tip	NA	C
Family: Hesperidae				
72	<i>Matapa aria</i> (Moore, 1866)	Common Branded Redeye	NA	R
73	<i>Udaspes folus</i> (Cramer, 1775)	Grass Demon	NA	R
74	<i>Spialia galba galba</i> (Fabricius, 1793)	Indian Grizzled Skipper	NA	VC
75	<i>Suastus gremius gremius</i> (Fabricius, 1798)	Indian Palm Bob	NA	VC
76	<i>Telicota bambusae bambusae</i> (Moore, 1878)	Oriental Dark Palm-Dart	NA	UC
77	<i>Borbo cinnara</i> (Wallace, 1866)	Rice Swift	NA	VC
Family: Papilionidae				
78	<i>Graphium doson eleius</i> (Fruhstorfer, 1907)	Dakhan Common Jay	NA	C
79	<i>Graphium agamemnon menides</i> (Fruhstorfer, 1904)	Dakhan Tailed Jay	NA	UC
80	<i>Papilio polytes romulus</i> (Cramer, 1775)	Indian Common Mormon	NA	VC
81	<i>Graphium nomius nomius</i> (Esper, 1799)	Indian spot Swordtail	NA	R
82	<i>Papilio demoleus demoleus</i> (Linnaeus, 1758)	Northern Lime Swallowtail.	NA	VC
83	<i>Graphium sarpedon sarpedon</i> (Linnaeus, 1758)	Oriental Common Bluebottle	NA	R

serial number corresponds with the figure numbers of plate for individual species, *VC-Very Common (≥ 50 individuals), C-Common (30-50 individuals), UC-Uncommon (5-30 individuals), R-Rare (≤ 5 individuals); WPA- The wild life (protection) amendment act, 2022.)

In the surveyed area, as per the IUCN threat category 4 species are listed under the red list viz. *Euploea core*, *Hypolimnas misippus*, and *Junonia almana* are under the Least Concerned category, and *Castalius rosimon* under the Vulnerable category. As per the sightings of the butterflies, 42% were very common (35), 17% common (14), 17% uncommon (14), and 24% were categorized rare (20) in the Navsari Agricultural University. *Graphium nomius* a

summer visitor in Gujarat is also found in NAU. Total of 45 species of butterflies has been reported from the Regional Institute of Education campus, Bhubaneswar [16]. Despite being located at the northern tip of the Western Ghats, Navsari Agricultural University is not situated near any forested areas. Nevertheless, it supports an impressive diversity of butterfly species, with 83 different species recorded within its relatively small area. This stands in stark

contrast to the findings of Rai and Chaudhary [35-40], who documented only 27 butterfly species in the Hastinapur Wildlife Sanctuary. The comparison highlights that, despite its limited size and lack of proximity to forests, Navsari Agricultural University demonstrates a remarkable potential to sustain a significantly

higher diversity of butterflies. This suggests that certain factors within the university's environment, such as the availability of diverse plant species and suitable habitats, may be playing a crucial role in supporting this rich butterfly biodiversity.

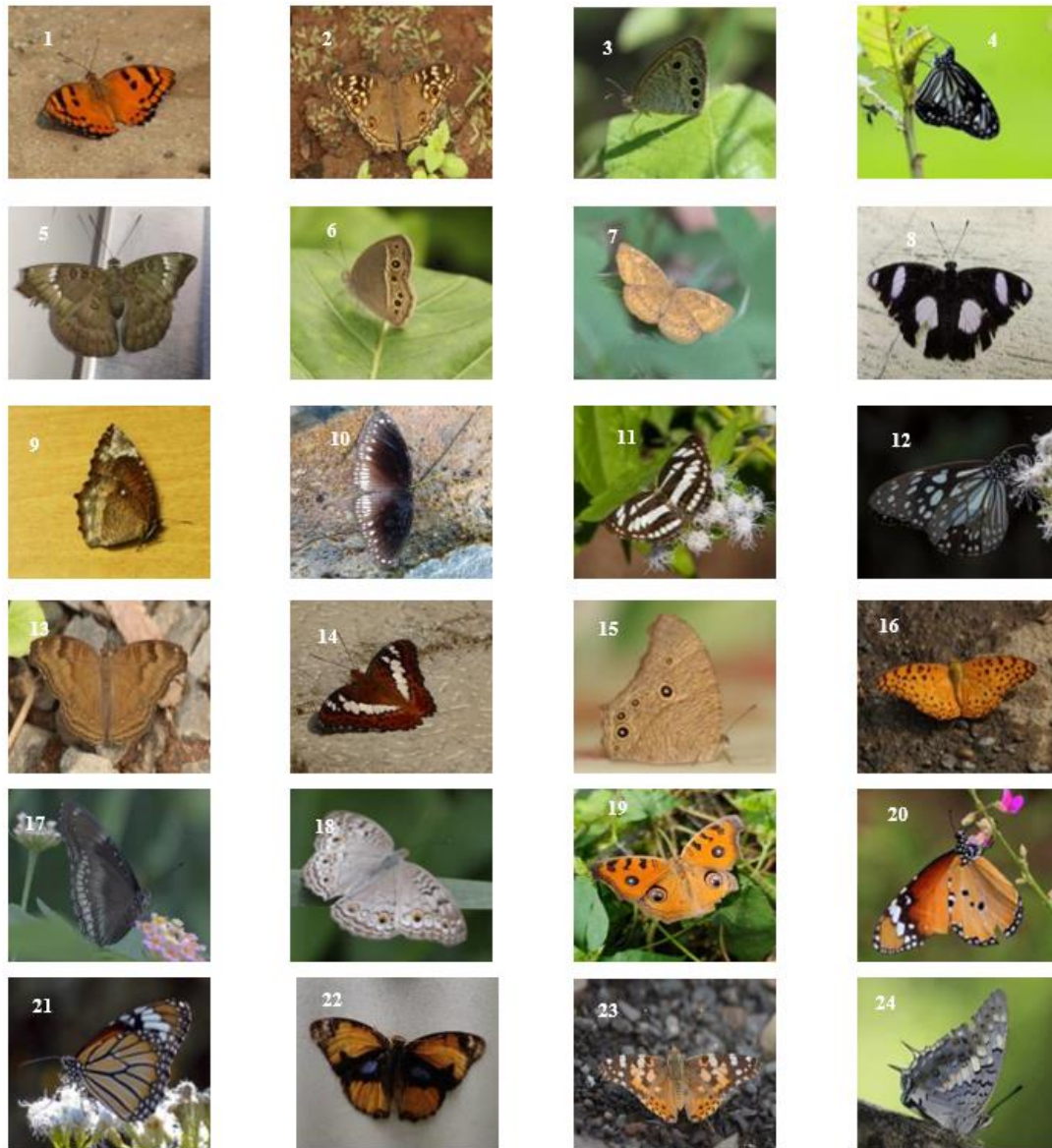


Plate 1 (Fig. 1-24.) Butterflies of the Navsari Agricultural University

1. *Symphaedra nais*, 2. *Junonia lemonias lemonias*, 3. *Ypthima huebneri*, 4. *Parantica aglea aglea*, 5. *Euthalia aconthea meridionalis*, 6. *Mycalesis perseus tabitha*, 7. *Ariadne merione merione*, 8. *Hypolimnas misippus*, 9. *Elymnias hypermnestra undularis*, 10. *Euploea core core*, 11. *Neptis hylas varmona*, 12. *Tirumala limniace exoticus*, 13. *Junonia iphita iphita*, 14. *Moduza procris procris*, 15. *Melanitis leda leda*, 16. *Phalanta phalantha phalantha*, 17. *Hypolimnas bolina jacintha*, 18. *Junonia atlites atlites*, 19. *Junonia almana almanac*, 20. *Danaus chrysippus chrysippus*, 21. *Danaus genutia genutia*, 22. *Junonia hierta hierta*, 23. *Vanessa cardui*, 24. *Charaxes solon solon*

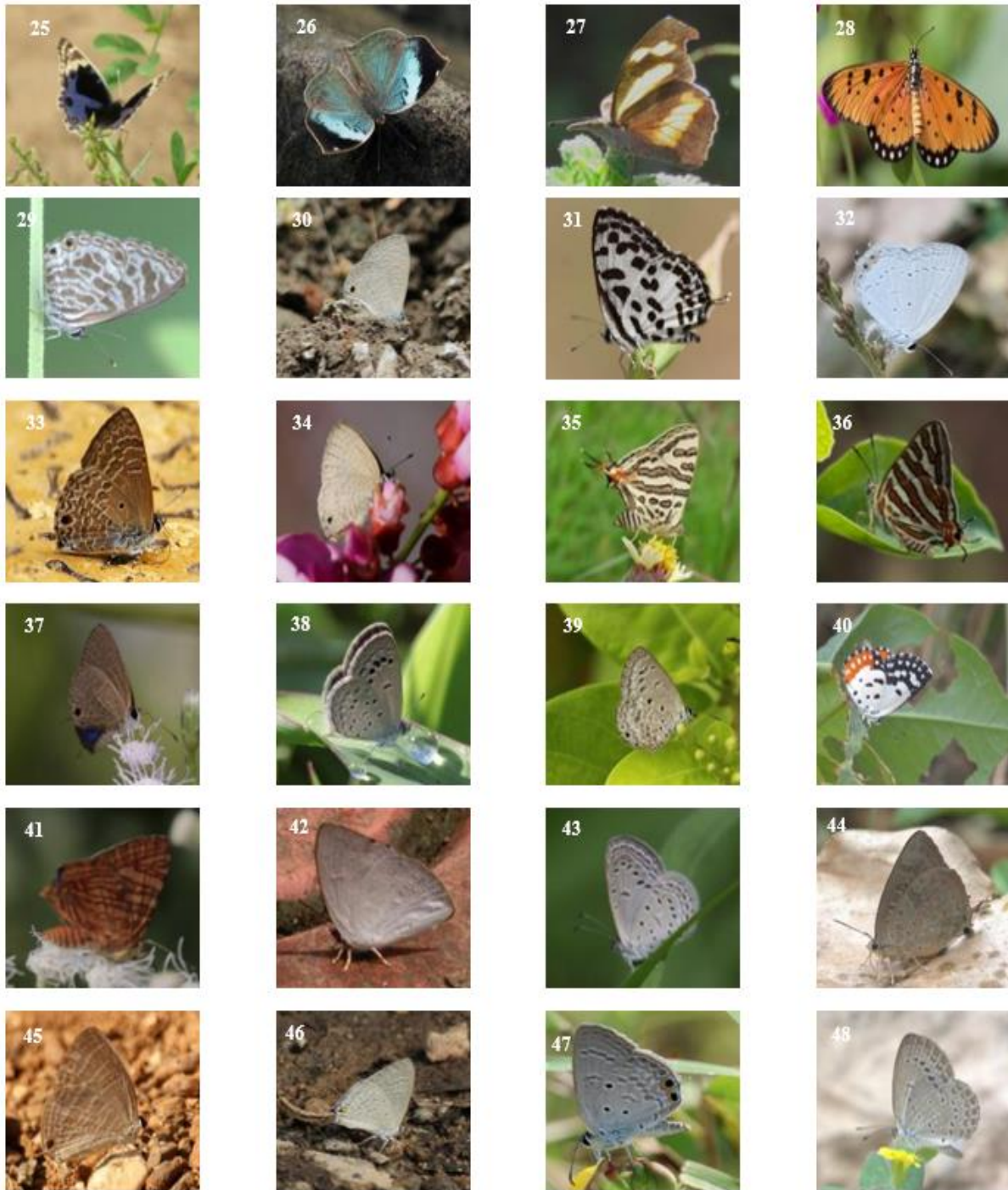


Plate 2 (Fig. 25-48.) Butterflies of the Navsari Agricultural University

25. *Junonia orithya*, 26. *Kallima horsfieldii*, 27. *Libythea myrrha rama*, 28. *Acraea terpsicore*, 29. *Leptotes plinius plinius*, 30. *Nacaduba beroe gythion*, 31. *Castalius rosimon rosimon*, 32. *Everes lacturnus syntala*, 33. *Anthene lycaenina lycaenina*, 34. *Prosotas nora airdates*, 35. *Spindasis ictis ictis*, 36. *Spindasis vulcanus vulcanus*, 37. *Jamides bochus bochus*, 38. *Zizina otis indica*, 39. *Chilades lajus lajus*, 40. *Talicauda nyseus nyseus*, 41. *Spindasis elima elima*, 42. *Curetis thetis*, 43. *Zizula hylax hylax*, 44. *Arhopala amantes amantes*, 45. *Jamides celeno celeno*, 46. *Catochrysops strabo Strabo*, 47. *Euchrysops cnejus cnejus*, 48. *Zizina otis otis*

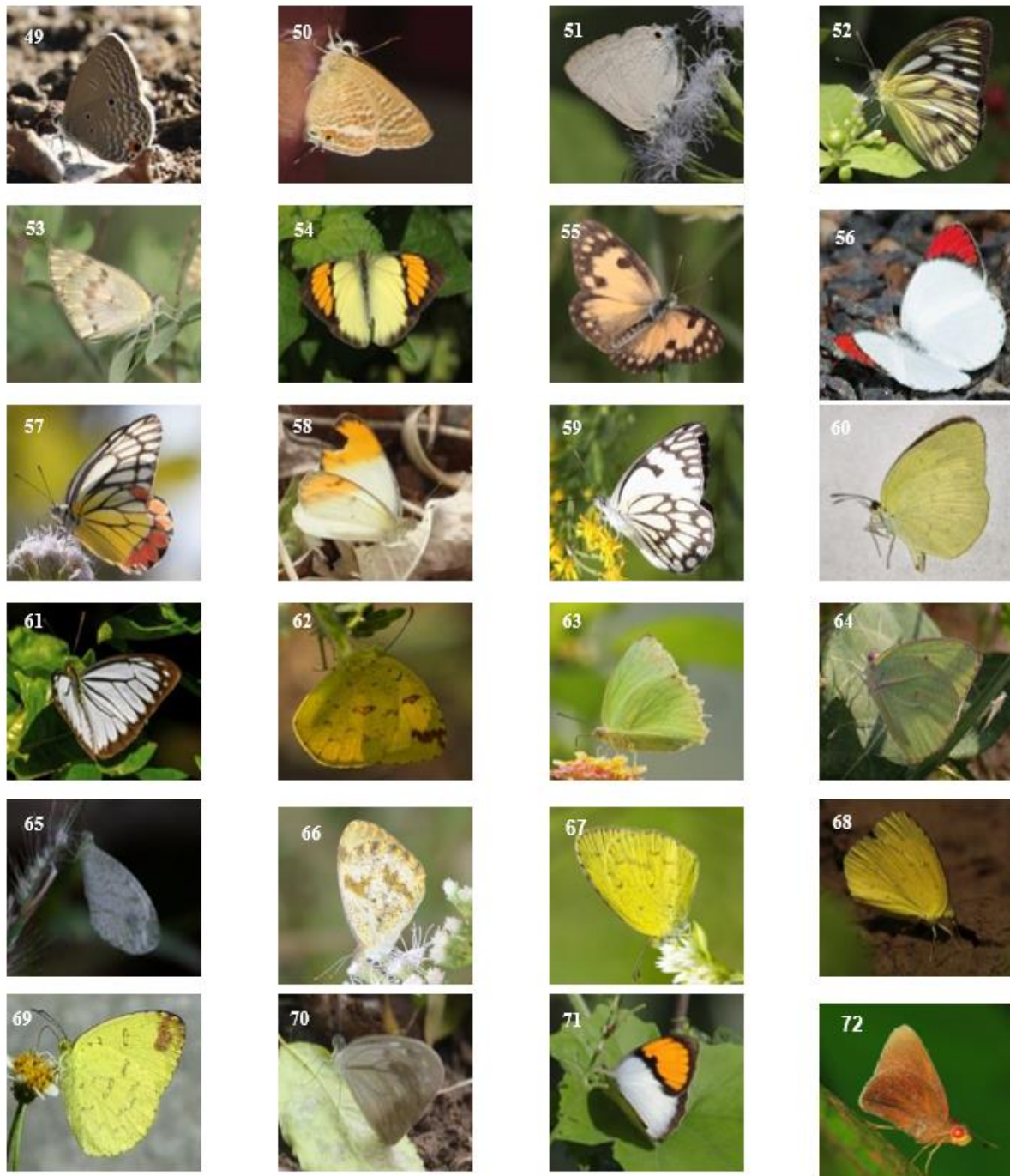


Plate 3 (Fig. 49-72.) Butterflies of the Navsari Agricultural University

49. *Chilades pandava pandava*, 50. *Lampides boeticus*, 51. *Virachola perse ghela*, 52. *Cepora nerissa phryne*, 53. *Colotis fausta fulvia*, 54. *Ixias pyrene sesia*, 55. *Colotis amata amata*, 56. *Colotis danae danae* (Photo not captured), 57. *Delias eucharis*, 58. *Colotis etrida etrida*, 59. *Belenois aurota aurota*, 60. *Eurema laeta laeta*, 61. *Pareronia hippia*, 62. *Eurema hecabe hecabe*, 63. *Catopsilia pomona pomona*, 64. *Catopsilia pyranthe pyranthe*, 65. *Leptosia nina nina*, 66. *Colotis aurora* (Photo not captured), 67. *Eurema brigitta rubella* (Photo not captured), 68. *Eurema andersonii shimai*, 69. *Eurema blanda silhetana*, 70. *Appias libythea*, 71. *Ixias marianne*, 72. *Matapa aria*

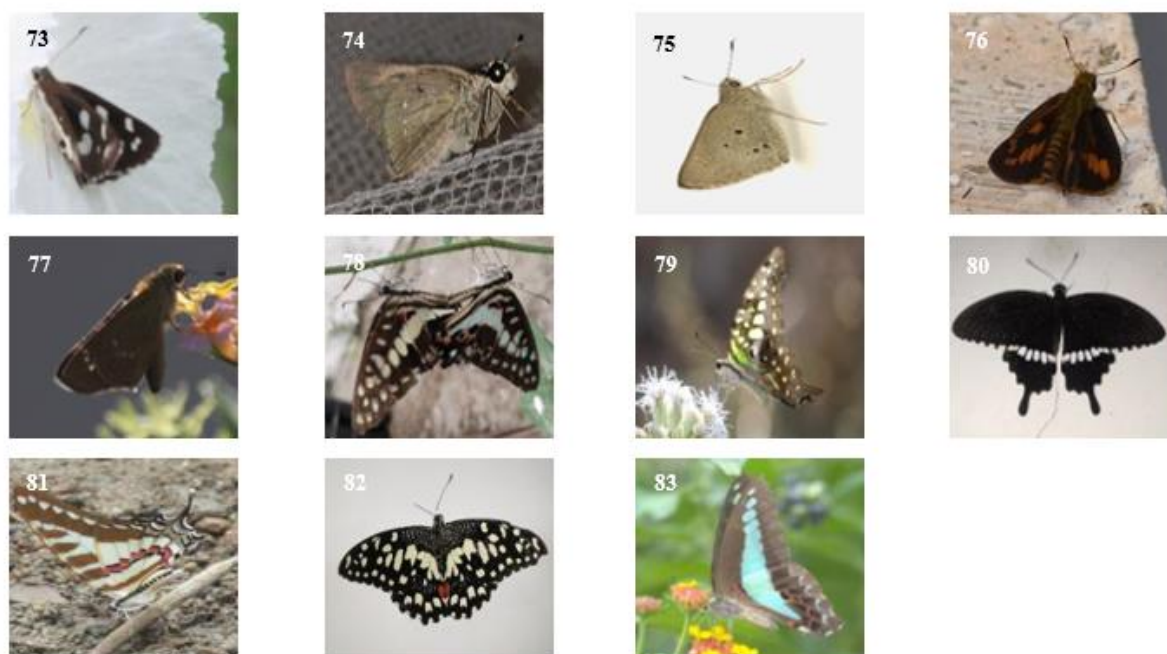


Plate 4 (Fig. 73-83.) Butterflies of the Navsari Agricultural University

73. *Udaspes folus*, 74. *Spialia galba galba*, 75. *Suastus gremius gremius*, 76. *Telicota bambusae bambusae*, 77. *Borbo cinnara*, 78. *Graphium doson eleius*, 79. *Graphium agamemnon menides*, 80. *Papilio polytes romulus*, 81. *Graphium nomius nomius*, 82. *Papilio demoleus demoleus*, 83. *Graphium sarpedon sarpedon*

4. CONCLUSION

The urban greenscape of Agricultural University forms a manmade modified habitat that helps restore the native diversity of butterflies with limited resources. Our study shows that a considerable plant diversity plays a significant role in maintaining the diversity of the butterflies [41]. It is evident that Navsari Agricultural University (NAU), Navsari, Gujarat has a diverse butterfly fauna.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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