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## Taxonomic Inventory and Ecological Guild Composition of Insect Fauna in the Agroecosystems of Baraut, Uttar Pradesh, India

Sonia Dhama<sup>1</sup>, Malti\*<sup>1</sup> and Lavi Sharma<sup>1</sup>

<sup>1</sup>Department of Zoology, Janta Vedic College, Baraut (Baghpat), Affiliated to Chaudhary Charan Singh University, Meerut, Uttar Pradesh, India

\* Corresponding author. E-mail- [maltitomar@gmail.com](mailto:maltitomar@gmail.com)

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### ABSTRACT

Describing the taxonomic composition and functional composition of insect communities in heavily modified agricultural landscapes is useful for bioindicators and conservation purposes. We created a baseline of the insect community across the agricultural and semi-urban parts of the Baraut region of Western Uttar Pradesh, India. Non-destructive sampling during diurnal and nocturnal foraging survey periods was undertaken using standard arthropod collecting methods in crops, field edges, leaf litter and synanthropic surfaces. Morphological identification resulted in 27 species belonging to 10 orders and 23 families. Order wise composition revealed a clear predominance of Coleoptera, followed then closely by Hemiptera & Hymenoptera with Carabidae being the most diverse family. Analyzing along functional feeding groups, the recorded taxa belong to Phytophages, Predators, Saprophages and Pollinators and suggest a somewhat balanced trophic representation and a functional biological pest mitigation system comprised primarily of native taxa. The survey noted the local naturalization and active foraging behavior by *Perillus cf. bioculatus* which suggests dynamic reorganizations of local food webs. Calculated diversity indices indicate moderate to high taxonomic diversity and thus ecological strength despite pressures from expansion of mono-cultures and chemical management in the region. Our field-documented baseline profile will be important for agronomic integrated pest management, native pollinator conservation and environmental monitoring across the Upper Gangetic Plains.

### Introduction

The Insecta, in terms of taxonomic diversity and ecological traits, is the most diverse and dominant metazoan group on the terrestrial stage. They perform key ecological roles that directly sustain crucial ecosystem services such as underlining critical ecosystem functions that sustain planetary cycling of resources (Wilson, 1987). Across dynamic landscapes, they are major macro-decomposers, specialised pollinators of key angiosperms, recyclers of nutrients, and important food web links (Losey & Vaughan, 2006; Yang & Gratton, 2014). In the input region of agricultural districts, the structure of insect community balances the provision of critical ecosystem services such as biological control of pests by predator guilds versus economic loss (Landis *et al.*, 2000). Because of their sensitivity to climatic changes on a micro-environmental scale, ainsurgence of pesticides, and localised loss of structure (hostplants), insect populations present better morphological records of the health of the macro environment in general, and suit themselves well for high impact assessments (McGeoch, 1998). In the Indian context, the Gangetic Plain is one of the world's most fertile agricultural zones, facing heavy land use changes driven by increased rural-urban land conversion, and chemical management practices in the agricultural and peri-urban zones. While, generic checklists of Indian insect fauna are well-known at the macro-level, systematic, field-validated accounts of the insect fauna of localised patches of habitat are scarce, especially in transitional districts such as Baghpat and Baraut locale, Western Uttar Pradesh. Their insect fauna, especially, of the tiny patches within larger agricultural zones remain largely unpunished, with a tendency to ignore the emergent population of naturalised bio control agents from exotic origins cropping into our fields. Ground-level taxonomy to the correct level

of Order and Family (Triplehorn & Johnson, 2005) is requisite to proper inventorying of baselines."This gives the necessary fundamentals to interpret the ecological health, ordinal richness and guild composition of a local ecosystems" (Samways, 2005) Agroecosystems of Baghpat reveal a patchwork composition of crop fields mainly saccharum (*Saccharum officinarum*), fodder grasses, legumes, medicines Ashwagandha (*Withania somnifera*) adjoined by semi-urban anthro-populaces, extinct croplands, and  $\beta$ -roadside presence of weeds. A configured biodiversity assemblage of focus orders survive within this propitious environment. Ecologically successful radiations, Coleoptera (ground beetles, darkling beetles, ladybirds) and Hemiptera (truebugs), jointly reign in vegetative and ground strata, concurrently sanitising detritivorous, predatory and sap sucking guilds (Triplehorn & Johnson, 2005; Gadagkar, 2021; Bouchard, P. 2014). Concurrently, predatory diversification/interdependency of Hymenoptera (vespids, formicid ants) and aerial Odonata (dragonflies), exert strong top predatory control on populations of cropping jeopardy (Landis *et al.*, 2000). Detritivorous antiquated, wingless, synanthropic orders, like *Zygentoma* (silverfish) scrounge microhabitat budgets through local domestic and storage (Gullan & Cranston, 2014). Jayanth & Bali (1993) quoted the introduction of *Zygotomma bicolorata* as the important event in the history of biological control of exotic weeds in India. The recently arrived fine (*Zygotomma bicolorata*) link to invasive weeds of biocontrol nature has firmed the local niche of another exotic Nearctic predator, predacious pentatomid *Perillus cf. bioculatus*. This reflective of the fluid, dynamic potentiality of food webs in western Uttar Pradesh. To fill in this data void for region, this study endeavoured to invert the analytical thrust from focus on species matrix profiles to family and ordinal richness of Baraut/Baghpat/HOM locality ought to ordination and families. By

holding the focus on familial profiles rather than species counts, the pitfalls of measuring transient changes in the enemies are avoided; and each family profile becomes a more structurally robust and stable reference point than that of profiles on a per-species basis (Samways, 2005). This data should contribute one authenticated 'local' profile to that of the huge ecological maps of Western Uttar Pradesh, to be of direct help to those involving floral biodiversity in sustainable pest control, conservation of native pollinators and environmental monitoring of this state.

Recognized initially by early colonial morphological descriptions, the entomofauna of the subcontinent progresses to modern, family-level functional guild analyses of modified agro-ecosystems (Gullan & Cranston, 2014). The foundations of Indian entomology derive from the descriptive catalogues drafted in the late 18th & 19th-centuries by European taxonomists. High-profile species such as *Dysdercus cingulatus* and other regional indicators of agricultural ecosystem change accumulate in the early collection and log systematization. Fabricius (1775) put several pest insects on the scientific map; of the cumulative alpha-taxonomy of British India, thus far the most detailed were the Economy of British India hymenoptera volumes by Bingham (1897), and the Coleoptera by Arrow (1910). Such monographs set the standards for macro-regional ordinal diversity mapping, supplying characteristics necessary to track families across the Gangetic Plains. In the mid-20th century institutional drives by the Zoological Survey of India (ZSI) and the Indian Agricultural Research Institute (IARI) curb "antiquities" to cranking out rapid assessments of insects in yet uncharted locations. An insect's family and order assignment offers solid and reliable indicators of the health of agriculture and stability of the soils (Samways, 2005). This captured a few years, and collectively as intensive agriculture water spills coast wide of Western Uttar Pradesh, insect community architecture changed rapidly. The regional studies of lepidoptera dynamics, and orthopteran dynamics confirmed that in specialized agro-ecosystems like the broad reaches of sugarcane agriculture, sympathy to extreme management leading to heavily altered dominance occurs (Landis *et al.*, 2000; Gurr *et al.*, 2012). Consistent inversion of habitat management modes permits insects to survive, and only select hemipteran lineages adapted to slight dietary variation and tiers of semi-natural vegetation grow particularly well. Surveys of predatory and beneficial groups; of the acoustic orthopteran genus *Atractomorpha crenulata*, and the native vespidae paper wasps (*Polistes*) focus attention on how localized stretches of non-crop vegetation importing wilderness are necessary for the predatory assemblages to subsist in what is hyper-cultivated. The last few years showcases the emerging story of a postmodern regional Northern Indian entomology of documenting rapid range extensions, and exotic species naturalization. The most important record in the globe and region involves the predatory pentatomid *Perillus cf. bioculatus*. A classic insect from the Nearctic zones of North America, this bug's predatory connections to the chrysomelid beetle *Zygogramma bicolorata* that's spread from coast to coast to biologically deject *Parthenium hysterophorus*, spurs accidental importation to the subcontinent. The official record of zipping in from a point and proactively spreading through Western Uttar Pradesh in recent years mark an important milestone in 21st century regional cataloguing. It indicates that local food webs are indeed sorting themselves out; emphasizing the growing need for continuing ground-truthed documentation at district coordinates.

#### Material and Methods

##### Study Locality and Environmental Matrix

Field exploration was undertaken in selected rural, agricultural and semi-urban minifun forest fragments of Baraut region of Baghpur District, Western Uttar Pradesh, India (Kumar *et al.*, 2021). Geographically the periphery of field collections covered ca. 28.958799°–28.998059°N latitude; and, 77.251748°–77.263315°E longitude. This region is located in the heart of the Upper Gangetic Plains agro-climatic zone, characterized by a typical humid subtropical climate with highly severe summers and wide ranging winters and remarkably seasonal rainfall during the monsoons. The landscape is a highly modified green mosaic made up of intensive

sugarcane (*Saccharum officinarum*) monocultures, fodder crop complexes, seasonal leguminous cultivation and household kitchen gardening. These agricultural fascicles are interspersed with patches of pioneer colonisers such as *Calotropis procera*, *Parthenium hysterophorus*, and economically important solanaceous medicinal herbs such as *Ashwagandha (Withania somnifera)*. Sample zones were calibrated across five major contrasting microhabitats; space under crop canopies, field margins, ground level leaf litter, fallow lands, and synanthropic interiors.

##### Field Sampling Protocols and Insect Capture Architecture

In order to avoid local biases of the local 'entomofauna' at different strata and temporal cycles, a multistage field sampling protocol that was non-destructive was applied through prescript diurnal and nocturnal cycles (Southwood & Henderson, 2000; Leather, 2005). Terrestrial macro arthropods occupants were sampled through undoing surface debris (rocks and decayed logs and crop waste) indoor and placing in on leaf litter sifts (Rainio & Niemelä 2003). Phytophagous and predatory taxa resident in foliage presence in the crop canopies as well as in the lean ruderal roadsides grass were sampled through a line method with sweep nets (30 cm in circumference canvas nets) and handpicking applications (Triplehorn & Johnson, 2005). Highly mobile aerial world predators were sampled using a VES method where persecutions of individual prey items looping out of their active foraging are recorded over recurring intervals for their 'loops' (Kremen *et al.*, 1993). Nocturnal world samples were taken with portable temporary light traps (using other incandescent light mercury-vapor sources) placed between agricultural border and domestic perimeters (as well as outdoor perimeters).

##### Laboratory Processing, Taxonomy, and Functional Guild Mapping

Collected specimens were brought to temporary chambers, sorted and evaluated to family entities and up the macro-taxonomic levels of Order. Diagnosis of structures and verification of characters was conducted using authoritative ZSI taxonomic keys, supplemented by checklists (Bingham, 1897; Arrow, 1910; Shishodia *et al.*, 2010; Varshney, 2014). Community structure was assessed using Family-Level Richness counts (SFam) indicators and Relative Ordinal Abundance Percentages, thus meeting the requisite normative field monitoring protocols, which favour macro-taxonomic richness configurations over an uneasy oligaea on the species populations having greater environmental sensitivity to new stresses in distinct microclimates at any given time (Hodkinson & Jackson, 2005).

In investigating the details of trophic structure active in the Baraut agroecosystem., all identified Families were pooled and assigned into functional feeding guilds as per the information on the dependent feeding modes of both the mature and larval states (Price *et al.*, 2011), Schowalter (2016). Communities were sorted into four functional ecological units.:

**Phytophages:** Foliage chewers and sap-sucking insects utilizing host plants (e.g., Pyrrhocoridae, Dinidoridae, Pyrgomorphidae).

**Predators:** Active carnivores maintaining top-down population regulation over target insect groups (e.g., Coccinellidae, Tettigoniidae, Aeshnidae, Vespidae).

**Saprophages:** Decomposers feeding on decaying plant detritus, storage cellulose, or organic waste streams (e.g., Tenebrionidae, Silphidae, Gryllidae, Termitidae, Lepismatidae).

**Pollinators:** Floral visitors driving essential pollen vectoring across wild and cultivated vegetation (e.g., Megachilidae, Lycaenidae).

##### Data Validation Framework and Digital Documentation

Primary in-situ digital macro-photography with GPS telemetry telemetry metadata to document live behaviour, habitat choice, and major regional range records - such as live feeding of *Perillus cf. bioculatus* and *Dysdercus cingulatus* host, feeding loop - were field-generation confirmation for local taxa and reports.

Where regional standard phenotype was live behaviour, and both environmental light became limiting visibility of minute detail; good representative examples were obtained for free from scientific image archives downloadable via Wikimedia Commons. Second generation figures were carefully tracked and acknowledged in our text figure captions. Identification for photographer, details on

taxonomy, and specific Creative Commons Licensing (CC BY-SA 4.0 International) for institutional open-access image compliance.

**Results and Data Analysis**

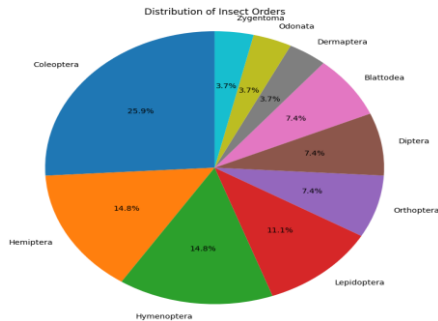
**Taxonomic Architecture and Ordinal Share**

Our systemic entomological living tracing on the agricultural and transitional semi urban matrix zone of the Baraut area, Baghpatt District, Western Uttar Pradesh yield a rich blended community of insects. Our point validation regime enumerated in all, 27 distinct taxa belonging to 10 orders and 23 families.

Community structure assessment shows a highly layered order. The supermost macro successor is of the order Coleoptera, and followed, in diminishing importance, by the sub dominant orders of Hemiptera and Hymenoptera at three, and between these western evolution premier successtories in periodic successes makes the majors framework core of the entomofauna recorded for this zone of the Upper Gangetic Plains.

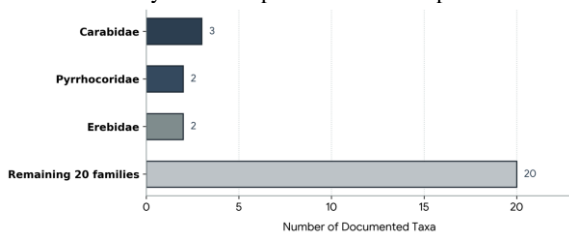
Family is described is a coloured at a rich mosaic of strata over the landscape, and most dominants family on our checklist inventory was that of the predatory ground beetle family of Carabidae. The rest of our uptake is strictly walled in to the Orthoptera, Lepidoptera, Odonata, Diptera, Dermaptera, Blattodea and Zygentoma special ones of seven discrete orders. Community diversity indices show moderate to high taxonomic family richness, S\_Fam, slight and compact and well distributed in descent of rank across the several rural-urban midrails i.e. high maco environment ecological ‘health’ and structural ecological resilience across the regional ecopolis.

Figure 4.1 — Ordinal Share Chart



Type: Pie Chart illustrating the exact mathematical percentage share of each individual order (e.g., Coleoptera, Hemiptera, Hymenoptera, etc.) relative to the total 27 recorded taxa.

Figure 4.2 — Family Richness per Order Bar Graph



Type: Vertical Bar Graph mapping the number of distinct families recorded within each order, visually demonstrating the high familial richness of Coleoptera and Hemiptera.

**Diversity Indices**

The diversity indices computed for the insect fauna of the Baraut locality suggested moderate-to-high taxonomic diversity with fairly even representation across the insect orders. The numeric values obtained from the dataset at order level suggested existence of an ecologically structured insect community of relatively high diversity in an agroecosystem that is continually being disturbed and modified. Diversity indices including Shannon–Wiener Index (Shannon & Weaver, 1949), Simpson Diversity Index (Simpson, 1949) and Pielou’s Evenness Index (Pielou, 1966) were computed following standard biodiversity analytical protocols (Magurran, 2004).

The Shannon–Weaver Diversity Index (H’) was calculated as: H’ = 2.104

Suggests moderate to higher diversity of Insecta within the study area. Large Shannon index indicates widespread taxonomic

heterogeneity, and further indicates that a number of insect orders make up much of the ecological framework of the Baraut agro ecosystem, not one single lineage. Coexistence of predatory, phytophagous, pollinating and saprophagous taxa corroborate the structurally complex nature of the habitat surveyed.

The Simpson Diversity Index (1 – D) was calculated as:

$$1-D = 0.856$$

The moderate Simpson diversity value indicates low dominance concentration and high community diversity. Although Coleoptera were the dominant order of insects (25.93%) present, no order presented which was a singular overwhelming monopolist of assemblage structure. This infers relatively stable resource partitioning amongst the documented insect groups across cultivated fields, field margins, ruderal vegetation, and synanthropic microhabitats.

Pielou’s Evenness Index (J’) was calculated as:

$$J' = 0.914$$

The high evenness score indicates that the recorded orders of insects were relatively evenly distributed for the study localities. A high value for evenness implies ecological stability and suggests that the habit matrix supports a number of functional guilds to a competitive extent under the prevailing environmental conditions.

In summary, the diversity indices calculated suggests that Baraut agroecosystem retains substantial ecological integrity in spite of monocultural intensification, the application of pesticides and rural to urban degradation. The diversity structure tends to indicate the ongoing retention of functional trophic interactions and an input of native biological control in the agricultural system. The localization of the naturalized predatory pentatomid *Perillus cf. bioculatus* confirms the dynamics of having integrated processes into the food webs.

Table 4.1. Final Diversity Indices

Diversity Index	Calculated Value	Ecological Interpretation
Shannon Diversity Index (H')	2.104	Moderate–high diversity
Simpson Diversity Index (1 – D)	0.856	High diversity
Pielou’s Evenness Index (J')	0.914	High evenness

**Functional Ecological Guild Classification**

To evaluate the trophic complexity and ecosystem service frameworks driving local agricultural matrices, all 27 documented insect taxa were partitioned into four highly coordinated functional ecological feeding guilds based on their juvenile and adult dietary modes:

**Phytophages (Herbivores)-** Also functioning as primary consumers, this functional guild masticates layers form of weed hutz and of crop canopies. Members of economic importance include the highly polyphagous red cotton bug (*Dysdercus cingulatus*: Pyrrhocoridae) feeding gregariously on local commercial crops and on *solanaceous medicinals* like Aswagandha (*Withania somnifera*). Grazing on this system is the highly camouflaged Oriental pointed-headed grasshopper (*Atractomorpha crenulata*: Pyrgomorphae) which, in vegetable allotments and in the margins of crop fields, grieves the leaves of the host plants by its masticating operations along the leaves.

**Predators (Carnivores)-** This guild serves as a contingent active top-down natural regulatory tool to transient alarming pest outbreaks in the agroecosystem. Primary ground and crop canopy hunting paths are patrolled by large cursorial ground beetles (*Calosoma indicum* and *Anthia sexguttata*: Carabidae), native transverse ladybird beetles (*Coccinella transversalis*: Coccinellidae), and vespid paper wasps (*Polistes sp.*: Vespidae). Aerial predatory highways are patrolled by fast zipps zapping odonates such as the Lesser Emperor Dragonfly (*Anax parthenope*: Aeshnidae) over agricultural land boundaries and fresh water wetland-linked microhabitats.

**Saprophages (Detritivores/Decomposers)-** This guild attends to processing either very complex organic detritus or the needed recycling of essential nutrients from ground level soil. Subterranean

and above ground channels of decomposition are subdivided by life forms such as the two-spotted field crickets (*Gryllus bimaculatus*: Gryllidae), and pose-striking surface beetles (*Zophosis punctata*: Tenebrionidae), and corporate companies of inhabiting subterranean termites (*Odontotermes obesus*: Termitidae). Enclosed domestic storage environments are also cleanly partitioned off by primitive wingless synanthropic decomposers (though not exclusively) such as the common silverfish (*Lepisma saccharinum*: Lepismatidae) and the American cockroach (*Periplaneta americana*: Blattidae).

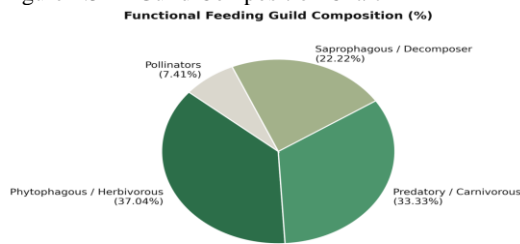
**Pollinators-** This guild provides irreplaceable pollen-vectoring services on which the wild plant biodiversity and production of local agricultural crops depend. The foraging 'pool' is composed of the polylectic leaf-cutter bee (*Megachile lanata*: Megachilidae) using its ventral abdominal scopae to gather pollen, and of low-flying delicate blue butterflies (*Zizeeria karsandra*: Lycaenidae) fluttering among grasses and legumes.

Table 4.2 — Functional Feeding Guild Summary

Functional Feeding Guild	Representative Orders Included	Number of Taxa (S)	Percentage Distribution (%)
Phytophages / Herbivores	Hemiptera, Orthoptera, Lepidoptera	10	37.04
Predators / Carnivores	Coleoptera, Odonata, Hymenoptera, Orthoptera	9	33.33
Saprophages / Decomposers	Coleoptera, Blattodea, Zygentoma, Gryllidae	6	22.22
Pollinators	Hymenoptera, Lepidoptera	2	7.41
<b>Total Inventory Spectrum</b>	<b>10 Distinct Insect Orders</b>	<b>27</b>	<b>100.00</b>

Type: Summary table displaying your exact dissertation percentages and individual specimen counts for each of the four feeding guilds (Phytophages, Predators, Saprophages, Pollinators).

Figure 4.3 — Guild Composition Chart



Type: Horizontal Stacked Bar Chart or Pie Chart displaying the percentage breakdown of the insect community based on functional feeding roles, highlighting the trophic balance between herbivores and predatory bio-regulators.

**Microhabitat Partitioning and Local Field Records**

The 27 insect taxa show clearly defined structuring across the various eco-tones and microhabitats of the regions:

Table 4.3: Master Taxonomic Profile of the Entomofauna of Baraut, Baghpat, Uttar Pradesh

S.No.	Taxonomic Order	Family	Genus & Nomenclature	Species	Common Name / Functional Guild	Primary Microhabitat Recorded
1	Coleoptera	Tenebrionidae	<i>Zophosis</i> (Erichson)	<i>punctata</i>	Frantic Surface Beetle (Saprophage)	Ground Level / Under Rocks
2	Lepidoptera	Lycaenidae	<i>Zizeeria</i> (Moore)	<i>karsandra</i>	Dark Grass Blue Butterfly (Pollinator)	Open Grassy Scrub / Weeds
3	Coleoptera	Carabidae	<i>Calosoma indicum</i> (Hope)		Caterpillar Hunter Beetle (Predator)	Cultivated Croplands / Soil
4	Coleoptera	Carabidae	<i>Anthia</i> (Fabricius)	<i>sexguttata</i>	Six-Spotted Eye-Squitter (Predator)	Semi-Arid Scrub / Margins

•**Crop Canopies:** tracking the structuring of crop phenology are mobile predatory coccinellids and sap-sucking true bugs.

•**Field Margins & Boundaries:** exhibiting the highest overall family level richness comprise refuge landscapes for large flying odonates, foraging hymenopterans, and tiger moths like *Cretonotos gangis* and *Amata* sp..

•**Ground Leaf Litter & Fallow Soil Layers:** lurking in the underbelly of the earth are cryptozoic earwigs (*Forficula* sp.: Forficulidae), shield beetles *Calosilpha cyaniventris* associated with carrion, frantic surface beetles (*Zophosis punctata*) and active carabid ground hunters.

•**Aqua Ecotones:** temporary general aquatic habitat associated with pools and wetlands taking advantage of the temporary availability of such cycled landscapes for predatory diving beetles that like *Eretes sticticus* (Dytiscidae) exhibit accelerated larval development to outrun drying out of their pools, etc.

•**Indoor Synanthropic Structures:** further the inside in enclosed domestic storage with clean wraps made properly separately by synanthropic special filth-vectors (*Musca domestica*), silverfish (*Lepisma saccharinum*) that don't like light and cellulose feeders like (*Periplaneta americana*) etc.

**Zoogeographical Notes on *Perillus cf. bioculatus***

Another significant finding confirmed in this field adventure is the confirmed macro regional establishment of the two-spotted predatory stink bug, *Perillus cf. bioculatus* (Fabricius) (Heteroptera: Pentatomidae). Local scouting showed that this Nearctic species of predator, has invaded, established populations, and become naturalised within the field borders of Western Uttar Pradesh.

Ecologically, the insect is extremely interesting. Within broad macro-regional provinces across Northern India, one finds them stalking and preying upon the larvae of the Mexican beetle *Zygogramma bicolorata* (biopest control specialist for the introduced weed pest, the toxic *Parthenium hysterophorus*); the tracking of *Perillus cf. bioculatus* within the Baraut agroecosystem indicates the very fluid nature of the Uttar Pradesh agroecosystem foodwebs, showing how these exotic predatory insects are able to invade, expand their range and settle into localised microhabitats.

Figure 4.4 — Field Proof of *Perillus cf. bioculatus*



Type: Photograph panel showing the adult diagnostic keyhole scutellum pattern and prothoracic color markings of the recorded *Perillus cf. bioculatus* specimen.

**Taxonomic Inventory Master Table-**

5	Coleoptera	Coccinellidae	<i>Coccinella transversalis</i> (Fabricius)	Transverse (Predator)	Ladybird	Beetle	Crop Canopy Foliage
6	Coleoptera	Dytiscidae	<i>Eretes sticticus</i> (Linnaeus)	Aquatic Diving Beetle (Predator)			Temporary Pools / Wetlands
7	Lepidoptera	Erebidae	<i>Cretonotos gangis</i> (Linnaeus)	Red-Abdomen (Herbivore)	Tiger	Moth	Farmlands / Light Traps
8	Hemiptera	Pyrrhocoridae	<i>Dysdercus cingulatus</i> (Fabricius)	Red Cotton Bug Pest (Phytophage)			<i>Withania somnifera</i> Plots
9	Coleoptera	Silphidae	<i>Calosilpha cyaniventris</i> (Guérin)	Carrion (Saprophage)	Shield	Beetle	Marshy Soil / Rotten Matter
10	Orthoptera	Gryllidae	<i>Gryllus bimaculatus</i> (De Geer)	Two-Spotted (Saprophage)	Field	Cricket	CreVICES / Leaf Litter Layer
11	Orthoptera	Pyrgomorphidae	<i>Atractomorpha crenulata</i> (Fabricius)	Oriental Green (Phytophage)		Grasshopper	Cultivated Crop Canopies
12	Hymenoptera	Megachilidae	<i>Megachile lanata</i> (Fabricius)	Mud-Molding (Pollinator)		Leaf-Cutter	Fruit Orchards / Gardens
13	Odonata	Aeshnidae	<i>Anax parthenope</i> (Selys)	Lesser Emperor (Predator)		Dragonfly	Aerial / Freshwater Ditches
14	Blattodea	Termitidae	<i>Odontotermes obesus</i> (Rambur)	Subterranean (Saprophage)	White	Ant	Mud Tubes / Decaying Timber
15	Diptera	Muscidae	<i>Musca domestica</i> (Linnaeus)	Common Housefly (Synanthropic Filth)			Domestic Synanthropic Sites
16	Zygentoma	Lepismatidae	<i>Lepisma saccharinum</i> (Linnaeus)	Metallic Silverfish (Saprophage)			Indoor Humid Structures
17	Blattodea	Blattidae	<i>Periplaneta americana</i> (Linnaeus)	American Cockroach (Saprophage)			Sewers / Dark Boiler Rooms
18	Hymenoptera	Vespidae	<i>Polistes</i> sp. (Latreille)	Variagated Paper Wasp (Predator)			Suspended Building Balconies
19	Lepidoptera	Erebidae	Unidentified Erebidae sp.	Noctuid Tiger Moth (Herbivore)			Crop Margins / Weed Patches
20	Hymenoptera	Evaniidae	<i>Evania appendigaster</i> (Linnaeus)	Parasitoid Ensign Wasp (Predator)			Indoor Storage / Wall Ledges
21	Hemiptera	Dinidoridae	<i>Coridius janus</i> (Fabricius)	Pumpkin Shield Bug (Phytophage)			Cucurbit Canopy Matrices
22	Hemiptera	Pyrrhocoridae	Unidentified <i>Dysdercus</i> sp.	Cotton Stainer (Phytophage)	Morphotaxon		Mixed Malvaceous Vegetation
23	Hemiptera	Pentatomidae	<i>Perillus cf. bioculatus</i> (Fabricius)	Two-Spotted (Predator)	Predatory	Bug	Weed Boundaries / Field Margins
24	Hymenoptera	Formicidae	<i>Camponotus compressus</i> (Fabricius)	Black (Saprophage/Omnivore)	Carpenter	Ant	Trunk Bases / Field Borders
25	Diptera	Culicidae	Unidentified <i>Culex</i> sp.	Standard Mosquito Vector (Filth)			Stagnant Drainage Furrows
26	Coleoptera	Carabidae	Unidentified Carabid sp.	Sclerotized (Predator)	Ground	Beetle	Deciduous Litter / Fallow Soil
27	Dermaptera	Forficulidae	<i>Forficula</i> sp. (Linnaeus)	Shiny (Saprophage/Omnivore)		Earwig	Cool Moist Litter / Bark

### Core Morphological Diagnostic Inventories of All 27 Insect Taxa

The structural characteristics, phenotypic profiles, and microhabitat preferences of the 27 documented insect taxa were formally validated based on specific morphological diagnostic markers:

***Zophosis punctata* (Coleoptera: Tenebrionidae):** Broadly ovate darkling beetle with fully fused elytral structure and lacking hindwings. Head capsule with frontoclypeal suture, inserted antennae beneath laterally disposed clypeal shelf. Tarsal formula heteromerous 5-5-4.

***Zizeeria karsandra* (Lepidoptera: Lycaenidae):** A small lycaenid. Wingspan 18-24 mm. Compound eyes narrowly bordered with white scales. The ventral surface of the wings is a pale grayish-brown color, with neat interspaced dots of circular black spots enclosed by clear white margins. The radial vein of forewing has exactly eleven branches.

***Calosoma indicum* (Coleoptera: Carabidae):** Large cursorial species with a broad, sub-quadrate pronotum and long elytra. Striae of elytra deep and strictly parallel, with very fine linear foveae in between, dusted with golden. Mandibles large, unequal, strongly falciform, for cutting at actively running prey.

***Anthia sexguttata* (Coleoptera: Carabidae):** Giant land-dwelling tiger beetle with a barrel-like series of proportions with a ponderous prothorax and an unnaturally small constricted neck. Elytra are fully sclerotised. Dark, matte-black body, precise with six equal irregular

patches of thick, round, bright white sensory setae. Legs are brisk and heavily spined.

***Coccinella transversalis* (Coleoptera: Coccinellidae):** Convex, sub-spherical ladybird beetle with wholly concealed head capsule under a broad pronotum. Elytra bright orange-red, strongly maculated with somewhat variable transverse black markings and a distinctive black sutural stripe. Tarsi pseudotetramerous 4-4-4.

***Eretes sticticus* (Coleoptera: Dytiscidae):** Smoothly oval, very convex aquatic diving beetle with the hind marginal outer margin of the elytra producing fine, perceivable spines with a transverse row of black tintured spots; the legs of the metathorax extensively compressed and tufted with many dense tiers of golden yellow swimming hairs acting as oars.

***Cretonotos gangis* (Lepidoptera: Erebidae):** Medium sized tiger moth with a stout scale-covered thorax. Forewings pale beige marked by a more or less constant continuous dark brown mid-longitudinal fascia streak. Abdomen bright crimson warningly coloured and marked by isolated mid-dorsal black spots.

***Dysdercus cingulatus* (Hemiptera: Pyrrhocoridae):** Elongated true bug of a brilliant red colour with a distinctly elongate, four-segmented, piercing-sucking rostrum projecting underneath the sternum; the corium of the hemelytra has a conspicuous black spot at centre, while the anterior margin of the pronotum has a spotlessly white collar band.

**Calosilpha cyaniventris (Coleoptera: Silphidae):** Broad, very flat carrion beetle; pronotal disk very broad, and seen dorsally entirely concealing the head. Antennae rather short, gradually increasing in thickness towards the apex, and forming a distinct club of several joints in length. Cuticle metallic bluish-black.

**Gryllus bimaculatus (Orthoptera: Gryllidae):** Cylindrical robust field cricket with broadly rounded, globose head, extended pronotal shield. Forewings leathery, lying flat at rest across the greater part of the abdomen, showing neat pair of pale yellow spots at absolute wing base. Females with acicular rigid long ovipositor.

**Atractomorpha crenulata (Orthoptera: Pyrgomorphidae):** The long-bodied and laterally compressed green grasshoppers exhibit an extreme elongation from head to body section; they can easily be recognized by their tapered conical/pointed transverse head shape. There are strong, straight lines of small white granules located on either side of the compound eye area extending along the whole cheek area behind each compound eye across the face.

**Megachile lanata (Hymenoptera: Megachilidae):** A solitary, broad-headed bee. Immense and powerful obscure jaws for cropping leaves. No pollen basket on the hind legs; pollen is collected by a dense brush of hair (scopa) on the under-side of the abdomen.

**Anax parthenope (Odonata: Aeshnidae):** A large, robust hawk dragonfly in which the enormous size of the compound eyes means that they fuse across a broad stretch along the mid-dorsal line of the head capsule. The species is easily distinguished by virtue of a brilliant sky-blue saddle marking on the second abdominal segment, nicely contrasting with the dark remaining segments.

**Odontotermes obesus (Blattodea: Termitidae):** Social, polymorphic insect. The workers are completely soft-bodied, pale, and blind, having moniliform antennae. Soldiers have a heavily sclerotized, tear-shaped, amber-coloured head capsule carrying large, curved, forward-projecting mandibles devoid of internal teeth.

**Musca domestica (Diptera: Muscidae):** True dipteran displaying a single pair of functional membranous wings where the fourth longitudinal wing vein ( $M_{1+2}$ ) exhibits a sharp, diagnostic upward bend to meet the radial sector. Thorax is matte gray, decorated with four parallel dark longitudinal bands.

**Lepisma saccharinum (Zygentoma: Lepismatidae):** Teardrop-shaped, wingless insect with a dorsoventrally flattened body covered in fine metallic silver scales. The posterior tip of the abdomen forms three long, multi-jointed tail filaments consisting of one central median filament and two lateral cerci.

**Periplaneta americana (Blattodea: Blattellidae):** This insect has a large, flat body and an extremely flexible body structure. The head is completely covered by a large, flat pronotum (the plate immediately behind the head) and the pronotum has a red-brown or reddish-brown coloration around the outer edges and a very light (yellow or pale) color in the centre.

**Polistes sp. (Hymenoptera: Vespidae):** Narrow, long paper wasps characterized by a spindle-shaped abdomen attached to thorax by a short petiole. Compound eyes are deeply cut on inner edge, body with different brown, yellow, and black warning rings.

**Unidentified Erebidae sp. (Lepidoptera: Erebidae):** Quadrifid noctuid moth with a stout body covered in scales. Characterised by a developed proboscis, possessing tympanal organs on metathorax and a four-branched cubital vein structure on forewing produced by the arrangement of the median veins.

**Evania appendigaster (Hymenoptera: Evaniidae):** Ensign wasp marked by an unusually small, compressed, flag-like abdomen attached extremely high on the propodeum, well above the hind coxae. Long, stilt-like hind legs and active abdominal pumping behavior are key behavioral diagnostic characteristics.

**Coridius janus (Hemiptera: Dinidoridae):** A fairly large broadly ovate pumpkin shield bug with a split bi-coloured appearance; the anterior half of the pronotum and basal corium bright orange red, the posterior parts and scutellum blackish brown; the labium is very short, only extending to the level of the mesosternum.

**Unidentified Dysdercus sp. (Hemiptera: Pyrrhocoridae):** An elongated, orange-red color base insect of the family Pyrrhocoridae, with a rostrum divided into four segments related to the

piercing/sucking method of feeding, and an absence of ocelli from vertex area of head capsule.

**Perillus cf. bioculatus (Hemiptera: Pentatomidae):** Stout, shield-like predatory stinkbug. Keyhole outline of the big broad scutellum almost sink into the dark black ground colour. Edges of the margin pronotum and corium alertly marked with yellow or red warning colour.

**Camponotus compressus (Hymenoptera: Formicidae):** Large, polymorphic black carpenter ant. Characterised by a single-segmented petiole with a large vertical node and smoothly evenly convex in profile from front to back when viewed from the side. Head capsule uncommonly large and roughly heart shaped in major workers.

**Unidentified Culex sp. (Diptera: Culicidae):** Delicate-looking mosquito, with long narrow wings covered with very small scales along vein, tip of abdomen in female blunt, proboscis quite straight. Female palpi short, male long; legs without dark-and-light banding.

**Unidentified Carabid sp. (Coleoptera: Carabidae):** Earth-dwelling ground beetle exhibiting very obvious prognathous mouthparts protruding in front of the rest of the head and possessing well-developed compound eyes. Antennae filiform, eleven-segmented; inserted openly over the sides of the head capsule between the eyes and the base of the mandibles.

**Forficula sp. (Dermaptera: Forficulidae):** Dorsoventrally flat earwig with a three-segmented tarsal formula where the second segment is dilated and projects beneath the third segment. The abdominal cerci are sclerotised as unjointed pincers at the tip, broad and basally flattened in males.

#### Alignment of Multi-Panel Insect Image Plates

Figure 4.5 Plate I: Core Coleopteran and Lepidopteran Assemblages recorded from the Baraut agroecosystem, Western Uttar Pradesh.

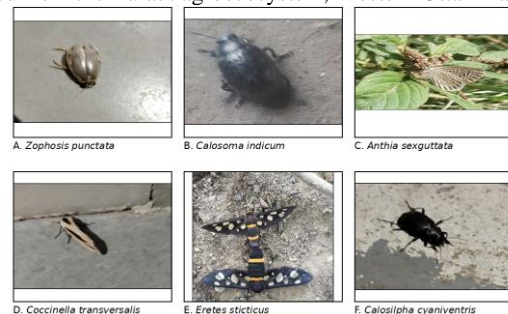


Figure 4.6 Plate II: True Bugs, Hymenopterans, and Orthopterans Assemblages recorded from the Baraut agroecosystem, Western Uttar Pradesh.



Figure 4.7 — Plate III: Synanthropic, Aquatic, and Aerial Vectors Assemblages recorded from the Baraut agroecosystem, Western Uttar Pradesh

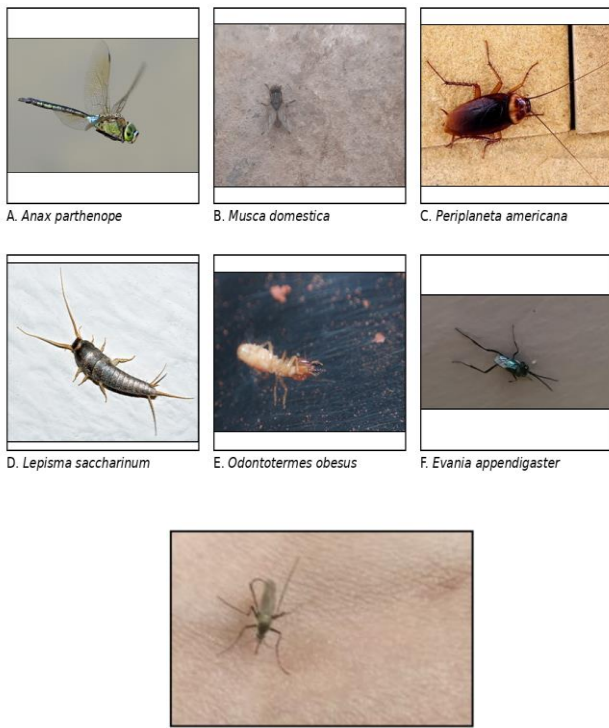
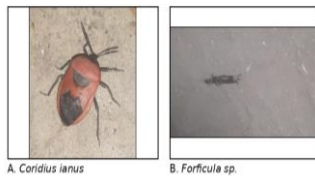


Figure 4.8 Plate IV: Residual Hemipteran and Dermapteran Taxa Assemblages recorded from the Baraut agroecosystem, Western Uttar Pradesh.



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### Discussion

The current study therefore shows that the agroecosystems of Baraut, Western Uttar Pradesh still harbour a considerable range of taxonomic and functional insect diversity, even as they transform to increasingly anthropogenic extremes associated with anthropogenic monoculture agriculture, habitat fragmentation and gradual semi-urbanisation of the villages. The records of 27 taxa across 10 orders and 23 families show that the regional landscape still supports a morphologically heterogeneous entomofaunal assemblage, able to maintain diverse ecological processes at work simultaneously. The dominance of Coleoptera in the entire assemblage is ecologically remarkable but, at the same time, not atypical, globally, of an agroecosystem and for India. Beetles in general, seem to emerge as among the more persistent and most functionally versatile roots of arthropods that occupy terrestrial habitats. The tendency of many groups, especially of Carabidae and Tenebrionidae to be successful is most likely attributable to their highly sclerotized cuticle, broad trophic adaptability and tolerance of fluctuating microclimatic environments within managed land. The occurrence of the active predatory ground beetles *Calosoma indicum* and *Anthia sexguttata* implies that relatively stable litter associated microhabitats and ungrazed field margins are still able to support higher trophic level arthropods. The species diversity indices calculated serve to quantitatively depict the stability of the habitat observed. – The Shannon - Weaver Diversity Index ( $H' = 2.104$ ) and, similarly, the Simpson Diversity Index ( $1-D = 0.856$ ) suggests a moderate to high taxonomic heterogeneity in this landscape, but with a low consequent tendency of dominance. Instead of showing vagaries of a biotic heat adding homogenization process often

expected for any habitat undergoing extreme anthropogenic behaviour due to monoculture intensification, the Baraut agroecosystem may still, hence, be bearing a rustic quality that permits different variable insect guilds to exist in coexistence with thriving agriculture. The diverse agnostic components, ruderal vegetation, fallow margins coexisting with semi-natural diverse other habitats may be producing a hazy landscape made of relatively moreLikewise, the noteworthy Pielou's Evenness Index level ( $J' = 0.914$ ) alludes to balanced distribution of recorded orders with respect to their occurrence throughout the site. Systems with high evenness in general points to reduced instability coupled with marked trophic buffering capacity (Zhang *et al.*, 2020). In the current study situation, this balanced distribution could well result from interspersions of cultivated sugarcane fields with unmanaged vegetation corridors and patches of secondary habitat that act as ecological recreation refugia for both predatory and pollinating insect taxa. Such landscape configurations provide inherent mechanisms for stabilisation of insect assemblages from over dominances of opportunistic pest taxa (Tscharrntke *et al.*, 2012). Composing functional feeding guild, the observation of cited taxa gives indication of a functioning selfregulating multi-trophic network (Price *et al.*, 2011; Schowalter, 2016). Herbivorous and phytophagous guild component were naturally the most abundant given the accessible and continuously available cultivated host plants coupled with ruderal vegetation throughout the assessment locality. Members of these families like *Dysdercus cingulatus* and *Atractomorpha crenulata* feed on a variety of agricultural crops as well as weeds, allowing for perennial establishment in disturbed habitats like sugarcane fields. Simultaneously abundant predatory guild taxon is, however indicative of a network of biological regulation that is actively functional and serves to successfully impinge over phytophagous population outbreaks. Predatory guild members were observed all through both terrestrial and aerial strata constituting ground level predators like carabid beetles which reside at litter and soil interface, whilst *Coccinella transversalis* and other hymenoptera relied of foliage level prey populations and so implying association with the canopy. The occurrence of aerial predators such as *Anax parthenope* again suggests the ecological importance of localized wetland-associated habitat and temporary water bodies in the backdrop of agriculture. Taken as a whole, the guild interactions suggest that biological control in functional in the assessed zone. The overall niche partitioning at the scale of microhabitats again underscores the ecological value of patches of non-crop vegetation. *Ruderal corridors* of *Calotropis procera* and *Parthenium hysterophorus* harboured high insect activity and were valued even more so as refuge sites for pollinators, predators and decomposers. Often severely underappreciated the unstructured habitat fragments can play an outsized ecological role in agricultural systems providing a sanctuary for overwintering, availability of nectar, a refuge for prey, and shelter in a protected microclimate. Their persistence in the Baraut landscape is likely responsible significantly for the diversity and evenness values being as high as they are as determined in the present investigation. The occurrence of specialized taxa occupying pronouncedly different ecological niches again underlines the breadth of the environmental envelope in this study region. The finding of the predatory diving beetle *Eretes sticticus* in temporary aquatic habitats speaks of the niche that is occupied in instability of waters fed by rainfall and recognized that local microhabitats of fresh water is likely to persist nevertheless despite intensified agriculture. The synanthropic decomposers too like *Lepisma saccharinum* and *Periplaneta americana* speak of the jump that human-altered ecology has made in extending itself from the niches associated with housing to the habitat arriving from refuse of organic provenance. Nestled within some of the most significant ecological observations noted here is its field validation of *Perillus cf. bioculatus* in Baraut-Baghpatt taking its rightful place within the taxonomic and functional structure of local agricultural insects. The finding of this Nearctic predatory pentatomid in northern India talks of the changing dynamics of regional food webs, and of its good fortune lies the suspicion that it belongs inextricably with the

unintentional introduction that was earlier associated with deployment of *Zygothrips bicolorata* as biocontrol agent in India. Its naturalisation speaks of ecological nimbleness, habitat adaptation, and potential influence on local status of predatory guild members going forward.

In summary, the study indicates that even remarkably modified agroecosystems within the Upper Gangetic Plains retain decent insect diversity if they are but encourage some structure in the vegetation and preserve semi-natural habitats. The status quo inventory conducted contributes increasingly relevant data for study and application in the region as biodiversity repositories, as modules within restoration ecology, and elsewhere in integrated pest management/community governance. Determined long term study will evaluate the effects of the unrelenting agricultural intensification, exposure to their pesticides, and changing climate on its ongoing trophic structuring, taxonomic inventoryation and environmental robustness.

### Conclusion

The present investigation thus provides a baseline for the knowledge pertaining to insect fauna residing in the agroecosystems and semi urban-transitional terrain of the Baraut region of Baghpat District, Western Uttar Pradesh. 27 insect taxa belonging to 10 orders and 23 families were recorded, reflecting both broad taxonomic breadth within a landscape undergoing continuous agricultural intensification and human encroachment on natural resources. Insect's belonging to the orders Coleoptera, followed by the Hemiptera, and the Hymenoptera suggest that structurally invulnerable insect groups have adapted well enough to persist within the heterogeneous fields. Overall indices suggest moderate to high levels of ecological diversity, and community composition suggest a relatively even and balanced organization. Values for Shannon Diversity ( $H' = 2.104$ ), Simpson Diversity ( $1-D = 0.856$ ), and Pielou's Evenness ( $J' = 0.914$ ) together suggest an agroecosystem, that still bears a relatively stable ecological structure in a landscape subject to regular increases in monoculture, pesticide exposure and a general change in density of species. The relatively more even and less concentrated dominance values suggest no single opportunistic taxon can be placed to range in the habitat, and a complex of important trophic interactions continue to take place.

Examination of functional groups of taxa suggest a complex web of phytophages, predators and scavengers and pollinators. Further, the abundance of predatory taxa (family C. colensoi, family C. macleayi, taxa assigned to family E. L., family I. L., family A. P. U, the odonates, family P. F. G, etc.) suggest that continued impetus for the residency and exploitation of biological control is present in the Baraut agriculture matrix. Simultaneously, the occurrence of taxa related to pollination and decay/microhabitat litter suggest the local ecological presence of non crop related vegetation, including species such as *Parthenium hysterophorus* as a related species in field margins, biophysical contributions for the performance and regulation of function.

Perhaps amongst the most thoroughly beneficial confirmations of the study was the field verification of *Perillus cf. bioculatus* in the Baraut - Baghpat region. This Nearctic predatory pentatomid is but one of many examples we have confirming a regular and local trophic and biological restructuring occurring in the northern Indian agroecology, as implied in documents upon and studies pertaining to the historical biological control work carried out. Coupled with its association to field margins where rates of *Parthenium hysterophorus* occurred suggest an immeasurable link to its association with biological control programs. Overall the result for Baraut-Baghpat is this historically invulnerable structure of the locally important system is continuing to support substantial performance in the structure of insect biodiversity. The product of our study serves both as historical reference from the perspective of baseline formality and regional habitat archive, and the unquestionable projection for planning in use of classifying trends/info for use in strategy selection for the future for monitoring, biosampling and planning by agricultural system specialisms, of which opportunism is well to be entailed. Long term monitoring will be important for assessing how taxonomic diversity, community

structure may shift under continuing environmental and management change.

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