TAXONOMY, DISTRIBUTION, AND SPECIES COMPOSITION OF SYRPHID FLIES (DIPTERA: SYRPHIDAE) IN JAMMU AND KASHMIR, INDIA

Thesis Submitted for the Award of the Degree of

DOCTOR OF PHILOSOPHY

in

Zoology

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2025

DECLARATION

I, hereby declare that the presented work in the thesis entitled "**Taxonomy, distribution, and species composition of syrphid flies (Diptera: Syrphidae) in Jammu and Kashmir, India"** in fulfilment of degree of **Doctor of Philosophy (Ph. D.)** is outcome of research work carried out by me under the supervision of **Dr A. Najitha Banu**, working as Associate Professor, in the **Department of Zoology,** School of Bioengineering & Biosciences, Lovely Professional University, Punjab, India. In keeping with general practice of reporting scientific observations, due acknowledgements have been made whenever work described here has been based on findings of other investigators. This work has not been submitted in part or full to any other University or Institute for the award of any degree.

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CERTIFICATE

This is to certify that the work reported in the Ph. D. thesis entitled "**Taxonomy, distribution, and species composition of syrphid flies (Diptera: Syrphidae) in Jammu and Kashmir, India"** submitted in fulfillment of the requirement for the award of degree of **Doctor of Philosophy (Ph.D.)** in the **Department of Zoology,** School of Bioengineering & Biosciences, is a research work carried out by **Amir Maqbool**, Registration No. **42100199**, is bonafide record of his original work carried out under my supervision and that no part of thesis has been submitted for any other degree, diploma or equivalent course.

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Abstract

This is the first comprehensive report on the hoverflies of Jammu and Kashmir, documenting and updating the taxonomy of Syrphid fauna of the union territory along with the bio-ecological perspectives. Sampling over different agro-climatic zones of Jammu and Kashmir from 2021-2024 and collecting over 2000 specimens revealed 72 hoverfly species across 38 genera, dominated by genus *Eristalinus*, *Eristalis* and *Sphegina*. The overall abundance showed, *Eristalis arbustorum* to be the most abundant species (12%), followed by *Episyrphus balteatus* (7%), *Eristalis tenax* (5.6%), and *Eristalis cerealis* (5.3%). In the present study, 11 new to science species were discovered, 4 new genera and 5 species were documented for the first time in India, while 15 species were documented for the first time from Jammu and Kashmir. In the present study, previous taxonomic misidentifications that had persisted in prior research, have been critically addressed and rectified. Further, the confirmation of doubtful taxa from the union territory has also been made. Diagnosis and descriptions have been supplemented with high quality images of live as well as mounted specimens that can be used as pictorial keys along with the updated genera and species identification keys provided in the report. Almost all species have been provided with the important male genitalia characters, descriptions as well as supplementary high quality slide microphotographs. In some closely resembling species molecular characterization has been done, utilizing mitochondrial genome sequences, essential in modern taxonomy for delineation of the species. This is the first study from the Jammu and Kashmir UT taking into account the floral host interactions of hoverfly species whereby a total of 60 species of flowering were observed for syrphid fly species mostly within the Asteraceae and Apiaceae. *Mentha longifolia* was the most favoured flowering plant at higher altitudes with 39 species observed visiting and *Sisymbrium loeselii* was the most favoured flowering plant at lower altitudes with 24 syrphid species visiting the flowers. The present study revealed two significant patterns in syrphid fly species diversity: a unimodal distribution across an altitudinal gradient in the Kashmir Himalayas peaking at mid atitudes (2300-2500m (amsl)) and a negative correlation with urbanization intensity. These findings offer significant insights into the ecological relationships of syrphid flies and how they respond to both natural and anthropogenic environmental gradients, contributing to our broader understanding of insect diversity patterns in mountainous regions and urban landscapes. This taxonomic report will serve as a baseline to facilitate the work of taxonomists, and the obtained data will assist in future conservation plans and the implementation of integrated pest management (IPM) programs incorporating the region's predatory hoverflies.

Keywords: Hoverflies; taxonomy; biodiversity; altitudinal gradient; urbanization gradient.

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In the name of Allah, The most gracious, most merciful

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Amir Maqbool

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LOVELY PROFESSIONAL UNIVERSITY

CHAPTER-1

Introduction

Introduction

Hoverflies (Syrphidae), an ecologically significant family of dipteran insects, represent a critical component of terrestrial ecosystems, playing multifaceted roles in pollination, biodiversity maintenance, and ecological balance. In the diverse and geographically complex landscape of India, particularly in the mountainous region of Jammu and Kashmir, these fascinating insects exhibit remarkable adaptability and intricate ecological interactions that merit comprehensive scientific exploration.

Hoverflies are essential pollinators in both agricultural and wild environments, contributing significantly to the health and productivity of these ecosystems (Larson et al. 2001; Inouye et al. 2015). To effectively conserve natural habitats and manage crops, it's crucial to understand and measure the pollination services they provide. Adding to their value, the larvae of some hoverfly species are insectivores, preying on agricultural pests like thrips and aphids, making them valuable biological control agents (Tenhumberg and Poehling, 1995; Nelson et al. 2011; Dunn et al. 2020). This dual role as both pollinators and pest controllers makes these often-overlooked insects potentially powerful allies in the pursuit of sustainable agriculture.

Syrphids, commonly known as flower flies or hoverflies, represent one of the most diverse and ecologically important insect groups globally. With 200 genera and more than 6,300 known species, the family is distributed almost everywhere (Skevington et al. 2019; Mengual et al. 2023; Evenhuis & Pape 2024). They are characterized by their distinctive mimicry of hymenopteran insects, remarkable flight capabilities, and critical ecosystem services. The distribution of syrphids is global with the exception of Antarctica and some remote oceanic islands.

India, with its remarkable array of biogeographic zones and diverse climatic conditions, harbors a rich tapestry of hoverfly diversity. While the true extent of this diversity remains to be fully unraveled, current estimates suggest the presence of approximately 360 hoverfly species in India (Ghorpade 2014; Sengupta et al. 2016; Sankararaman et al. 2020). These intriguing insects occupy diverse habitats, from the verdant rainforests of the Western Ghats to the majestic Himalayas, showcasing their remarkable adaptability and ecological significance (Shah et al. 2014; Mitra et al. 2008; Sengupta et al. 2023).

The Indian subcontinent, characterized by its extraordinary ecological heterogeneity, offers a unique natural laboratory for understanding hoverfly diversity and ecological adaptations. Jammu and Kashmir, with its pronounced altitudinal variations ranging from subtropical zones to alpine ecosystems, presents an exceptional geographical context for investigating syrphid biodiversity and ecological responses. The region's complex topographical gradients, spanning from approximately 220 meters to over 8,600 meters above sea level (Romshoo et al. 2020), create a mosaic of ecological niches that challenge and shape hoverfly community structures.

The union territory of Jammu and Kashmir, located in the northernmost part of India, encompasses a geographically varied area, positioned between latitudes 32.28–37.06° and longitudes 72.53–80.32°, with altitudes ranging from 220 to 8611 m (amsl). Nestled amidst the majestic Himalayas, Jammu and Kashmir stands out as a region of exceptional biodiversity. This northernmost region of India, characterized by its varied topography, ranging from snow-capped peaks to verdant valleys, offers a diverse array of environments that sustain a prolific variety of hoverfly species. The unique blend of temperate and alpine ecosystems in J&K creates ideal conditions for a diverse array of flowering plants, which in turn attract and sustain a remarkable diversity of hoverflies. Despite harbouring a rich diversity of life, the insect fauna of J&K remains largely undocumented. This lack of comprehensive documentation stems from the fact that most insect collections in the region were conducted during early expeditions by European taxonomists and collectors, often limited to a small number of locations (Shah et al. 2014). Preliminary studies have revealed the presence of 171 species from the Western Himalayan region (Shah et al. 2014; Sankararaman et al. 2022; Wachkoo et al. 2021) with numerous hoverfly species from Jammu and Kashmir, highlighting its significance as a potential hotspot for hoverfly diversity in India (Shah et al. 2014; Wachkoo et al. 2021; Maqbool et al. 2024b). However, comprehensive surveys and taxonomic studies are still lacking, leaving much to be discovered about the true extent and distribution patterns of hoverflies in this region.

Hoverflies, like many other pollinating insects, exhibit varying degrees of specialization in their floral preferences. Some species are generalists, readily visiting a wide array of flowering plants, while others exhibit a more specialized diet, relying on specific plant species for their nutritional needs. Adult hoverflies rely on floral nectar for energy and pollen as a source of vital elements such as proteins, lipids, and vitamins (Faegri and Pijl, 1979). These floral nutrients are essential for their longevity and reproductive viability (Shahjhan 1968). Given this dependence on flowers, strategically planting attractive and nutritious plants could be a viable strategy for conserving hoverfly populations, ultimately leading to better biological control of plant-eating pests (Heimpel & Jervis 2005). However, to successfully implement such bio-control strategies (Colley and Luna 2000; Tooker et al. 2006).

Comprehending the floral host relationships of hoverflies is essential for understanding their ecological roles and predicting their responses to environmental changes. In Jammu and Kashmir, the pronounced altitudinal zonation establishes discrete ecological gradients that facilitate the development of structurally and compositionally distinct phytocoenoses, each exhibiting characteristic floristic assemblages reflecting specific environmental constraints, microclimatic parameters, and edaphic conditions. These elevation-dependent vegetation zones demonstrate clear phytosociological differentiation, with plant communities exhibiting adaptive responses to variables including temperature regimes, precipitation patterns, soil characteristics, and atmospheric pressure variations that collectively determine species composition, abundance patterns, and ecological niche partitioning across the mountainous landscape's vertical environmental continuum. As one ascends the slopes, the composition of flowering plants shifts, influencing the distribution and abundance of hoverflies along this gradient. Lower elevations, with their warmer temperatures and longer growing seasons, typically support a greater diversity of flowering plants, providing ample foraging opportunities for a wider range of hoverfly species. Conversely, higher elevations exhibit reduced floristic diversity due to harsher climatic conditions and shortened growing seasons, consequently supporting fewer hoverfly species adapted to these resource-limited environments.

Urbanization, a hallmark of human development, is rapidly transforming landscapes worldwide, leading to habitat loss, fragmentation, and degradation. These changes have profound implications for biodiversity, particularly for insects that rely on specific plant resources and microclimatic conditions. Hoverflies, despite their adaptability, are not immune to the pressures of urbanization.

Alarmingly, a recent report from the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) disclosed that over 40% of the world's invertebrate pollinators, including bees and butterflies, are facing extinction (Potts et al. 2016). This decline is likely linked to habitat loss and degradation caused by intensive agriculture and urbanization (Potts et al. 2010), posing a serious threat to future food security. Studies conducted in urban areas across the globe have consistently shown a decline in insect diversity and abundance compared to their rural counterparts (Schweiger et al. 2007; Bates et al. 2011; Biella et al. 2022;). The replacement of natural habitats with concrete jungles, coupled with increased pollution levels and altered microclimates, creates a hostile environment for many insect species. Furthermore, the homogenization of urban landscapes, often characterized by a limited diversity of ornamental plants, can disrupt the delicate balance between pollinators and their floral hosts.

Given the decline of traditional pollinators, alternative pollinators like hoverflies are becoming increasingly important in various ecosystems (Orford et al. 2015; Rader et al. 2020). Interestingly, research on pollinator populations indicates that hoverflies may be declining at a slower rate than other pollinators, such as wild bees (Biesmeijer et al. 2006, Carvalheiro et al. 2013, Powney et al. 2019). This relative stability suggests that hoverflies could play a vital role in maintaining pollination services amidst ongoing environmental changes.

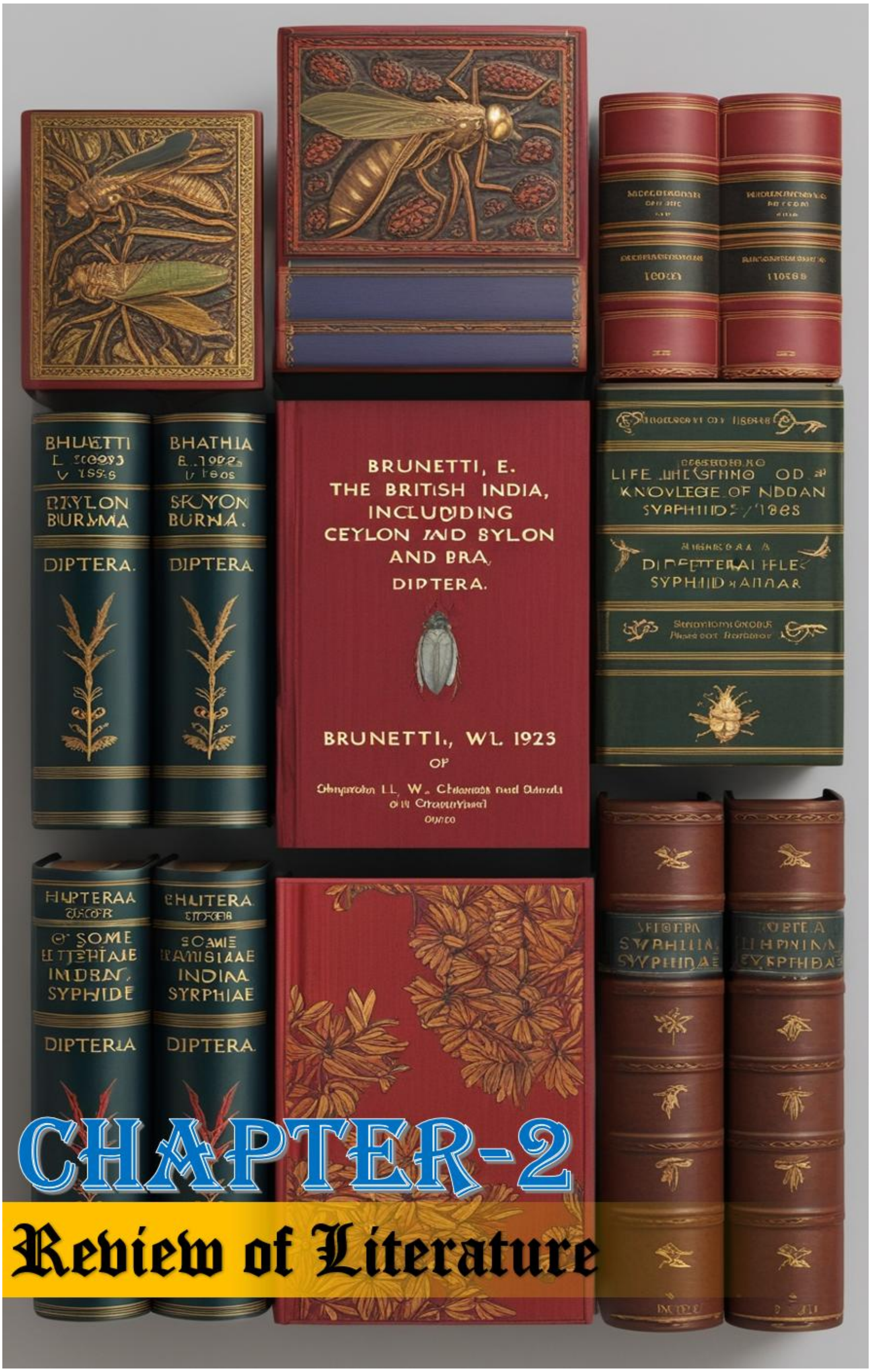
Altitudinal gradients, with their inherent changes in temperature, precipitation, and other environmental factors, act as natural laboratories for studying ecological patterns and processes. As elevation increases, there is a general trend of decreasing temperature, atmospheric pressure, and availability of resources, leading to distinct zonation patterns in plant and animal communities. Hoverflies, with their sensitivity to environmental changes, exhibit clear responses to altitudinal gradients. As one ascends a mountain slope, the composition of hoverfly communities' shifts, reflecting the changing availability of suitable habitats and floral resources. Species adapted to warmer temperatures and lower elevations may be replaced by cold-tolerant species at higher altitudes. Furthermore, the life cycles and phenologies of hoverflies are frequently correlated with the flowering seasons of their host plants, which can differ markedly across altitudinal gradients.

In recent years, mountains, including the Himalayas, have received growing attention due to their rich biodiversity and the increasing threats they face. Mountainous regions encompass approximately 25% of global terrestrial biodiversity (Wester et al. 2019). However, the Himalayan region, including Jammu and Kashmir, exhibits pronounced climate change signatures: rising temperatures, glacial recession, and dynamically shifting precipitation patterns. (Bahuguna et al. 2014; Rashid et al. 2015; Romshoo et al. 2015; Rowan et al. 2015). Coupled with extensive land-use changes, these factors pose a significant threat to the Himalayan region's biodiversity (Hamid et al. 2018). To understand the impact of these threats and prevent the loss of native species, establishing baseline biodiversity inventories is crucial (Bharti & Wachkoo 2013; Sarnat et al. 2013).

Identifying hoverflies in India is challenging due to the absence of comprehensive reference collections, taxonomic revisions, and identification keys. The taxonomy of Indian hoverflies remains incomplete and complicated. Since Brunetti's work in 1923 and Ghorpade's major contributions in 1994 and 2014, there has been no definitive reference source for hoverfly species in India.

The syrphid fauna of India is highly diversified and currently consists of around 362 species in 73 genera whereas 171 species from the western Himalayan region are known (Wachkoo et al. 2021; Sankararaman et al. (2022). India is known for its remarkable biodiversity however, knowledge on the majority of its insect fauna is particularly limited. Likewise, Indian syrphid flies have not been the subject of a dedicated investigation, and the precise number of species is still unknown (Shah et al. 2014; Wachkoo et al. 2021).

Therefore, the goal of the present study was to update and document the taxonomy of the syrphid fauna inhabiting the UT of Jammu and Kashmir. This will serve as a baseline to make it easier for future taxonomists verify what is already known and to encourage more taxonomic research. Future conservation plans and the execution of integrated pest management (IPM) initiatives involving the region's predatory hoverflies would benefit from the data produced. Additionally, it would support the use of local syrphids as possible pollinators in agricultural and natural systems.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CHAPTER-2
Review of Literature

Review of Literature

The Syrphidae (Diptera: Syrphidae), commonly known as flower flies or hoverflies, are a diverse group of insects globally recognized for their ecological roles as pollinators, natural pest control agents, and bioindicators. With over 6,000 species described worldwide, the Syrphidae exhibit significant variability in morphological features such as wing venation, genitalia, and coloration patterns (Hull 1941; 1942; 1944; 1950). The Indian subcontinent, particularly the northwestern Himalayan region, including Jammu and Kashmir, is an important hotspot of Syrphid diversity. This region features a unique confluence of Palaearctic and Oriental influence (Maqbool et al. 2024c; Das 1998), and its varied altitudinal and climatic conditions have contributed to a rich, yet relatively unexplored Syrphid fauna (Shah et al. 2014; Ghorpade 2015). Despite its ecological and biogeographic significance, Syrphidae research in this region remains fragmented and relies heavily on morphology-based taxonomy, with minimal applications of molecular tools such as DNA barcoding or phylogenetics.

Historical Foundations (1920s–1950s)

The taxonomic study of Indian Syrphid fauna began in the early 20th century. Enrico Adelelmo Brunetti (22 May 1862 – 21 January 1927) was one of the first researchers to provide a detailed account of Indian hoverflies (Brunetti 1907a; 1907b; 1908; 1915), contributing descriptions and revisions that formed the basis of subsequent taxonomic work. In 1923, Brunetti wrote 'The Fauna of British India, including Ceylon and Burma', a comprehensive work cataloguing 245 species of Syrphidae spanning 51 genera. This publication served as the most comprehensive reference volume on the Syrphidae family in the Indian subcontinent at that time. Brunetti's initial surveys laid the groundwork for hoverfly taxonomy in India, with numerous species descriptions now forming the basis of Syrphid research throughout the subcontinent (Brunetti 1923). Curran (1929) contributed significantly to the classification of Syrphidae through comparative global studies, providing a framework later used in regional Indian research. A decade after Brunetti's foundational work (1923) Bhatia & Shaffi (1933) expanded on Brunetti's work by describing additional Indian Syrphid taxa and added important details about the life-histories of some Indian hoverfly species. They provided valuable records for the Northwestern Himalayas, including initial documentation of key genera such as *Eristalis* and *Cheilosia* in Jammu and Kashmir. These historical studies provided foundational descriptions, however, suffer from outdated classifications and lack modern revisions rendering them prone to synonymies or taxonomic ambiguities.

Hull (1942; 1944; 1950) further advanced Syrphid taxonomy by refining and revising global Syrphidae classifications, placing Indian Syrphidae within a broader evolutionary and systematic context. His contributions were critical for identifying diagnostic morphological characters, such as male genital traits, which remain integral to hoverfly taxonomy. Though Hull's contributions were primarily global in scope, they supported taxonomic frameworks subsequently applied in regional studies, such as those in Jammu and Kashmir. Another milestone during this era was Deoras (1943), whose surveys added species-specific records for Indian Syrphidae but without significant revisions or analysis of high-altitude diversity.

Expansion of Regional Research (1950s–1980s)

By the mid-20th century, systematic taxonomic research into Indian Syrphidae gained momentum. A study of the Syrphidae in the Karakorum Mountains was conducted by Van Doesburg in (1955). Hippa (1968) made substantial global contributions that influenced Indian taxonomy by emphasizing morphological diagnostic methods, particularly in high-altitude species. In the Indian context, Coe (1964) provided a comprehensive analysis of the diversity of hoverflies in the Oriental region, which indirectly influenced research conducted in Jammu and Kashmir.

Region specific research began to take shape with Nayar's series of contributions (1968a; 1968b) that explored the diverse hoverfly fauna in high-altitude regions of northern India, particularly focusing on the Eristalinae subfamily in the Northwestern Himalayas including Jammu and Kashmir. These works highlighted the unique biogeographic influences of the region and underscored the role of altitude in promoting species specialization. Concurrently, Kohli et al. (1988) expanded the geographic scope of Syrphid studies, including altitudinal records from the Western Himalayas, though the Kashmir-specific focus remained limited.

Consolidation and Checklist Development (1980s–2000s)

The 1980s to the early 2000s saw an increasing emphasis on consolidating and updating Syrphidae taxonomic records for the entire Indian subcontinent, with specific contributions for the northwest Himalayan region. Datta and Chakraborti (1984, 1986) conducted sophisticated surveys of the hoverfly assemblages in Jammu and Kashmir, documenting new high-altitude taxa and providing distribution data critical for understanding regional endemism. Kohli et al. (1988) reinforced the altitudinal specialization of Syrphidae in Jammu and Kashmir, analyzing their distribution across altitudinal zones while identifying ecological drivers of diversity. Kohli et al. (1988) expanded the geographic scope of Syrphid research within Jammu and Kashmir, though gaps in taxonomic revisions persisted.

During this period, Ghorpade emerged as a leading Indian Syrphid taxonomist. Expanding on earlier works, Ghorpade continued producing a series of works (1981, 1994, 1998) that highlighted generational shifts in approach to Syrphidae studies. His key contributions include exhaustive revisions of the tribe Syrphini (Ghorpade 1994), diagnoses of cryptic diversity within endemic northwestern taxa, and integrating biogeography into Syrphid taxonomy. Ghorpade's attention to *Paragus* subgenera (Ghorpade 1998) and revisions of Oriental hoverflies in his seminal work (Ghorpade 1994) brought greater clarity to genus- and species-level identification. Ghorpade's emphasis on resolving synonymies and refining diagnostic characters was critical for establishing systematic checklists in later years

From the 2000 onward, the focus shifted toward consolidating existing records into comprehensive checklists and databases. Shah et al. (2014) synthesized Syrphidae records for the Western Himalayas, listing 55 genera and 169 species, including notes on synonyms, type localities, and distribution. This research, based on historical literature and museum records, forms a baseline for understanding species richness and geographic spread. Ghorpade (2014) identified 553 syrphid species within the Indian subcontinent, categorized into 114 genera, 3 subfamilies and 14 tribes. However, 60 species and 7 genera were considered doubtful. Sengupta et al. (2016) updated hoverfly faunal records for India, compiling 69 genera and 355 species while standardizing current nomenclature. Ghorpade (2015) provided a comprehensive checklist of 340 species over 96 taxa from the Northwest Frontier of the Indian subcontinent.

While these taxonomic compilations represent fundamental systematic contributions to regional syrphid documentation, they constitute the primary informational framework for understanding Jammu and Kashmir's dipteran diversity.

However, these works exhibit significant methodological limitations that constrain their taxonomic utility. The absence of diagnostic photographic documentation prevents accurate visual identification protocols. Additionally, exclusive reliance on external morphological characterization occurs without detailed examination of critical taxonomic features. Specifically, male genetalia architecture and other genitalic structures remain unexamined, limiting species-level resolution capabilities. Furthermore, the lack of molecular phylogenetic analyses restricts modern taxonomic approaches. These limitations collectively hinder accurate species identification and constrain the potential for resolving complex taxonomic ambiguities within regional syrphid assemblages.

Recent Advances and Molecular Integrations (2010–Present)

Recent exploration in the Kashmir Himalayas has boosted the discovery of syrphid flies, uncovering both new species and expanding the known distribution of others. (Wachkoo et al. 2019, 2022; Maqbool et al. 2023, 2024). The most recent works on Syrphidae in Jammu and Kashmir have focused on addressing gaps in baseline data through targeted regional surveys and the use of modern approaches. Mengual & Barkalov (2019) introduced molecular tools, such as COI barcoding and ribosomal sequencing, to describe two new species of Rohdendorfia from Jammu and Kashmir. This investigation constitutes the first comprehensive integrative taxonomic framework implemented within the northwestern Himalayan biogeographical province, representing a methodological advancement through synergistic integration of molecular phylogenetic analyses, DNA barcoding protocols, and traditional morphological diagnostic approaches. The study establishes taxonomic standards by incorporating multi-gene sequencing alongside detailed morphometric assessments, thereby addressing critical impediments that have constrained accurate species delimitation within regional Syrphidae assemblages and facilitating resolution of cryptic complexes through independent molecular validation of morphologically-based hypotheses.

Based on adult morphology, male genitalia and DNA barcoding Wachkoo et al. (2021) reported *Lejogaster tarsata* (Megerle in Meigen 1822) and *Helophilus trivittatus* (Fabricius 1805) for the first time from India. Maqbool et al. (2023) reported the genus *Myathropa* for the first time from Indian subcontinent, expanding the known geographic range of this genus into the Kashmir Himalayas. This, along with the checklist by Shah et al. (2014), highlights the potential for discovering overlooked taxa in Jammu and Kashmir. However, these surveys remain limited in their geographic range, with significant under-sampling of remote high-altitude ecosystems.

Recently Maqbool et al. (2024) described a new species, *Spilomyia recta*, through comprehensive systematic characterization including molecular markers. This species was earlier misidentified from South Asia as *Spilomyia manicata* (Rondani, 1865). This is the sole legitimate species of the genus *Spilomyia* from India and Pakistan, and the third recognised species from Afghanistan, occurring in both the Palaearctic and Oriental regions.

Maqbool et al. (2024c) recently confirmed the presence of *Criorhina vivida* Brunetti, 1923 from India by providing the description of previously unknown male. In the same study, notes on the distribution and a country checklist of the genus was also provided.

Wachkoo et al. (2020) and Khan & Riyaz (2017) have examined Syrphid diversity in agricultural ecosystems within Kashmir, highlighting environmental factors such as pesticide use but offering limited contributions to regional taxonomy.

From adjacent regions, surveys in Himachal Pradesh (Sengupta et al. 2018) and northern Pakistan (Hassan et al. 2018) have documented shared taxa and biogeographic connections, further underlining the significance of Jammu and Kashmir as a transitional zone. These works also point to possible distributional continuity among high-altitude Syrphidae.

Current Challenges and Future Directions

While significant progress has been made in cataloguing Syrphidae within Jammu and Kashmir, challenges remain. Current research is largely reliant on morphology-focused methods, with few studies incorporating molecular tools such as DNA barcoding or phylogenetics. Historical records, particularly those by Brunetti (1920s) and Hull (1940s), demand thorough revision to resolve species-level ambiguities and synonymies. Remote and higher-altitude areas in Jammu and Kashmir also remain under-sampled, primarily due to logistical and geopolitical barriers.

Future research must prioritize integrative taxonomic approaches, combining traditional morphological analysis with molecular methods. Applying tools such as COI barcoding and nuclear gene sequencing, as seen in Mengual & Barkalov (2019), Wachkoo et al. (2021) and Maqbool et al. (2024) can uncover cryptic diversity and clarify evolutionary relationships between regional Syrphid taxa. Additionally, systematic surveys in underexplored regions are necessary to refine biogeographic patterns and document endemic taxa.

The Effects of Altitudinal Gradients on Hoverfly (Syrphidae) diversity

Altitudinal gradients represent key ecological zones where sharp environmental changes occur over short geographic distances, providing natural laboratories for understanding biodiversity patterns. Hoverflies (Syrphidae), an ecologically significant group of pollinators and biocontrol agents, exhibit distinct patterns in species richness and abundance along altitudes, often following unimodal diversity trends —a phenomenon whereby peak species diversity occurs at mid-elevational zones rather than monotonically decreasing with altitude, in temperate zones (Ferreira et al. 2012; Sommaggio et al. 2022). This pattern is influenced by abiotic drivers, particularly temperature, which constrains species richness at higher altitudes, and biotic factors like competition and floral diversity at lower and mid-elevations (Meyer et al. 2009; Babaei et al. 2018).

Hoverflies (Diptera: Syrphidae) are essential components of temperate ecosystems. As pollinators of flowering plants and predators of pest species during their larval stages, hoverflies provide critical ecosystem services (Keil & Konvička 2005). While hoverflies typically dominate pollinator communities at higher altitudes, they often compete with bees and other pollinators at lower elevations (McCabe et al. 2021; Sommaggio et al. 2022). Additionally, interactions between abiotic and biotic factors, including floral resource availability and thermal tolerance, contribute to unique patterns of species turnover and community composition along these gradients (Keil & Konvička 2005; Sinha et al. 2022). This review focuses on studies analyzing the effects of altitudinal gradients on hoverfly species richness and abundance, exploring abiotic and biotic drivers of diversity, comparative pollinator community dynamics, and the implications of climate change on altitudinal species distributions.

Sommaggio et al. (2022) while studying hoverfly diversity in the Dolomiti Bellunesi National Park, Italy, found that Syrphid fly abundance exhibited a unimodal distribution, peaking at elevations where floral diversity and resource availability were maximized. In contrast, bees followed a linear richness decline with increasing altitude. Similar results were identified in Central Europe, where hoverfly richness peaked at intermediate altitudes due to favourable temperature regimes and resource heterogeneity (Keil & Konvička 2005).

Mid-elevation peaks are partly attributed to the thermal physiology of hoverflies. Lower-elevation zones are characterized by higher temperatures, which increase competition from other pollinators like bees (McCabe et al. 2021; McCabe et al. 2019). Conversely, high altitudes are limited by thermal constraints that reduce larval developmental success for thermophilic hoverflies (Babaei et al. 2018). At mid-elevations, resource diversity is maximized, and competition with other taxa tends to be less pronounced, supporting unique hoverfly assemblages (Ferreira et al. 2012).

Temperature constitutes the predominant abiotic factor governing syrphid diversity patterns across elevational gradients (Keil & Konvička 2005; Ferreira et al. 2012). Altitudinal temperature decline imposes direct physiological constraints on hoverfly populations, reducing metabolic activity and constraining reproductive cycles. Himalayan investigations in Himachal Pradesh demonstrated strong correlations between hoverfly abundance and thermal parameters, with cold-adapted communities exhibiting reduced diversity at higher elevations (Sengupta et al. 2018; Sinha et al. 2022). European studies reveal thermal tolerance drives morphological trait selection, particularly body size and melanic coloration, with darker-pigmented species predominating in high-altitude thermal environments (McCabe et al. 2019).

Elevation differentially structures hoverfly assemblages through habitat complexity modifications, topographic gradients, and vegetation heterogeneity. Ferreira et al. (2012) demonstrated pronounced niche differentiation between lowland and upland dipteran communities, with mid-elevation zones exhibiting optimal niche predictability. Temperature regimes indirectly modulate hoverfly species richness by influencing phenological synchronization and larval resource dynamics (Babaei et al. 2018; Sinha et al. 2022). Extreme thermal fluctuations at high elevations disrupt mutualistic plant-pollinator networks, subsequently reducing syrphid abundance (McCabe et al. 2019).

Floral resource availability plays a crucial role in shaping hoverfly richness and abundance along altitudinal gradients. Hoverfly populations are reliant on adults' access to floral nectar and pollen and larvae's access to microhabitats like aphid-infested plants or decaying matter (Babaei et al. 2018). Studies have consistently demonstrated positive correlations between floral diversity, floral abundance, and syrphid richness at mid-elevations, suggesting that diverse floral communities act as ecological drivers for species diversity (Babaei et al. 2018; Hussain et al. 2018). Sommaggio et al. (2022) found that mid-elevation peaks in syrphid diversity corresponded with clusters of flowering plant species, while low and high altitudes provided fewer floral resources.

Larval microhabitats are equally important in determining hoverfly distributions. For example, saproxylic syrphids depend on decaying wood or organic matter, which decreases with altitude due to cold-constrained tree growth (Larrieu et al. 2015). Aphidophagous syrphids, meanwhile, require aphid-infested plants, frequently found in lowland habitats but shifting with the altitudinal distribution of host plants (McCabe et al. 2019).

Hoverflies also interact with other pollinators along altitudinal gradients. At lower altitudes, hoverflies may be outcompeted by bees, which capitalize on greater floral resources and nesting sites (Sommaggio et al. 2022). However, hoverflies dominate pollinator communities at mid and high altitudes, where bees experience thermal constraints (McCabe et al. 2021). This shift reflects hoverflies' resilience to high-altitude conditions and their ability to occupy generalized niches in pollination networks.

Species turnover along altitudinal gradients reflects the dynamic nature of hoverfly communities. Unlike nestedness, which occurs when lower-elevation assemblages are subsets of higher-altitude communities, turnover occurs as unique species replace others along elevation (Sommaggio et al. 2022). Ferreira et al. (2012) found that hoverfly assemblages were sharply partitioned along elevation, with NMDS analyses demonstrating clear separation of species into distinct mid-altitude niches.

Hoverflies exhibit community resilience at altitudes where other pollinators decline. Abrams et al. (2023) synthesized data showing bees' dominance wanes at altitudes exceeding 2000 m, with Diptera replacing Hymenoptera as primary floral visitors (McCabe et al. 2021). Hoverfly-dominated assemblages tend to maintain functional redundancy in pollination systems, ensuring ecosystem stability in these zones (Ferreira et al. 2012; McCabe et al. 2019).

Climate change presents a substantial threat to the stability of hoverfly distributions across altitudinal gradients. Warming trends may force thermophilic species to expand to higher altitudes, resulting in a loss of mid-elevation diversity and potential homogenization of hoverfly communities (McCabe et al. 2021). Phenological mismatches between hoverflies and flowering plants are also likely to increase under changing temperature regimes, disrupting key pollination services (Sommaggio et al. 2022).

Conclusion

The Syrphidae of Jammu and Kashmir represent a rich but underexplored assemblage shaped by the unique biogeography of the Northwestern Himalayas. While historical works by Brunetti, Bhatia, and Ghorpade have provided a solid foundation, the field remains constrained by outdated datasets, incomplete sampling, and a lack of molecular research. Recent advancements, including molecular phylogenetics and integrative taxonomy, indicate promising directions for future studies. Expanding survey efforts and employing modern methodologies are critical to uncovering the full taxonomic diversity of Syrphidae in this biodiversity-rich region.

Altitudinal gradients in temperate zones reveal robust patterns of hoverfly species richness and abundance, typically following unimodal trends driven by complex interactions between abiotic factors such as temperature and biotic drivers like floral diversity. Hoverflies' dominance as high-altitude pollinators emphasize their critical ecological role, particularly as global warming reshapes altitudinal distributions. Further studies should focus on integrating larval microhabitats into altitudinal research and monitoring range shifts driven by climate change.

Hoverflies exhibit clear and measurable responses to urbanization gradients, with urban areas favouring generalist species at the expense of functional richness and ecological resilience. Suburban and peri-urban landscapes serve as critical intermediate zones, balancing green space connectivity and floral resource diversity. However, urban-driven beta diversity declines and phenological mismatches pose challenges to ecosystem service provision. Moving forward, conservation actions must emphasize habitat heterogeneity, connectivity, and native floral resource availability in temperate urban contexts to sustain hoverfly populations and their functional roles.

Hoverfly Diversity and Composition Along Urbanization Gradients

Hoverflies (Diptera: Syrphidae) are important pollinators and biological control agents, with their functional diversity spanning larval feeding types (e.g., aphid predators, saprophages) and adult foraging traits. Urbanization gradients, which encompass rural, suburban, and urban habitats, alter landscape structure, habitat connectivity, and floral resource availability, driving changes in hoverfly species richness, abundance, community composition, and functional traits. This review synthesizes findings from recent and foundational studies to evaluate how urbanization influences hoverfly diversity, functional traits, and ecosystem services in temperate zones.

Urbanization is strongly associated with declines in hoverfly diversity. Numerous studies confirm that highly urbanized areas harbour reduced hoverfly species richness and abundance compared to suburban or rural landscapes (Schweiger et al. 2006; Bates et al. 2011). Urbanization-induced habitat fragmentation and loss of native vegetation disproportionately filter out specialist species reliant on specific larval habitats or floral resources. De Groot et al. (2022) for example, discovered that urban and peri-urban woods in Slovenia maintained hoverfly richness comparable to rural sites, the functional composition shifted toward generalist species adapted to resource variability. Similarly, Bates et al. (2011) observed significant declines in hoverfly diversity along an urban-rural gradient in the United Kingdom, with community composition showing a dominance of generalists such as *Episyrphus balteatus* in urban areas, while rural sites supported higher niche specialization.

Suburban landscapes often emerge as biodiversity hotspots for hoverflies, reflecting an intermediate zone with sufficient floral resources and limited habitat fragmentation. In Northern Italy, hoverfly abundance peaked in suburban zones with moderate impervious surface cover (22-35%) before sharply declining in urban cores (Biella et al. 2021). These findings emphasize that suburban habitats may combine resources from both rural and urban matrices, offering niche space for diverse hoverfly communities. However, the ability of suburban environments to sustain hoverfly diversity depends on green space connectivity, patch size, and local floral heterogeneity.

Despite their adjustments to urbanization, hoverflies are not immune to biotic homogenization. Urbanization often drives beta diversity declines as hoverfly communities in urban cores become compositionally similar due to the dominance of a few widespread, generalist species (e.g., *Syrphus ribesii*) (Schweiger et al. 2006; McCune et al. 2023). This homogenization is concerning as it reduces ecological redundancy and resilience—the capacity for ecosystems to maintain function despite environmental disturbances.

Functional trait filtering is among the most pronounced effects of urbanization on hoverfly communities, with traits such as foraging specialization, dispersal ability, body size, and larval ecology influencing species' ability to persist in modified environments. Generalist foragers with broad dietary preferences and flexible habitat requirements are disproportionately favoured in urbanized landscapes. Biella et al. (2021) found that urbanization gradients reduced the functional richness of hoverfly communities, as specialists dependent on specific larval microhabitats (e.g., aphidophagous or saproxylic species) were lost. Schweiger et al. (2006) similarly observed that species with specialized resource niches were most vulnerable to intensive land use, while functional diversity within generalist groups remained stable.

The dependence on floral resources during adulthood further shapes hoverfly responses to urban environments. Urban landscapes, dominated by ornamental or invasive plant species, often fail to meet the needs of specialist nectar-feeders. Floral traits such as corolla depth and nectar accessibility create mismatches that prevent some hoverfly species from utilizing widespread urban blooms effectively (Klečka et al. 2018). Despite this challenge, generalist hoverflies exploit these resources opportunistically. Traits such as elongated mouthparts and polyphagy, observed in dominant urban species like *Episyrphus balteatus* and *Eupeodes corollae*, enable these species to thrive in urban settings characterized by small, tubular flowers (Branquart & Hemptinne 2000).

Shifts in hoverfly functional responses impact broader ecosystem services. In urbanized temperate regions, hoverflies often dominate pollinator guilds where other groups, such as solitary bees, decline due to limited nesting resources and pesticide use (Bates et al. 2011; Rocha et al. 2018). However, urban habitats may also limit hoverfly-mediated aphid control, as prey abundance and diversity fluctuate irregularly in response to environmental stressors (e.g., heat islands, pesticide usage in gardens) (Rocha et al. 2018).

The structure and connectivity of green spaces play a critical role in supporting hoverfly populations within urban-fragmented landscapes. Research consistently highlights the importance of larger patch sizes and linked networks (e.g., hedgerows, roadside verges) in maintaining hoverfly diversity and functional attributes (Moquet et al. 2017). For instance, isolated forest fragments in southern France exhibited lower species richness and reduced functional trait diversity compared to better-connected patches, with landscape connectivity and structural heterogeneity serving as important predictors of hoverfly occurrence and assemblage composition (Ouin et al. 2006). Similarly, Grossmann et al. (2022) emphasize that urban dry grasslands, when connected by ecological corridors, support diverse pollinator communities, including endangered species.

Suburban and peri-urban green spaces offer intermediate patch connectivity that is critical for sustaining hoverfly diversity. For example, Schirmel et al. (2018) found that increasing the proportion of semi-natural habitats within agricultural-dominated regions significantly enhanced the species richness of hoverflies across rural-to-urban landscape gradients. Ecological corridors also facilitate dispersal and genetic connectivity. Notably, Wittische et al. (2023) reported unexpectedly high genetic flow among urban hoverfly populations, challenging assumptions about the colonization barriers posed by fragmented urban environments.

Urban environmental changes, including heat islands, altered microclimates, and year-round resource availability, impact hoverfly phenology. Urban microclimates often extend hoverfly activity periods, enabling urban populations to exploit resources over longer periods compared to rural counterparts (Luder et al. 2018; Zaninotto et al. 2021). However, this phenological expansion is not without consequences. Urban warming can create temporal mismatches between hoverfly activity and floral resource peaks, with flowering advancing earlier in the year while pollinator flight periods remain static (Fisogni et al. 2020). For specialist species, phenological mismatches may lead to reduced survival and lower reproduction rates, particularly during early spring (Fisogni et al. 2020).

Interestingly, the phenological responses of migratory and non-migratory hoverfly species differ. Luder et al. (2018) observed that non-migratory species are more resilient to urban-induced phenological changes, likely due to their reliance on stable local resources compared to the more variable resources used by migratory species. These findings highlight the need to examine phenology in more detail to better understand hoverfly resilience to urban environmental change.

Conservation strategies must prioritize habitat heterogeneity, native floral resources, and connectivity to alleviate the adverse effects of urbanisation on hoverfly populations. Numerous studies highlight the significance of urban green spaces as biodiversity reservoirs when managed appropriately. For example, flower strips and hedgerows within residential and peri-urban regions significantly increase hoverfly abundance, particularly for aphidophagous species that contribute to biological pest control (Haenke et al. 2009; Moquet et al. 2017). In addition, designing urban parks with diverse flowering plant species (including native species) can help support pollination and pest control functions year-round.

Ecological corridors, such as vegetated road verges and hedgerows, are particularly effective for connecting fragmented habitats and maintaining hoverfly beta diversity (Schirmel et al. 2018). Larger green patches and ecological infrastructure at landscape scales have repeatedly been shown to enhance overall richness and disproportionately benefit specialist and saproxylic species (Ouin et al. 2006; McCune et al. 2023). Management practices that promote urban habitat connectivity can also sustain populations of species with limited dispersal ability.

Hypothesis

The comprehensive taxonomic and ecological investigation of Syrphidae (Diptera) in the Jammu and Kashmir Union Territory will test the following primary hypotheses:

1. Taxonomic Diversity Hypothesis:

The region harbours an unexplored and potentially high degree of taxonomic complexity within the Syrphidae family, with the potential to discover many undescribed species, novel genera and unrecorded species distributions.

2. Biodiversity and Distribution Hypothesis:

Hoverfly species diversity in the Jammu and Kashmir region exhibits significant variation along altitudinal gradients, with species richness and composition demonstrating a unimodal distribution pattern, peaking at mid-elevation zones, and showing a negative correlation with increasing urbanization intensity.

3. Ecological Interaction Hypothesis:

Syrphid fly species demonstrate specialized floral host interactions, with preferential associations varying across different altitude zones, particularly influenced by dominant plant families such as Asteraceae and Apiaceae.

Objectives

1. Comprehensive taxonomic revisions and preparation of syrphid fly species inventory of Jammu and Kashmir.
2. Plant pollinator interactions along an elevation gradient.
3. Species composition along variable environmental gradients.


CHAPTER-3
Materials & Methods

MATERIALS AND METHODS

3.1 Study Area

UT of Jammu and Kashmir

Situated in the far north of India, the union territory of Jammu and Kashmir (Figure 1) spans a geographically diverse region, within the latitude 32.28–37.06° and longitude 72.53–80. 32°, with altitudes ranging from 220 to 8611 m (amsl). This region forms a geographic part of western Himalayas (Figure 2). The Western Himalayan region of India includes Jammu and Kashmir to the west, Himachal Pradesh in the centre, and Uttarakhand to the east. Based on physiographic characteristics, it's categorized into four zones: the Shivalik Hills (foothills across several states), the Lower Himalaya (including ranges like Dhauladhar and Pirpanjal), The Great Himalaya (located north of the Kashmir Valley and portions of Kumaon and Garhwal) and the Trans Himalaya (comprising the Karakoram, Ladakh, and Zanskar ranges) (Shah et al. 2014).

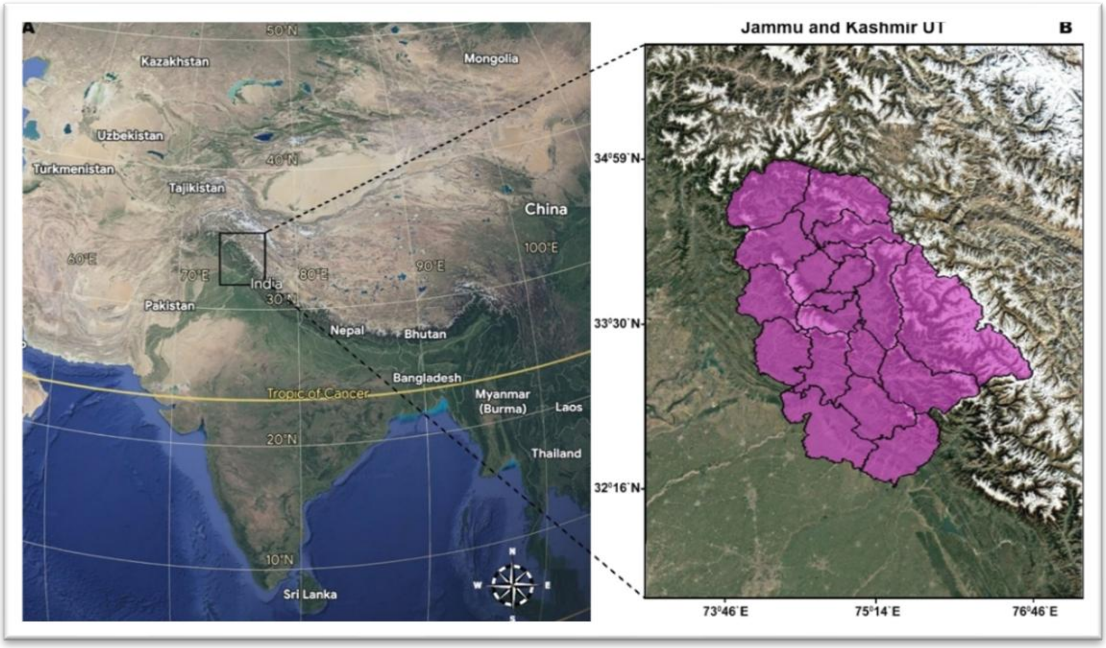

Figure 1: Map showing Indian Subcontinent (A), study area (UT of Jammu and Kashmir-B).

3.2 Sampling sites:

Sampling for general hoverfly collection was carried-out in different locatiotions of Jammu and Kashmir including low altitude urban centres as well as high altitude alpine forests and grasslands (Figure 4). For urbanization analysis, sampling was done from 3 sites selected based on urbanization level of low (Rafiabad, Baramulla), moderate (Khanabal, Anantnag) and High (MA road, Srinagar). For urbanization gradient analysis, sampling localities were strategically selected across three distinct anthropogenic disturbance categories: low-intensity urban development (Rafiabad, Baramulla district), intermediate urbanization pressure (Khanabal, Anantnag district), and high-density urban matrix (MA Road, Srinagar district). For altitudinal gradient assessment, sampling protocols were implemented across three distinct elevational transects: Rafiabad (spanning 1800-2400 meters above sea level), Botapathri (encompassing 2100-3000 meters above sea level), and Limber Wildlife Sanctuary (ranging from 2100-2600 meters above sea level). These sites provided comprehensive elevational coverage for investigating altitude-mediated ecological patterns and species assemblage dynamics across alpine and subalpine environments.

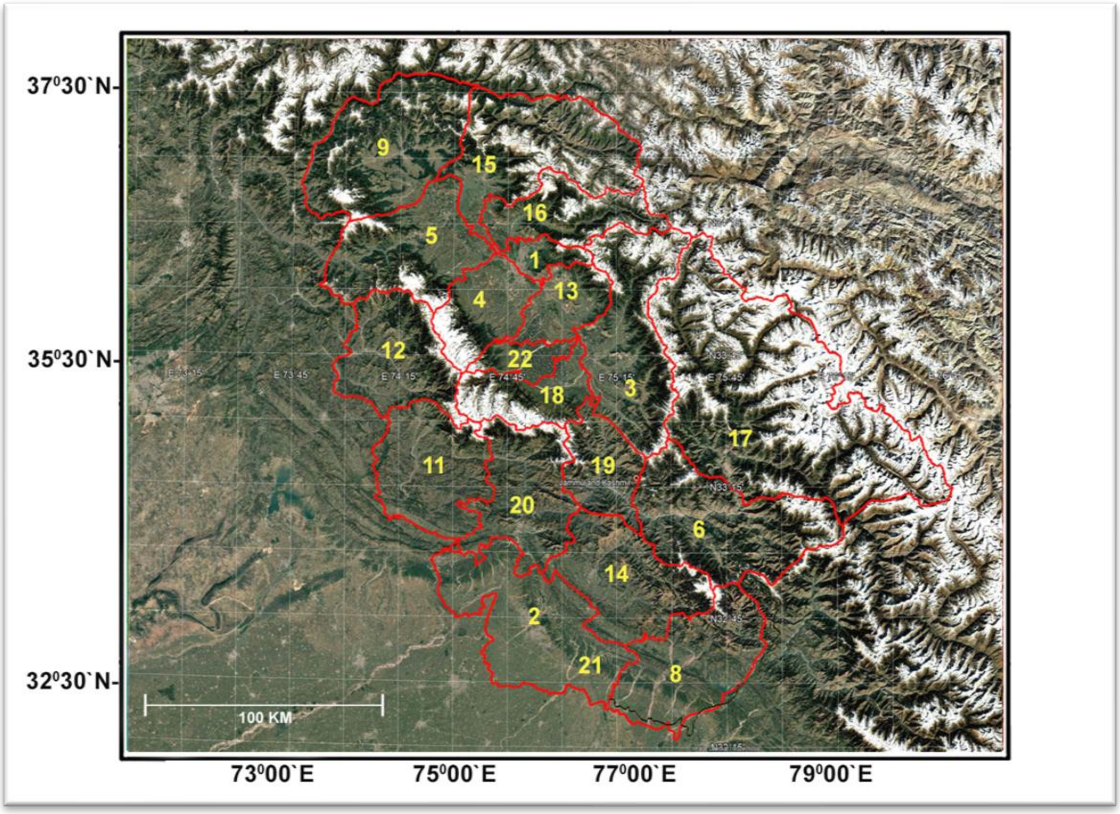

Figure 2: Map of UT of Jammu and Kashmir showing different districts. 1: Srinagar; 2: Jammu; 3: Anantnag; 4: Budgam; 5: Baramulla; 6: Doda; Kathua; 9: Kupwara; 11: Rajouri; 12: Poonch; 13: Pulwama; 14: Udhampur; 15: Bandipora; 16: Ganderbal; 17: Kistwar; 18: Kulgam; 19: Ramban; 20: Reasi; 21: Samba; 22: Shopian.

To collect and monitor adult hoverfly species from the study area, passive and active standardized methods were used. Passive collections were made using yellow pan traps (Montoya 2021) and entomological nets were utilised for active sampling (Leather 2005). Pan-trap sampling methods are regarded as the standard technique for studying hoverfly species diversity, as they capture a greater proportion of hoverfly species richness (Nielsen et al. 2011), in addition to being an economical sampling method (Westphal et al. 2008). The employment of active netting in conjunction with pan-traps, enhances the diversity of sampled species. (Nielsen et al. 2011). Both sampling methods were used simultaneously during sampling events.

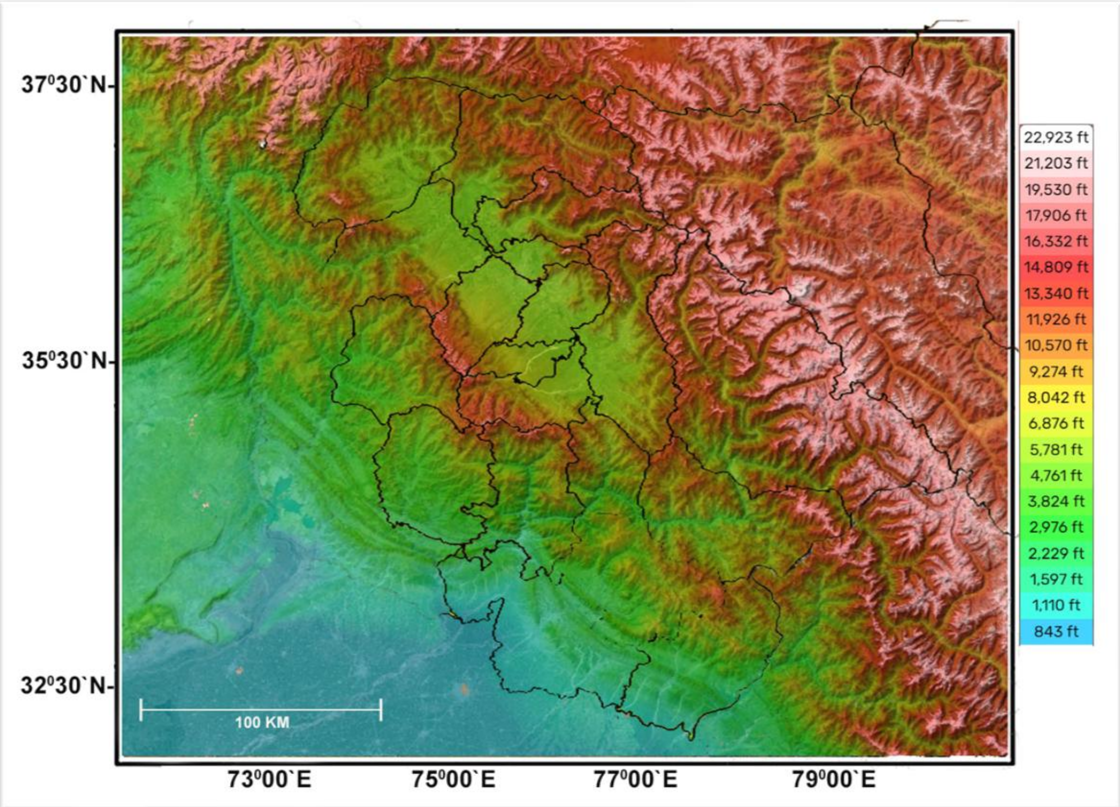

Figure 3: Digital Elevation Map (DEM) of Jammu and Kashmir.

3.3 Sampling design

For the collection of adult fly specimens and to characterize the spatial distribution of

Syrphid diversity, bi-weekly surveys and sampling were conducted in different localities distributed along variable altitude and urbanization gradient (Bates et al. 2011; Sommaggio et al. 2022).

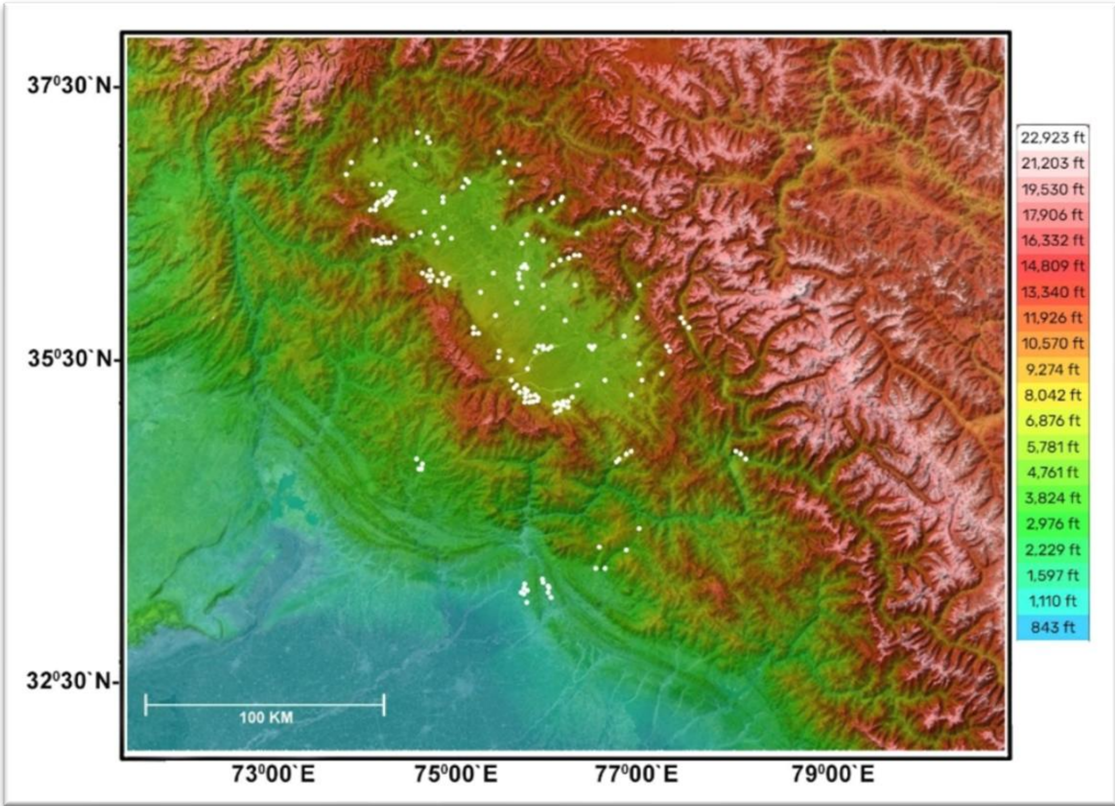

Figure 4: Digital Elevation Map (DEM) of Jammu and Kashmir showing total sampling events

3.3.1 Altitudinal gradient:

3.3.2 Samples were collected at various elevations in the northern Kashmir Himalayas. Three sites with an altitudinal gradient were selected for sampling: Botapathri, with an altitudinal gradient of 2300-3000 m a.s.l., Limber, with an altitudinal gradient of gradient of 2100-2600 m a.s.l. Rafiabad, with an altitudinal gradient of 1800-2300 m (amsl) (Figure 5). Circular plots with a radius of 50 meters were selected, maintaining an approximate distance of 100 meters between consecutive sites. 3 sampling points were selected within each plot and 3 yellow pan traps (15 cm radius; 5 cm height) were placed within each sampling point. Biweekly activation of pan traps was done every month from May to October (2021-2023). Water containing a few drops of liquid baby soap (surfactant) was kept in the pan traps (Figure 8). Samples were collected from pan traps after 24 hrs in the field. Sampling was discarded in case of raining. Netting along the transects was simultaneously carried out on the same days on which pan traps were activated. The surveys were conducted using the sweeping method, with a speed of 500–600 m per hour along each line, covering a range of 5 m for insect collection around the line. Within each transect, the samples from the three plots were pooled together.

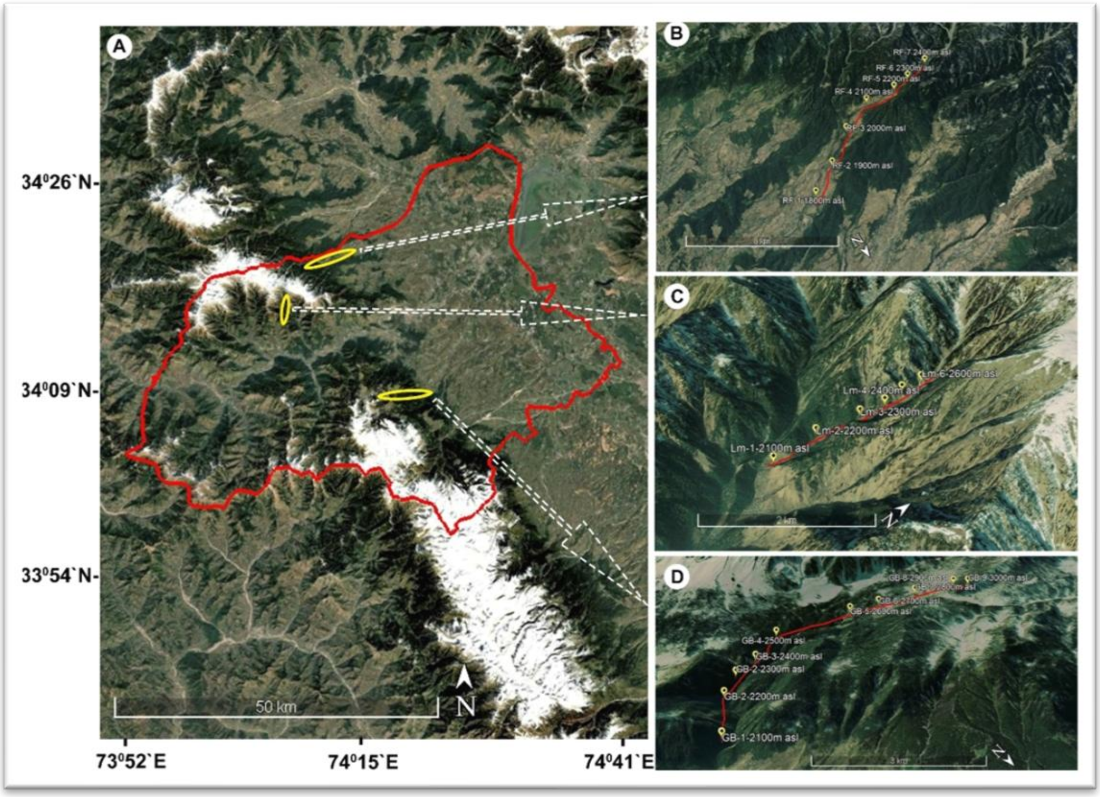

Figure 5: Map showing altitudinal transact sampling sites in district Baramulla (A), Rafiabad transact (B), Limber Transact (C), Gulmarg-Botapathri Transact (D).

3.3.3 Urbanization gradient:

To study the effect of urbanization, 3 sampling sites were selected based on urbanization level: Rafiabad forest patch (low) in district Baramulla with very low urbanization level, GDC Anantnag botanical garden with medium urbanization level (moderate) and GCW M.A. Road botanical Garden (high) in district Srinagar with a high level of urbanization.

3.4 Diversity Analysis

Alpha diversity, representing the average species diversity within a specific habitat, was determined for Syrphidae. Abundance was analyzed, and overall diversity was calculated using various indices, including the Shannon-Wiener index, species richness, evenness, and dominance diversity (Berger-Parker index, 1970). Hoverfly diversity assessment was conducted through systematic implementation of elevational transect methodology, employing standardized sampling protocols across distinct altitudinal zones to elucidate species assemblage patterns and community structure dynamics along environmental gradients (Hackenberger et al. 2009; Maity et al. 2018). Diversity indices were pooled across elevation gradients.

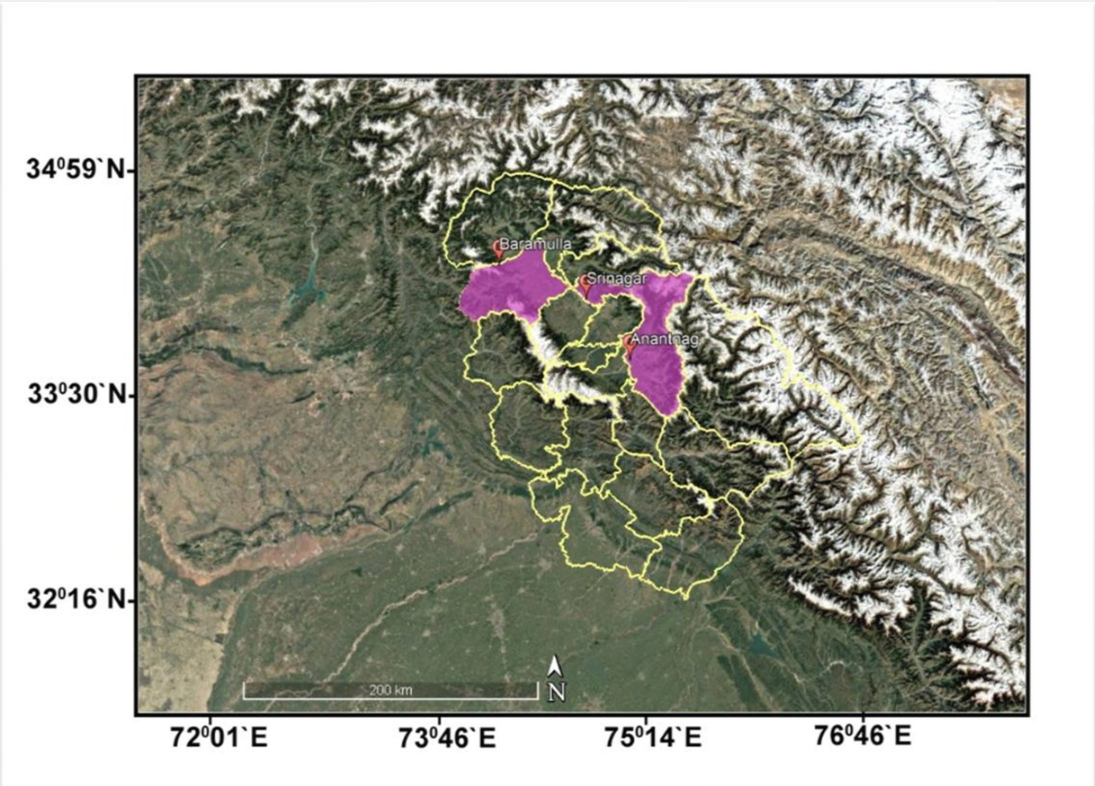

Figure 6: Map showing three sampling sites along an urbanization gradient in jammu and kashmir (Anantnag-high, Baramulla-low, Srinagar- moderated urbanization)

Shannon-Wiener's Diversity Index (Shannon & Wiener, 1949): This is a statistical measure that presupposes all species are represented in a sample and that the species have been randomly sampled**.** It is represented by the symbol H.

Shannon Index $H = -\sum_{i=}^{s} pi * ln\, p_i$ (where value of i lies between 1 to S)

Where, H= Shannon index

pi = proportion of individuals of species i, and

ln is the natural logarithm, and

S = species richness.

∑is the sum of calculations.

Evenness Index:

The Simpson's diversity index (SD) quantifies the likelihood that two randomly chosen individuals from a substantial population are of the same species. As a robust diversity measure, it emphasizes the most abundant species and is less influenced by species richness (Magurran 2004). Its complement (1 - SD) represents the Simpson's evenness index. The Berger-Parker dominance index (BPD) calculates the proportion of individuals in the most abundant species relative to the total population. Its reciprocal (1/BPD) serves as the Berger Parker evenness, which is considered a simple yet informative diversity measure (Magurran 2004). Due to the different sensitivities of these indices (SD is sensitive to species abundance distribution and BPD to species richness) both evenness indexes were calculated for more comprehensive ecological analysis.

3.5 Plant pollinator interactions

During sampling events, floral visitation patterns exhibited by hoverfly species were systematically documented through direct visual observation protocols, with visitation frequencies quantified using standardized behavioral monitoring techniques (Ambrosino et al. 2006). These observations were recorded and photographed (wherever possible). Reference specimens were also collected from the plants for future identification confirmation.

3.6 Mounting and Preservation

After collection the flies were killed with ethyl acetate vapours (Walker and Crosby 1998; Schauff 2001) and preserved dry (pinned) or in liquid preservative. Pinning was done in the following two ways:

1. Pin Mounting: The specimens were pinned (Krogmann 2010), stretched and kept in wooden boxes (Schauff 2001) for further taxonomic studies.

2. Card Mounting: Smaller syrphids were mounted on small triangular card points by glueing them to the card. To reduce the shrinking in very small species, ethanol preserved (70-75% ethanol) specimens were given HMDS (hexamethyldisilazane) treatment (Heraty & Hawks 1998) and later card-point mounted (Noyes 2009).

Labels: Labels were appended to each specimen carrying information regarding locality, date of collection and name of collector (Krogmann 2010).

3.7 Morphological studies

To conduct the morphological examination for taxonomic characterization, a stereozoom microscope (G2Mark, India) was used. Identification up to the lowest possible taxonomic level was carried out using illustrated guides (Stubbs and Falk 2002; Skevington et al. 2019) and following identification keys (Brunetti 1923; Ghorpade 1994; Van Veen 2004; Miranda et al. 2013). Specimens were also compared with the type material wherever possible. For terminology, the glossary in Skevington et al. (2019) and Van Steenis et al. 2023 was followed.

3.8 Dissections of Male Genitalia

We followed the genitalia extraction and preparation procedure outlined by Wachkoo et al. (2021). Male genetalia of freshly killed specimens were teased out with very fine, terminally hooked, teasing needles and observed under stereomicroscope. For dry and hard specimens, a relaxing fluid was used (Barber's fluid) to relax the apical segments and then genitalia were extracted carefully with the same hooked teasing needles. Dissected material was left overnight (12-14 hours) clearing in a 10-30% potassium hydroxide (KOH) solution to facilitate soft tissue dissolution. Subsequently, the genitalia were briefly immersed in acetic acid, thoroughly rinsed with ethanol, and then transferred to glycerine. The final step involved slide-mounting (temporary mount) the prepared genitalia in glycerol for detailed microscopic examination.

3.9 Photography

In our specimen photography methodology, we followed the protocol established by Wachkoo et al. (2021). Adult specimens were positioned within a lightbox for proper light diffusion and exposure (Figure 13). Batches of variable focus images were generated utilizing an image stacking equipment (Stackrail rs90) (Figure 17). Multiple focus images captured with a digital mirrorless camera (Nikon Z50) supplemented with a 100mm macro lens (Tokina, Japan) were then focus stacked using Combine ZP software into a single merged image. The final images were cleaned and processed in Adobe Photoshop CS4.

For slide photography, we adopted the methodology of Maqbool et al. (2021). Genitalia slides were positioned on a cardboard stage, with transmission light being produced by a dimmable LED light source. The previously described camera setup was employed to capture these images (Figure 19).

Our approach ensured precise, high-resolution documentation of specimen morphological details through carefully controlled photographic techniques, facilitating accurate scientific visualization and analysis.

3.10 Distributional pattern maps

Species distribution maps were generated using Google Earth and ArcGIS software (ESRI 2011). Field-collected GPS data were converted into point-type shapefile layers and plotted on the study area map (Bogusch 2020).

3.11 Data Analysis

Influence of elevation on hoverfly diversity was analysed. Polynomial regression models of the second degree (quadratic) were used, with elevation serving as the independent variable ($P < 0.05$). Species abundance across different sampling sites with variable urbanization gradient was compared for differences using Kruskal-Wallis test followed by a post-hoc test (Dunn's test). For the analysis of species compositional data standard statistical analyses were performed using R software (version R 4.02), employing different packages (Hmisc and vegan). Graphs were generated with ggplot2, ggpubr and Microsoft excel.

Figure 7: Active Netting with entomological net

Figure 8: Pooting technique to collect small specimens

Figure 9: Yellow pan trap with 24hr catch

Figure 10: Specimens preserved in ethanol (wet preservation)

Figure 11: Live specimens collected in ventilated collection tubes (20-50ml)

Figure 12: Live specimens transported in cool thermocol boxes

Figure 13: Live specimen photography setup

Figure 14: Light box for proper diffusion of specimens during photography

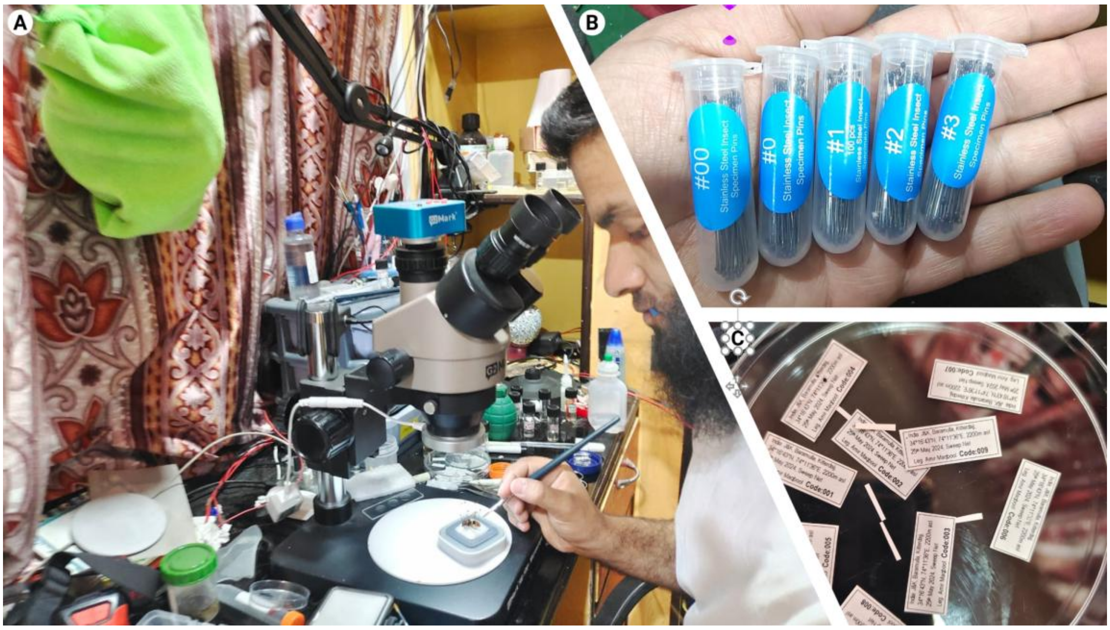

Figure 15: Cleaning (A), Pinning (B) and labelling of specimens (C)

Figure 16: Stretching and pinning (A& B) and drying (C) of specimens

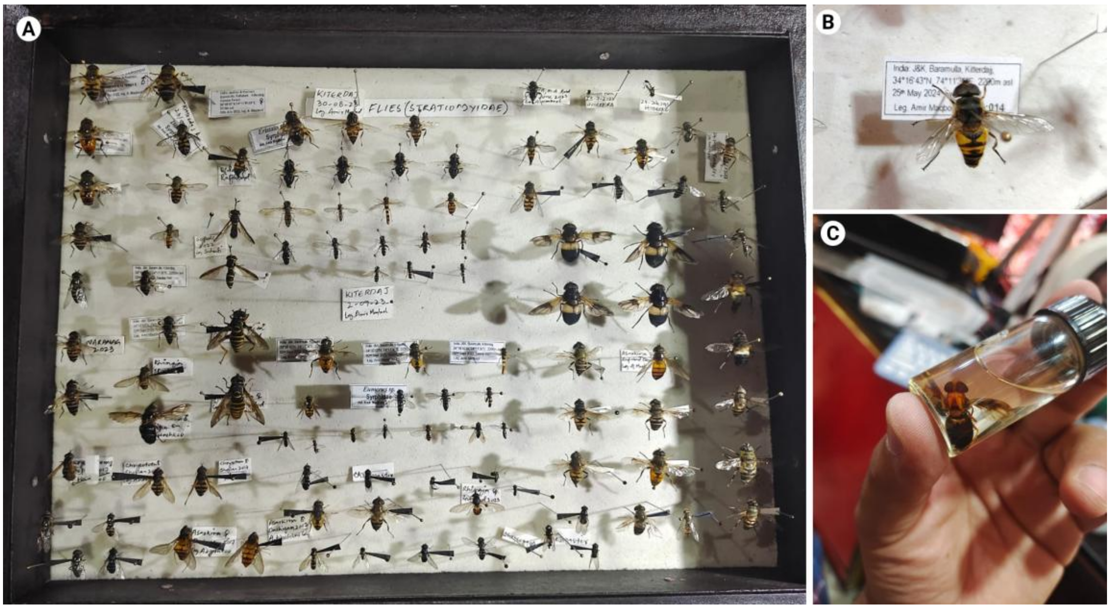

Figure 17: Dry preservation in Insect storage box (A& B) and wet preservation in ethanol (C)

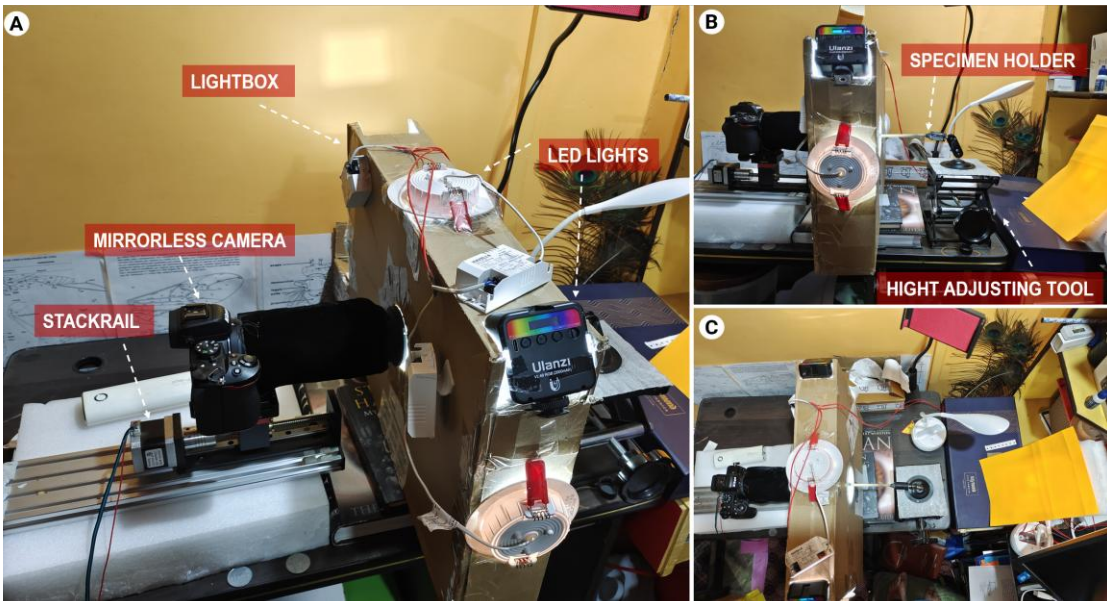

Figure 18: Stack and stitching photography setup, A-oblique view, B- side view, C-top view

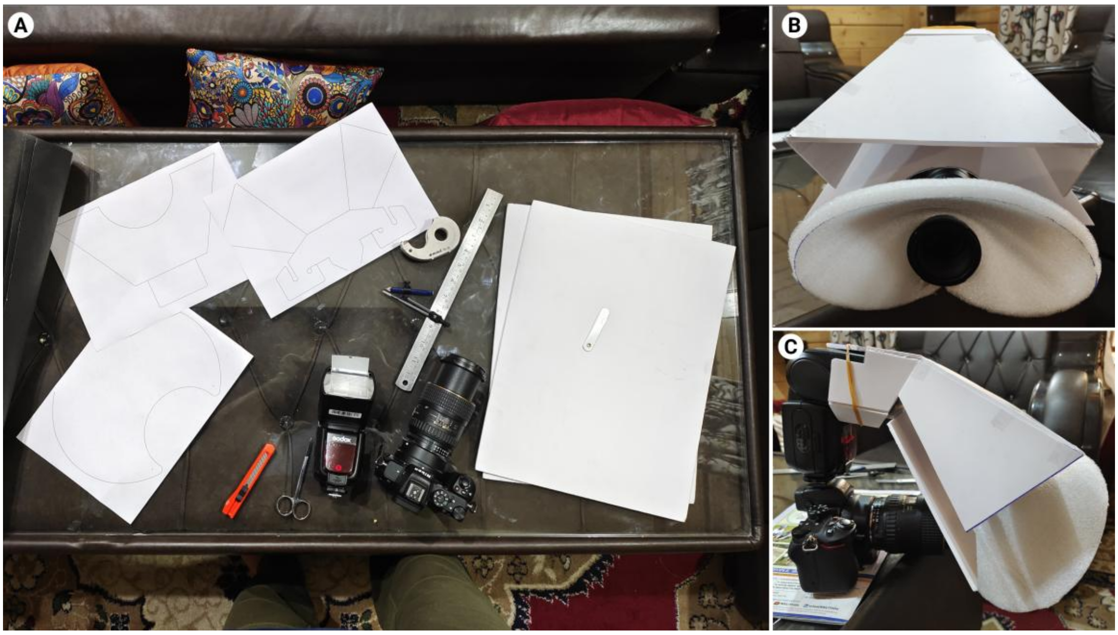

Figure 19: Construction details of flash diffuser for field photography

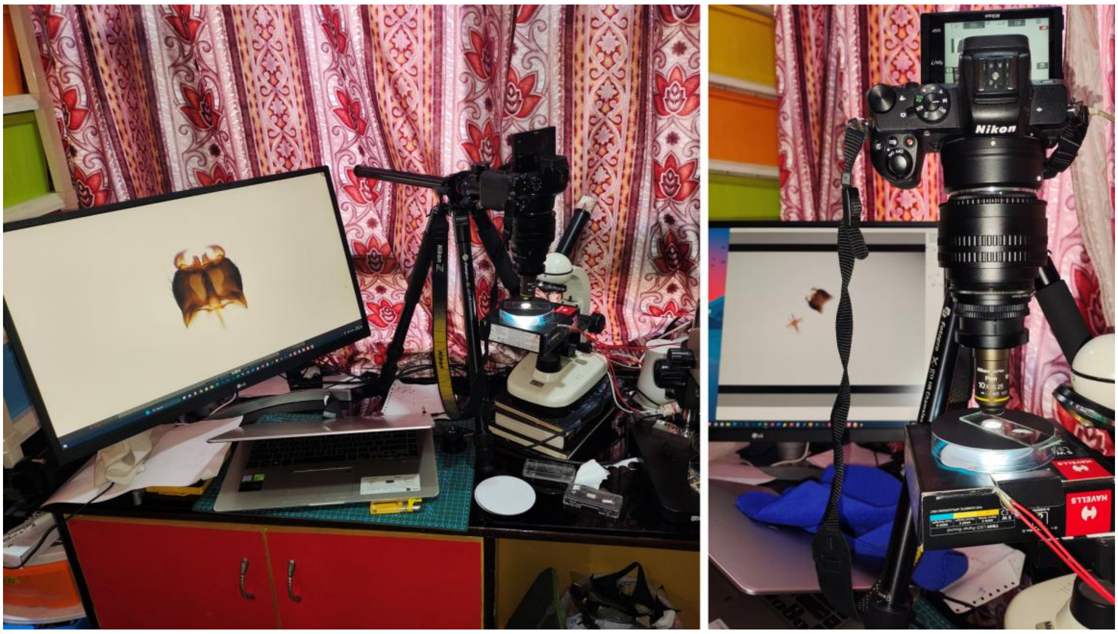

Figure 20: Micro-photography setup for slide photography

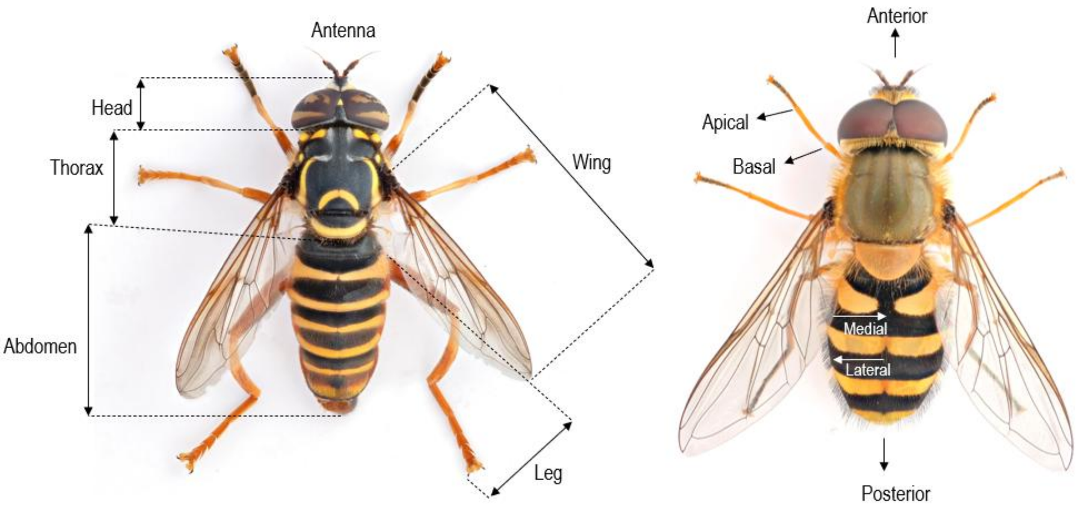

Figure 21: Syrphidae orientation and body divisions. A- *Spilomyia recta* ♂ (dorsal view), B- *Syrphus ribesii* ♂ (dorsal view)

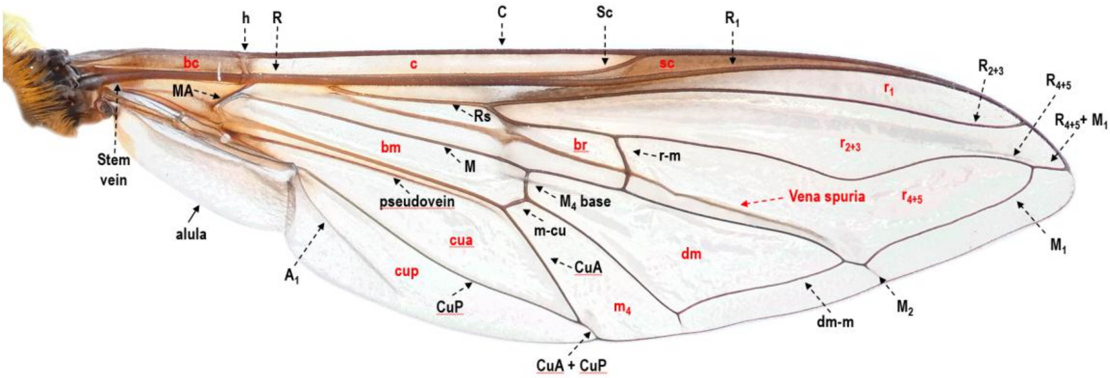

Figure 22: A typical syrphid wing (*Megasyrphus kashmirensis* n. sp) showing 'veina spuria' (black marks=veins, red marks=cells)

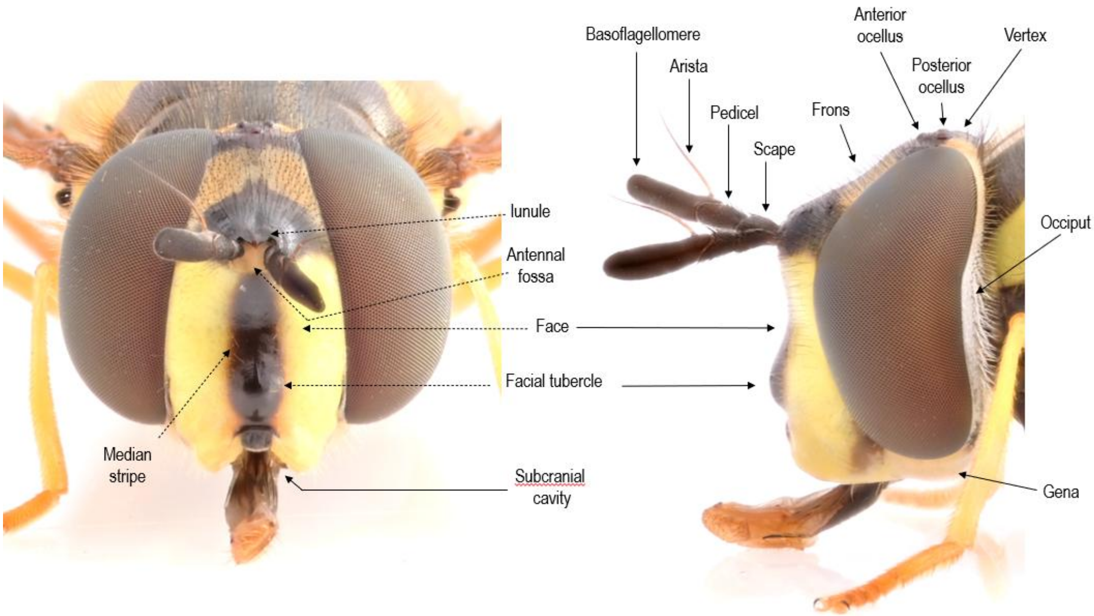

Figure 23: Head (*Chrysotoxum corbetti* ♀ Ghorpade,) 1994, frontal view (A) and lateral view (B)

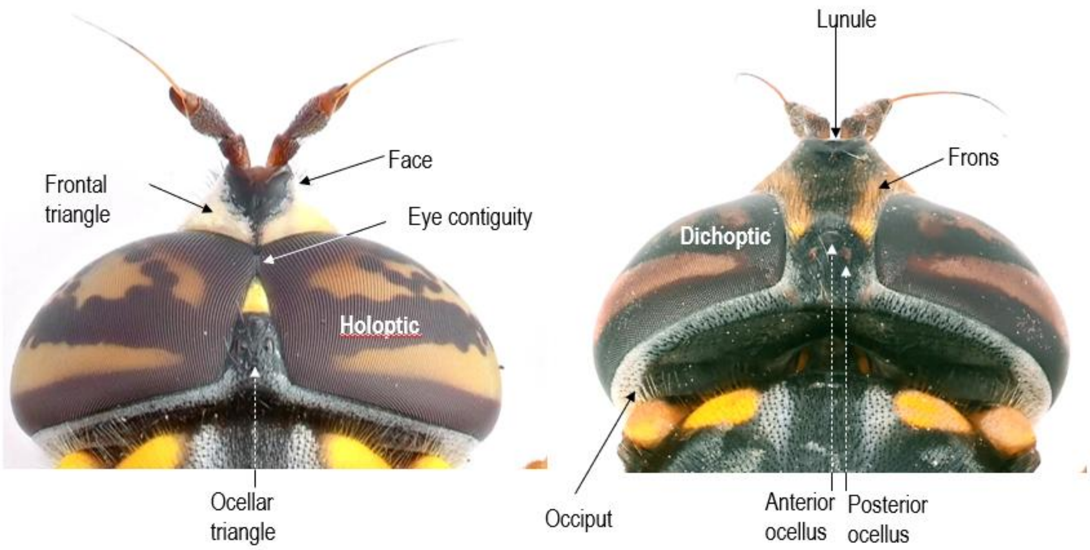

Figure 24: Head dorsal view *Spilomyia recta.* A- ♂, B- ♀

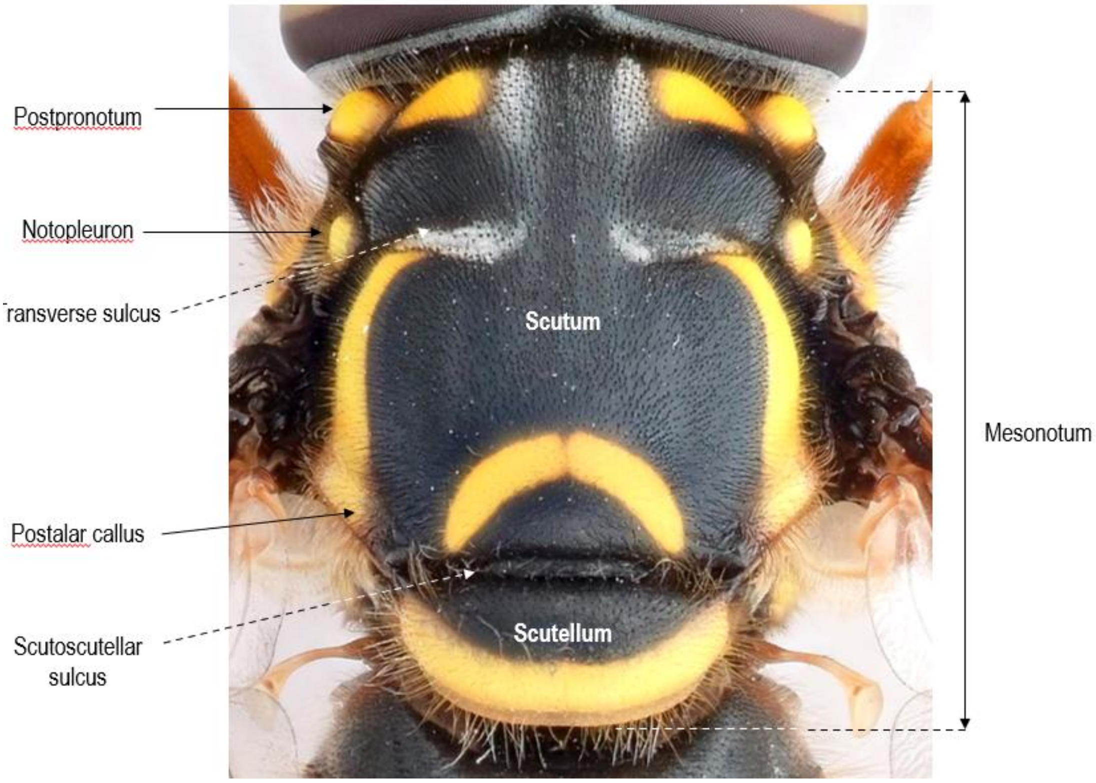

Figure 25: Mesonotum dorsal view (*Spilomyia recta* ♂)

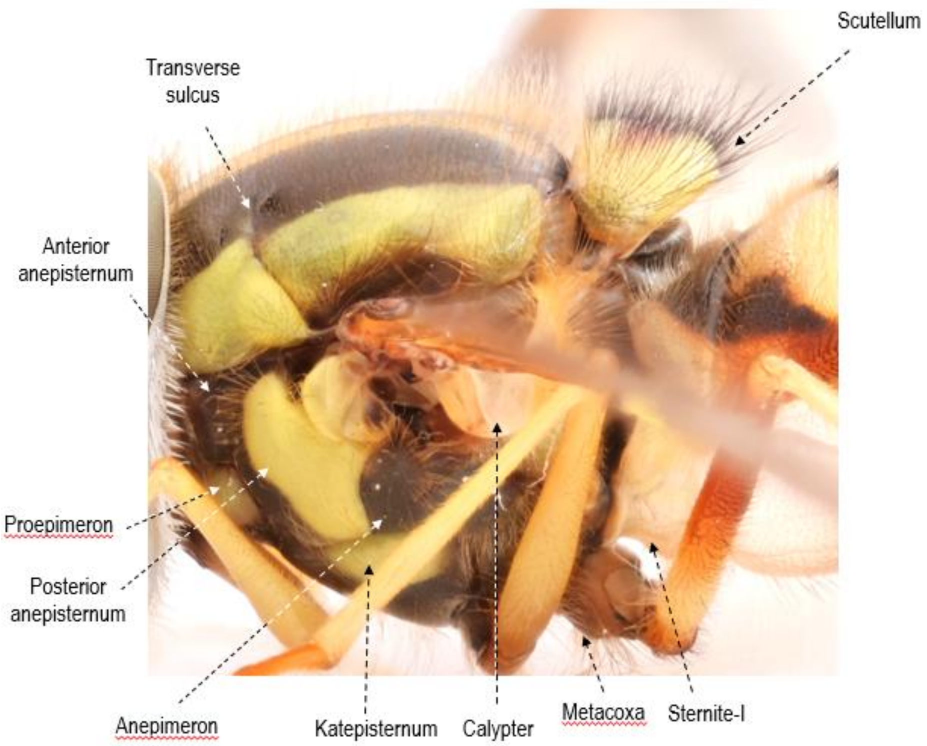

Figure 26: Mesonotum lateral view (*Chrysotoxum baphyrum*♂)

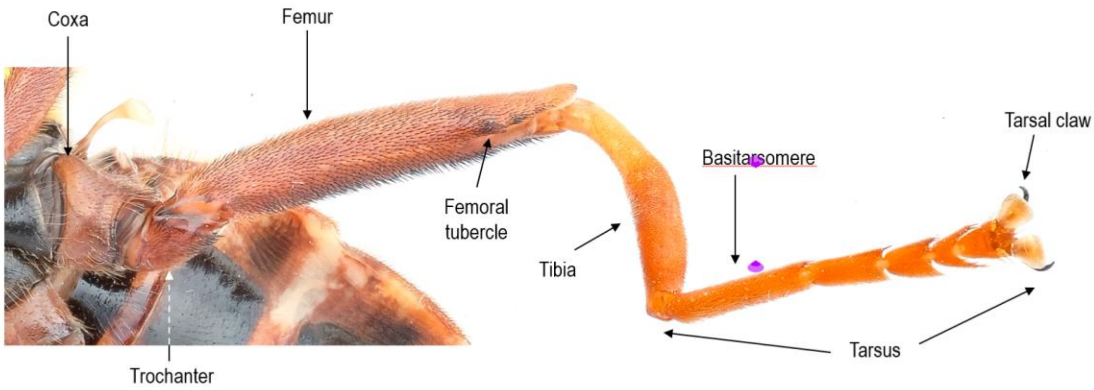

Figure 27: Hind leg ventral view (*Spilomyia recta* ♂).

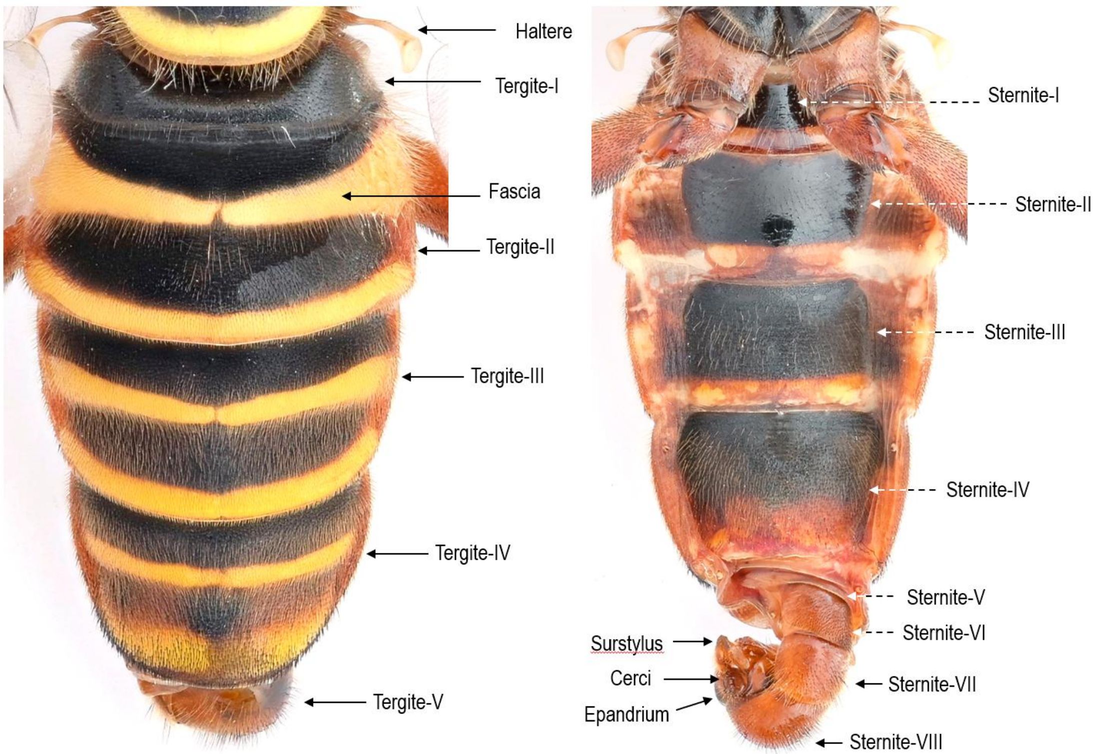

Figure 28: Abdomen (*Spilomyia recta* ♂). A-dorsal view, B-ventral

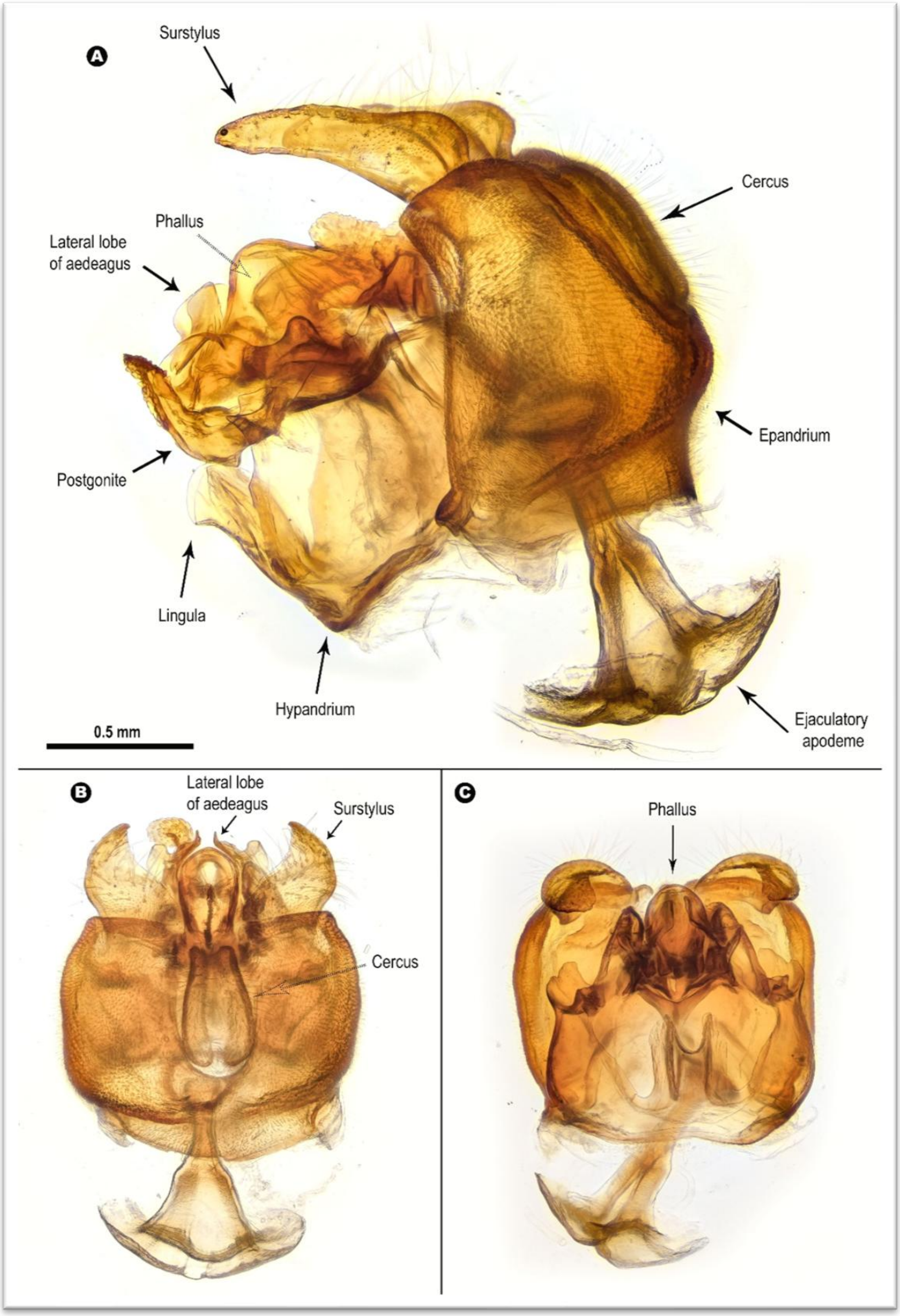

Figure 29: Male genitalia A. lateral view, B. Dorsal view, C. Ventral view (*Paragus bicolor*)


CHAPTER-4
Results & Discussion

Results and Discussion

During the current surveys more than 2000 specimens of syrphid flies were collected from different sampling sites, using sweep net and yellow pan traps. In the present study, based on the morphological studies, anatomical characteristics of male genitalia and molecular analysis, 72 hoverfly species across 38 genera were documented from various sites of J&K (Table 1). The community composition was dominated by three genera: *Eristalinus* and *Sphegina* (each 9% of total composition) and *Eristalis* (8%). Among individual species, *Eristalis arbustorum* was most abundant (12%), followed by *Episyrphus balteatus* (7%), *Eristalis tenax* (5.6%), and *Eristalis cerealis* (5.3%).

The study yielded significant taxonomic discoveries:

1. 11 new to science species were discovered belonging to 3 subfamilies:
    - **a.** 7 species from subfamily Eristalinae
        - **i.** ***Brachyopa kashmiricum*** n. sp
        - **ii.** ***Chrysogaster himalaynana*** n. sp
        - **iii.** ***Sphegina conifera*** n.sp
        - **iv.** ***Sphegina robusta*** n.sp
        - **v.** ***Sphegina baccha*** n.sp
        - **vi.** ***Sphegina parbati*** n.sp
        - **vii.** ***Spilomyia recta*** n. sp)
    - **b.** 1 species from Pipizinae
        - **i.** ***Neocnemodon indiana*** n. sp
    - **c.** 3 species from Syrphinae
        - **i.** ***Eriozona bombylans*** n. sp
        - **ii.** ***Megasyrphus kashmirensis*** n. sp and
        - **iii.** ***Platycheirus pseudoalbimanus*** n. sp

2. 4 genera are recorded for the first time from India:
    - **i.** *Brachyopa*
    - **ii.** *Chrysogaster*
    - **iii.** *Myathropa and*
    - **iv.** *Neocnemodon*)

3. 5 species were recorded for the first time from India:
    i. ***Helophilus trivittatus*** (Fabricius, 1805)
    ii. ***Lejogaster tarsata*** (Meigen, 1822)
    iii. ***Myathropa semenovi*** Smirnov, 1925
    iv. ***Paragus karnaliensis,*** Claussen & Weipert (2004)
    v. ***Volucella linearis*** Walker, 1852

4. 15 species were recorded for the first time from J&K:
    i. ***Eristalinus tarsalis*** (Macquart, 1855)
    ii. ***Graptomyza flavonotata*** Brunetti, 1917
    iii. ***Rhingia laticincta*** Brunetti, 1907
    iv. ***Rhingia sexmaculata*** Brunetti, 1913
    v. ***Sphegina bispinosa*** Brunetti, 1915
    vi. ***Sphegina tricoloripes*** Brunetti, 1915
    vii. ***Volucella peleterii*** Macquart, 1834
    viii. ***Volucella ruficauda*** Brunetti, 1907
    ix. ***Xylota nursei*** Brunetti, 1923
    x. ***Allobaccha apicalis*** (Loew, 1858)
    xi. ***Asarkina porcina*** (Coquillett, 1898)
    xii. ***Baccha maculata*** (Walker, 1852)
    xiii. ***Chrysotoxum antiquum*** Walker, 1852
    xiv. ***Chrysotoxum corbetti*** Ghorpade, 1994 and
    xv. ***Meliscaeva cinctelloides*** Ghorpade, 1994)

5. Presence of two species, **(*Ceriana dimidiatipennis*** (Brunetti, 1923) and ***Criorhina vivida*** Brunetti, 1923) which was previously doubtful was also confirmed from India.

Taxonomy of hoverflies of J&K

Family Syrphidae Latreille, 1802

Diagnosis:

The wing features a "spurious vein" (Figure 29) that gives an impression of vein-like thickening located between veins R and M. Additionally, the first branch of vein M either connects to the unbranched vein R4+5, creating a closed cell r4+5, or the branches of vein M curve upwards, running almost parallel to the wing's edge. occasionally M_1 turns abruptly up to meet vein R_{4+5} before the margin, combined with a closed discal medial cell (dm). (Ssymank et al. 2021).

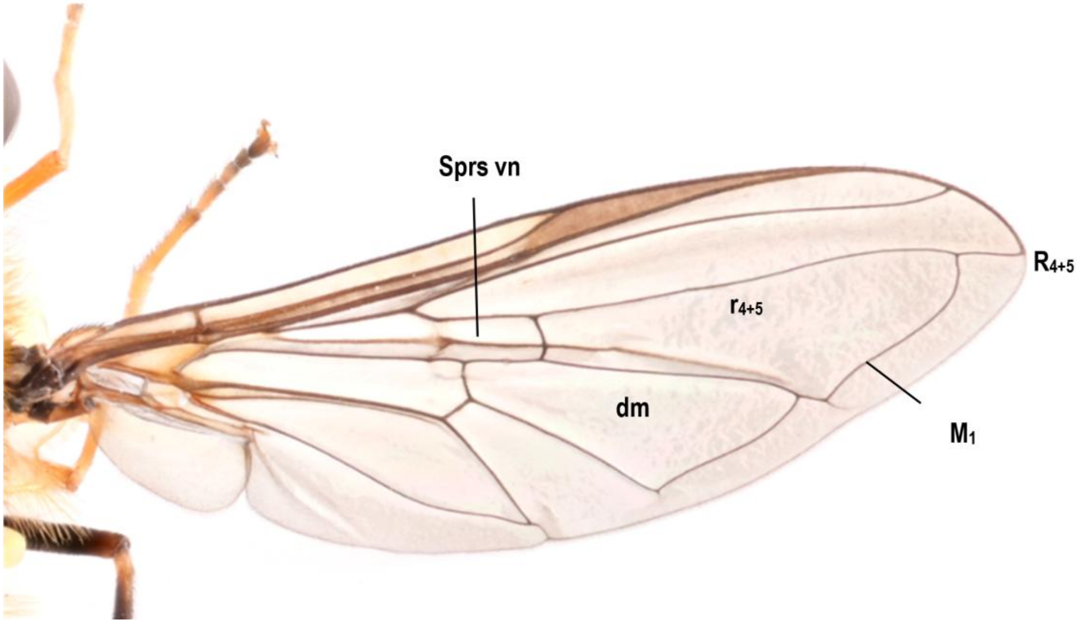

Figure 30: A typical syrphid wing showing

Four subfamilies are currently recognized within the Syrphidae: Eristalinae, Microdontinae, Pipizinae and Syrphinae (e.g., Mengual et al. 20 15). In the present study specimens collected come under all but one (Microdontinae) family.

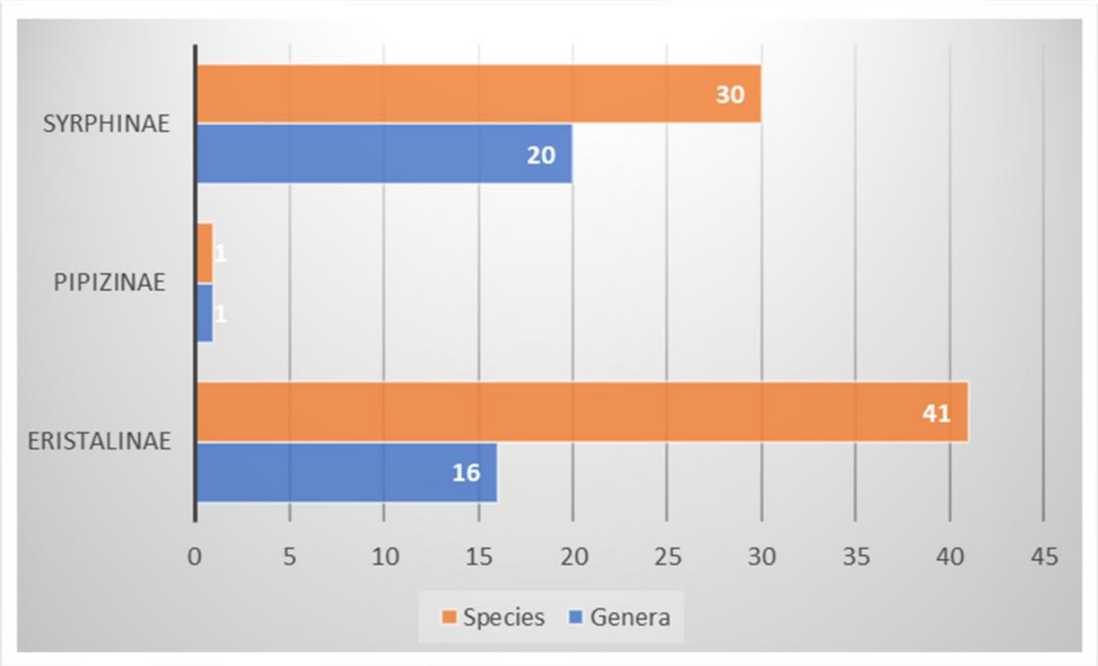

Figure 31: Subfamily distribution of Syrphide of Jammu and Kashmir

Table:1 Hoverfly species account of Jammu and Kashmir UT

S.N0	Subfamily	Genus	Species	Remarks
1	Eristalinae	*Brachyopa*	***Brachyopa kashmiricum* n. sp**	**New species and First genus record from India**
2	Eristalinae	*Ceriana*	***Ceriana brevis*** (Brunetti, 1923)	
3	Eristalinae		***Ceriana dimidiatipennis*** (Brunetti, 1923)	**First photographic evidence**
4	Eristalinae	*Chrysogaster*	***Chrysogaster himalaynana* n. sp**	**New species and First genus record from India**

5	Eristalinae	*Criorhina*	***Criorhina imitator*** Brunetti, 1915	
6	Eristalinae		***Criorhina pallipilosa*** Hull, 1944	
7	Eristalinae		***Criorhina rubropilosa*** Hull, 1950	
8	Eristalinae		***Criorhina vivida*** Brunetti, 1923	**Presence of this species was previously doubtful in India but now confirmed**
9	Eristalinae	*Eristalinus*	***Eristalinus aeneus*** (Scopoli, 1763)	
10	Eristalinae		***Eristalinus arvorum*** (Fabricius, 1787)	
11	Eristalinae		***Eristalinus megacephalus*** (Rossi, 1794)	
12	Eristalinae		***Eristalinus sepulchralis*** (Linnaeus, 1758)	
13	Eristalinae		***Eristalinus taeniops*** (Wiedemann, 1818)	
14	Eristalinae		***Eristalinus tarsalis*** (Macquart, 1855)	**New record for J&K**
15	Eristalinae	*Eristalis*	***Eristalis arbustorum*** **(**Linnaeus, 1758**)**	
16	Eristalinae		***Eristalis brevifacies*** Coe, 1964	

17	Eristalinae		***Eristalis cerealis*** Fabricius, 180	
18	Eristalinae		***Eristalis himalayensis*** Brunetti, 1908	
19	Eristalinae		***Eristalis tenax*** (Linnaeus, 1758)	
20	Eristalinae	*Ferdinandea*	***Ferdinandea isabella*** Hull, 1942	
21	Eristalinae		***Ferdinandea montana*** Hull, 1942	**First photographic evidence**
22	Eristalinae	*Graptomyza*	***Graptomyza brevirostris*** Wiedemann, 1820	
23	Eristalinae		***Graptomyza flavonotata*** Brunetti, 1917	**New record for J&K**
24	Eristalinae	*Helophilus*	***Helophilus trivittatus*** (Fabricius, 1805)	**Reported as new country record**
25	Eristalinae	*Lejogaster*	***Lejogaster tarsata*** (Meigen, 1822)	**Reported as new country record**
26	Eristalinae	*Myathropa*	***Myathropa semenovi*** (Smirnov, 1925)	**Reported as first genus record from India**
27	Eristalinae	*Rhingia*	***Rhingia laticincta*** Brunetti, 1907	**New record for J&K**
28	Eristalinae		***Rhingia sexmaculata*** Brunetti, 1913	**New record for J&K**
29	Eristalinae	*Sphegina*	***Sphegina bispinosa*** Brunetti, 1915	**New record for J&K**

30	Eristalinae		***Sphegina conifera* n.sp**	**New species**
31	Eristalinae		***Sphegina robusta* n.sp**	**New species**
32	Eristalinae		***Sphegina baccha* n.sp**	**New species**
33	Eristalinae		***Sphegina parbati* n.sp**	**New species**
34	Eristalinae		***Sphegina tricoloripes*** Brunetti, 1915	**New record for J&K**
35	Eristalinae	*Spilomyia*	***Spilomyia recta*** van Steenis, Maqbool & Wachkoo, 2024	**New species described and reported**
36	Eristalinae	*Syritta*	***Syritta pipiens*** (Linnaeus, 1758)	
37	Eristalinae	*Volucella*	***Volucella linearis*** Walker, 1852	**New record for India**
38	Eristalinae		***Volucella peleterii*** Macquart, 1834	**New record for J&K**
39	Eristalinae		***Volucella pellucens*** (Linnaeus, 1758)	
40	Eristalinae		***Volucella ruficauda*** Brunetti, 1907	**New record for J&K**
41	Eristalinae	*Xylota*	***Xylota nursei*** Brunetti, 1923	**New record for J&K**
42	Pipizinae	*Neocnemodon*	***Neocnemodon indiana* n. sp**	**First genus record from India**
43	Syrphinae	*Allobaccha*	***Allobaccha apicalis*** (Loew, 1858)	**New record for J&K**
44	Syrphinae	*Asarkina*	***Asarkina porcina*** (Coquillett, 1898)	**New record for J&K**

45	Syrphinae	*Baccha*	***Baccha maculata*** (Walker, 1852)	**New record for J&K**
46	Syrphinae	*Betasyrphus*	***Betasyrphus isaaci*** (Bhatia, 1933**)**	
47	Syrphinae	*Chrysotoxum*	***Chrysotoxum antiquum*** Walker, 1852	**New record for J&K**
48	Syrphinae		***Chrysotoxum baphyrum*** Walker, 1849	
49	Syrphinae		***Chrysotoxum corbetti*** Ghorpade, 1994	**New record for J&K**
50	Syrphinae	*Dasysyrphus*	***Dasysyrphus orsua*** (Walker, 1852**)**	
51	Syrphinae	*Didea*	***Didea vockerothi*** Ghorpade, 1994	
52	Syrphinae	*Episyrphus*	***Episyrphus balteatus*** (de Geer, 1776)	
53	Syrphinae	*Eriozona*	***Eriozona bombylans* n. sp**	**New species**
54	Syrphinae	*Eupeodes*	***Eupeodes corollae*** (Fabricius, 1794)	
55	Syrphinae		***Eupeodes latifasciatus*** (Macquart, 1829)	
56	Syrphinae	*Ischiodon*	***Ischiodon scutellaris*** (Fabricius, 1805)	
57	Syrphinae	*Megasyrphus*	***Megasyrphus kashmirensis* n. sp**	**New species**
58	Syrphinae	*Melanostoma*	***Melanostoma orientale*** (Wiedemann, 1824)	
59	Syrphinae	*Meliscaeva*	***Meliscaeva cinctelloides*** Ghorpade, 1994	**New record for J&K**

60	Syrphinae		***Meliscaeva strigifrons*** (Meijere, 1914)	
61	Syrphinae	*Paragus*	***Paragus bicolor*** (Fabricius, 1794)	
62	Syrphinae		***Paragus karnaliensis,*** Claussen & Weipert (2004)	**New record for India**
63	Syrphinae		***Paragus quadrifasciatus*** Meigen, 1822	
64	Syrphinae	*Parasyrphus*	***Parasyrphus kashmiricus*** Ghorpade, 1994	
65	Syrphinae		***Parasyrphus thompsoni*** Ghorpade, 1994	
66	Syrphinae	*Platycheirus*	***Platycheirus pseudoalbimanus* n. sp**	**New species**
67	Syrphinae	*Scaeva*	***Scaeva pyrastri*** (Linnaeus, 1758)	
68	Syrphinae	*Sphaerophoria*	***Sphaerophoria bengalensis*** Macqaurt	
69	Syrphinae		***Sphaerophoria rueppellii*** (Wiedemann, 1830)	
70	Syrphinae		***Sphaerophoria scripta*** (Linnaeus, 1758)	
71	Syrphinae	*Syrphus*	***Syrphus dalhousiae*** Ghorpade, 1994	
72	Syrphinae		***Syrphus ribesii*** (Linnaeus, 1758)	

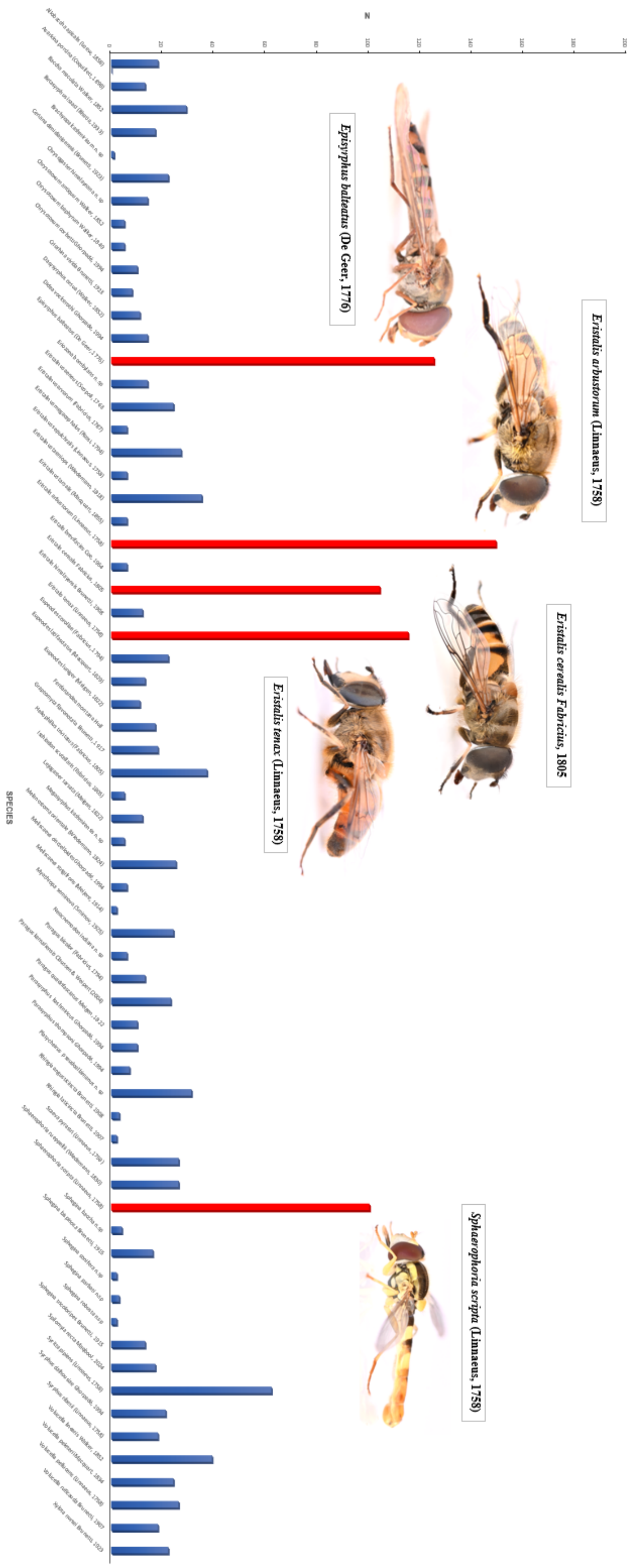

Figure 32: Relative abundance of hoverflies of Jammu and Kashmir UT

Key to the sub families of Syrphidae for Jammu and Kashmir

1a. Post pronotum bare; male abdominal tergite V visible in dorsal view ………………………………………………………..…….**Syrphinae** Leach, 1815

1b. Post pronotum with at least a few suberrect or appressed hairs, male abdominal Tergite V not visible in dorsal view……………………………….…………………..…….**2**

2a. mostly to entirely small black flies; round facial pits near eye margin below; rounded oral margin without a notch……………………….**Pipizinae** Rondani, 1856

2b. mostly slender with yellow and black patterns; facial groove near eye margin below; notched oral margin ……………………………………...**Eristalinae** Newman, 1834

Subfamily Eristalinae

This subfamily is represented by 35 species in 17 genera

Key to the genera of Eristalinae for Jammu and Kashmir

1a. Antennae shorter than the head without terminal stylus ……………………….…. 2

1b. Antennae elongated longer than the head with terminal stylus ………………………………………………………*Ceriana* Rafinesque, 1815

2a. Arista always plumose, pilosity longer than times the arista width……………….3

2b. Arista bare or with short pilosity or, Pilosity at most twice the thickness of arista…4

3a. smaller flies with orange-brown abdomen lacking prominent bands or markings; cell R open ……………………………………………*Brachyopa* Meigen, 1822

3b. larger flies with prominent bands or marks on abdomen; cell R1 closed ……………………………………………………… ***Volucella*** Geoffroy, 1762

4a. Strongly sinuate vein R_{4+5} vein , curving into underlying cell…..………..………. **5**

4b. straight or almost straight vein R4+5, forming a straight upper margin of the underlying cell ……………………..……………………..…….……..….**8**

5a. Wing with closed cell R1 ……………………………………..…....……………. **6**

5b. Wing with open cell R1 ……………………………………………..……………..**7**

6a. Scutellum completely black; spotted eyes ……………..***Eristalinus*** Rondani, 1845

6b. Scutellum variable between brown to pale; eye spots absent………….……………………………….……………….……***Eristalis*** Latreille, 1804

7a. Eyes bare; scutum with wide black longitudinal vittae..……………..…………………………...…. ***Helophilus*** Meigen, 1822

7b. Eyes pilose; scutum without longitudinal black vittae …………………………………………………………***Myathropa*** Rondani, 1845

8a. r-m Crossvein present on top half, mostly top one third of discal cell ……………………………………………………………………………….....**9**

8b. r-m Crossvein present before the mid region of discal cell………...…………………………..……………...…………….**14**

9a. Presence of a conical or strong triangular tooth ventrally on hind femur……..……………………………………………… ***Spilomyia*** Meigen, 1803

9b. Tooth absent on hind femur…………………………………………………….**10**

10a. Mouth edge pronounced; facial tubercle pronounced or not………………..………………………………………………………..…..**11**

10b. Mouth edge not pronounced; face flat without a tubercle…………………………………………………….……..***Eumerus*** Meigen, 1822

11a. The face does not extend ventrally, with a distinctly defined mouth edge and, occasionally, a facial tubercle……………..……………….…….……………….**12**

11b. Facial extends ventrally with large genae, facial tubercle present. ……………………………………………………….…….***Criorhina*** Meigen, 1822

12a. thorax dull, grey dusted; scutellum with long bristles……………………………………………..***Ferdinandea*** Rondani, 1844

12b. thorax dark shinning; scutellum without long bristles…………………………………………...…….….……...……...….**13**

13a. Metasternum pilose; Hind femur greatly enlarged……………………………………***Syritta*** Lepeletier & Serville, 1828

13b. Metasternum bare or very short pilosity; hind femur normal………………..………………………………….***Xylota*** Meigen, 1822

14a. Abdomen petiolate and constricted at tergite II, Eyes holoptic in male ………………………………….……………………. ***Sphegina*** Meigen, 1822

14b. Abdomen elongate with parallel sides or oval; eyes holoptic or dichoptic in male …………………………………………...…………………………………**15**

15a. Mouth edge not extended into an elongated snout. ……………………………………………………………………………………..**16**

15b. Mouth edge extended into an elongated snout…..………..***Rhingia*** Scopoli, 1763

16a. Tergites 2-5 completely shiny……………..…………..***Lejogaster*** Rondani, 1857

16b. Tergites 2-5 exhibit a dull central region and shining borders, resulting in a prominent median dull patch on the abdomen. …………..…………………………………..……..…***Chrysogaster*** Meigen, 1803

Genus *Brachyopa* Meigen, 1822

Diagnosis:

Small to medium sized (4–12 mm) species, somewhat broad, mostly brown, brown-red or brownish black coloured flies with a yellowish face; pilose postpronotum; bare eyes; Basoflagellomere is round to oval, with the antennal basoflagellomere segment frequently exhibiting a discernible sensory pit; subbasal arista may be naked or possess lengthy plumosity. Vein R4+5 is linear; crossvein rm is positioned anterior to the midpoint of the discal cell; vein M1 is oblique relative to vein R4+5. (Van Veen 2004; Vujic et al. 2018)

Distribution: Holarctic, Oriental (single species) (Van Steenis 2014; Evenhuis & Pape 2024)

Brachyopa kashmiricum n.sp (Figure 33)

Type material: Holotype ♂: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; $34^0$16'44"N $74^0$11'32"E; 2100m (amsl)., 05 June 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00084).

Type locality: India (Jammu & Kashmir: Kashmir)

Etymology: The species epithet '*kashmiricum*' refers to type location (Kashmir).

Diagnosis: This species is very similar to the only known Oriental species (*Brachyopa exigua* Steenis, 2015) but several key features set it apart: hypostomal bridge not completely hairless, a little longer, hairy arista, a uniformly brownish-yellow thorax with longitudinal dark areas, a brownish-orange abdomen with a darker margin; and distinct male genitalia.

Description:

Face slightly protruding, colour orange-yellow with brownish ocellar triangle; oral cavity oval; clypeus elongate, orange-yellow; head with pale pilosity; white microtrichose pilosity on face, vertex and ocellar triangle; frons shiny with narrow microtrichosity along eye margins; antennae yellowish-orange, black bristly pile on dorsoapical part of 1st and 2nd antennal segments short and oval, clear sensory pit on basoflagellomere; arista short and pilose; mesonotum shinning, medially with darker longitudinal areas, pale pilosity along the lateral margin of scutum and pleurae, longer black bristles along the margin of scutellum;

haltere yellow; abdominal tergites I-II with broad yellowish white mediolateral areas, rest of the tergites brownish orange with dark brown margins; genitalia as in Figure

Preferred habitat(s): Found in a damp wet forest near a willow tree with sap run.

Floral host range: Data insufficient

Remarks: This is the first genus record for India and second species from the Oriental.

Genus *Ceriana* Rafinesque, 1815

Diagnosis: Antennae inserted on a fairly well-developed frontal prominence, equal in length to, or longer than, the scape and pedicel combined, eyes bare; abdomen subcylindrical, only slightly petiolate, tergite II wider than long, not constricted (anterior margin of tergite II as wide as tergite I) (Van Veen 2004; Vujic et al. 2018)

Ceriana brevis (Brunetti, 1923)

Ceria brevis Brunetti, 1923

Type Material: ♀, NHMUK, examined

Type Locality: India (Pusa)

Diagnosis: Antennae inserted on a fairly well-developed frontal prominence, equal in length to, or longer than, the scape and pedicel combined, eyes bare; no spots on 1st abdominal segment; markings on thorax and abdomen orange-brown (Brunetti, 1923).

Distribution: India (Jammu & Kashmir), Pakistan (Brunetti 1923; Knutson et al. 1975; Aslamkhan et al. 1997; Shah et al. 2014; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): sub-urban gardens, open forest edges

Floral host range: Data insufficient

Remarks: This species is a potter wasp mimic and endemic to India and Pakistan

Ceriana dimidiatipennis (Brunetti, 1923) (Figure 34)

Ceria dimidiatipennis Brunetti, 1923

Type Material: ♂, NHMUK, examined

Other Material:

1♂1♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00200 to CUZM-A_Maqbool00201); 1♂4♀: INDIA- Jammu and Kashmir, Anantnag, Khanabal, 34^{0}44'40"N 75^{0}7'44"E 1620m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00202 to A_Maqbool00206);

Type Locality: Pakistan (Hangu & Abbottabad)

Diagnosis: Antennae inserted on a fairly well-developed frontal prominence, equal in length to, or longer than, the scape and pedicel combined, eyes bare; two longitudinal short yellow spots on thorax behind suture; each side of 1st abdominal segment with a large sulphur-yellow spot on; pale markings of thorax and abdomen sulphur-yellow (Brunetti, 1923).

Distribution: India (Jammu & Kashmir), Pakistan (Brunetti 1923; Knutson et al. 1975; Aslamkhan et al. 1997; Shah et al. 2014; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): sub-urban gardens, open forest edges

Floral host range: *Sisymbrium loesli* L, *Lathyrus oleraceus*

Remarks: This species is a potter wasp mimic and endemic to India and Pakistan

Key to the species of genus *Ceriana* for Jammu and Kashmir

1a. Tergite I without any spots; colour of markings on thorax and abdomen orange brown ……….…………………………..…………. ***C. brevis*** (Brunetti, 1923)

1b. Tergite I featuring a prominent, sulfur-yellow patch on either side…………………………..….………………..… ***C. dimidiatipennis*** (Brunetti, 1923)

Genus *Chrysogaster* Meigen, 1803

Diagnosis: Small, lustrous black hoverflies exhibiting metallic reflections ; third antennal segment pale orange, antennal arista orange/red; vein M1 meeting vein R_{4+5} in a right angle; the apical section of vein R_{4+5} (between intersection of R_{4+5} with M1 and the costal margin) approximately equivalent in length to the cross-vein r-m; tergites 2-5 exhibit a central and lateral region with contrasting colour and texture, with the middle half of each tergite being matte, dark brown, and black, or blue-black, the lateral parts metallic green, gold or blue; male: eyes meeting on frons; female: frons with transverse, parallel grooves (Van Veen 2004; Vujic et al. 2018).

Distribution: Widely distributed in Palearctic, some afrotropical species (Evenhuis & Pape 2024)

Preferred habitat(s): moist meadows and along flowring heathland margins. The larvae are aquatic and semiaquatic and saprophagous.

Chrysogaster himalaynana **n. sp** (Figure 35)

Criorhina vivida Brunetti, 1923

Criorhina vivida Brunetti, 1923: 285.

Type material: Holotype ♂: **INDIA**- Jammu and Kashmir, Baramulla, Rafiabad; $34^0$16'44"N $74^0$11'32"E; 1900m (amsl)., 05 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00079).

Paratypes: 1♂, 2♀♀: INDIA-with same data as holotype except (CUZM-A_Maqbool00080 to CUZM-A_Maqbool00082).

Type locality: India (Jammu & Kashmir: Kashmir)

Etymology: The species epithet '*himalayana*' refers to the type location region (Himalaya).

Diagnosis:

This hoverfly has a shiny black body with bluish reflections. The eyes have sparse, short yellow hairs, mostly on the upper portion. The antennae are mostly reddish, with the base segments being brownish and the lowest segment having a reddish-orange underside. A distinctly raised, triangular area containing the simple eyes (ocelli) is present on the top of the head, as is a triangle of long black hairs. The face is finely wrinkled on the sides and has a small, shiny facial tubercle in the middle. Short, sparse yellow hairs cover the face except for the smooth area beneath the antennae and the central bump. The wings are completely covered in tiny hairs (microtrichose) and have dark veins, except for orange sections at the bases of some veins. The thorax is shiny black with bluish reflections, lightly dusted with pollen at the front, and covered in semi-recumbent hairs. The oval abdomen is dull due to a thick coating of pollen, except for the shiny sides and rear edge of segments II-IV. Short, light yellow, flattened hairs cover the abdominal segments. Longer yellow hairs are found on the sides of segment I and across the front of segment II. The underside of the abdomen is shiny, except for the first segment which is covered in pollen.

World distribution: India, Pakistan? (Brunetti 1923: 285; Maqbool et al. 2024).

Preferred habitat(s): forest with over-mature and senescent trees.

Floral host range: *Chaerophyllum reflexum, Conium maculatum, Heracleum candicans, Mentha longifolia, Spiraea bella L.*

Remarks: First genus record from India. Brunetti (1915) described *Chrysogaster (Orthoneura) indica* from India which was later shifted under genus *Orthonevra* (*Orthonevra indica*).

Genus *Criorhina* Meigen, 1822

Diagnosis: Large, hairy bumblebee or bee mimics characterized by a strongly downwards extended face and an oblique anterior cross vein (r-m) reaching anterior margin of the discal cell in the distal half (Van Veen 2004; Vujic et al. 2018).

Criorhina imitator Brunetti, 1915

Type Material: ♀, ZSI, Kolkata, ZSI0000004453, examined

Type Locality: India (Uttarakhand: Garhwal: Onari)

Diagnosis: Thorax relatively lustrous black, exhibiting grey pruinosity at the front, covered with dense pilosity, predominantly black, but yellow on the front half and in a narrow strip at the posterior margin; femora black pilose, mid-basitarsus with a pair of spines, shorter than width of basitarsus abdomen moderately shining black, with black pilosity; yellowish pilosity on tergite II, posterior borders of tergite III and the entire surface of tergites IV and V, long, prominent, and vivid red pilosity **(**Brunetti 1915).

World distribution: India, Pakistan? (Brunetti 1915: 237; 1923: 284; Maqbool et al. 2024).

Preferred habitat(s): forest with over-mature and senescent trees.

Floral host range: Data insufficient

Remarks: This species is endemic to India**.**

Criorhina pallipilosa Hull, 1944

Type Material: ♂, NHMUK, examined

Type Locality: India (Jammu and Kashmir: Kashmir: Gulmarg)

Diagnosis: Thorax shining black anteriorly, pale brownish white pruinose posteriorly with black and yellow pilosity; femora lightly shining black, except for the brownish yellow apical tips; abdomen white or yellow pilose with tergite II wholly covered with greyish white pilosity. (Hull 1944; 1950)

World distribution: Indian: Jammu & Kashmir: Gulmarg (Hull 1944; 1950; Maqbool et al. 2024).

Preferred habitat(s): forest with over-mature and senescent trees.

Floral host range: Data insufficient

Remarks: This species is restricted to Kashmir region**.**

Criorhina rubropilosa Hull, 1950

Type Material: ♀, NHMUK, examined

Type Locality: India (Jammu and Kashmir: Kashmir: Gulmarg)

Diagnosis: Thorax black, greyish white pruinosity on anterior half and brown pruinosity towards posterior half with a pair of large wedge-shaped spots towards posterior region, covered with white pilosity entirely; tergite II has elongated white pilosity on its basal half, while the posterior half of tergite II and the basal half of tergite III are characterised by dense, erect black pile, the posterior part of tergite III, more narrowly towards the sides, and the tergite IV-V with thick, erect, rather long, bright orange-red pilosity. (Hull 1950)

World distribution: India (Hull 1950; Maqbool et al. 2024).

Preferred habitat(s): forest with over-mature and senescent trees.

Floral host range: Data insufficient

Remarks: This species is restricted to Kashmir region**.**

Criorhina vivida Brunetti, 1923 (Figure 36)

Criorhina vivida Brunetti, 1923: 285.

Type material: "Holotype", "Criorhina vivida Brun / Type ♀ / det. Brun. 1921–2", "Kashmir / 8–9000 ft / vi–01", "India / Pres. By / Col. C. G. Nurse / 1922–309", "J. Skevington / Specimen # / 45678", NHMUK [examined]

Additional material. India: 1 ♂, 2 ♀♀, Jammu and Kashmir, Dist. Kulgam, Aharbal, 33.6441, 74.777; 2270 m. a.s.l.; 9.vii.2023; Aijaz A. Wachkoo leg. A_Wachkoo00101 to A_Wachkoo00103 (GDCK).

Type locality: India (Jammu & Kashmir: Kashmir)

Diagnosis: contrasting bright yellow lunule against the dark brown frontal triangle; ground colour of thorax black with dense long yellow pile on anterior half and posterior margin of scutum; long black and dense pile in between, towards the posterior half of scutum; wings pale grey; abdominal tergite I with yellowish white spots at baso-lateral corners. (Brunetti 1923; Maqbool et al. 2024)

World distribution: India, Pakistan? (Brunetti 1923: 285; Maqbool et al. 2024).

Preferred habitat(s): forest with over-mature and senescent trees.

Floral host range: Data insufficient

Remarks: Presence of this species was previously doubtful in India but now confirmed**.**

Key to the species of genus *Eristalinus* for Jammu and Kashmir

1a. Thorax colorful, covered in orange, yellow, and black pile……………………………………………………. ***C. imitator*** Brunetti, 1915

1b. Thorax concolorous, with grey brown, black, or bicolored pile with a mix of white pile...**2**

2a. Tergite I with two yellowish white baso-lateral spots…..... ***C. vivida*** Brunetti, 1923

2b. Tergite I without yellowish white spots……………………………………………**3**

3a. Entirely white pile on thorax; abdomen pile white, black and red…………………..…………………………………….. ***C. rubropilosa*** Hull, 1950

3b. Black and yellow pile on thorax; abdomen white or yellow pilose……………………………………………………..***C. pallipilosa*** Hull, 1944

Genus *Eristalinus* Rondani, 1845

Diagnosis:

Eyes with numerous small brown spots, or vertical bands; arista always glabrous; wing vein R4+5 looped (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Eristalinus aeneus (Scopoli, 1763)

- *Conops aeneus* Scopoli, 1763
- *Conops stygius* Newman, 1835
- *Eristalinus stygius* (Newman, 1835)
- *Eristalis aenescens* Macquart, 1842
- *Eristalis aeneus* (Scopoli, 1763)
- *Eristalis concolor* Philippi, 1865
- *Eristalis cuprovittatus* Wiedemann, 1830
- *Eristalis sincerus* Harris, 1841
- *Eristalis sincerus* Walker, 1849
- *Eristalis stygius* Newman, 1835
- *Eristalis taphicus* Wiedemann, 1830
- *Eristalomya auricalcica* Rondani, 1865
- *Lathyrophthalmus nigrolineatus* Hervé-Bazin, 1923
- *Musca leucocephala* Gmelin, 1790
- *Musca macrophthalma* Preyssler, 1791
- *Musca ochroleuca* Gmelin, 1790
- *Musca punctata* Müller, 1764
- *Syrphus aeneus* Fabricius, 1794
- *Syrphus auricalcicus* Rondani, 1865

Type material: ♀, NHMUK, London

Other material:

2♂2♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00207 to CUZM-A_Maqbool00210); 2♂4♀: INDIA- Jammu and Kashmir, Baramulla, Kulgam, Aharbal; 33^{0}38'39"N 74^{0} 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00211 to CUZM- A_Wachkoo00216); 1♂1♀: INDIA- Jammu and Kashmir, Baramulla, Limber, 34^{0}11'47"N 74^{0}09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00217 to A_Maqbool00218).

Type Locality: Slovenia (Idrija)

Diagnosis: Larger than *Eristalinus sepulchralis*; eyes marked with spots, meeting on frons, eye pilosity is brief and sparse, restricted primarily to the upper half (or less) of the ocular surface; the shortest distance from the upper edge of the mouth to the eye margin is roughly equivalent to the median length of the scutellum.; scutellar pilosity totally pale; pale pilosity distinctly adpressed on the anterior half of tergite III, orientated towards the lateral borders of the tergite; abdomen often with a slightly bronzy-black appearance lacking any dull patches (Van Veen 2004; Bot and Meutter 2023).

Distribution: Australia, Afghanistan, Afghanistan, Australia, China, Gilbert Islands, Hawaii, India (Delhi, J&K, Maharashtra, Uttarakhand, Uttar Pradesh), Pakistan, Wake Island (Brunetti 1923; Rahman 1940; Datta & Chakraborti 1984; Peck 1988; Shah et al. 2014; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): moderately anthropophilic, slow-moving rivers, freshwater; ponds, streams, and irrigation ditches (Vujic et al. 2019).

Floral host range: *Achillea millefolium*, *Brassica spp.*, *Chaerophyllum reflexum*, *Conium maculatum*, *Dacus carota* L, *Sisymbrium loesli* L, *Foeniculum vulgare*

Remarks: *E. aeneus* larvae inhabit freshwater seepages and diverse inland environments, including associations with animal excrement and sewage treatment facilities (Speight 2017).

Eristalinus arvorum (Fabricius, 1787) (Figure 37)

- *Eristalinus arvorum* (Fabricius, 1787)
- *Eristalis acervorum* Hervé-Bazin, 1923
- *Eristalis anicetus* Walker, 1849
- *Eristalis antidotus* Walker, 1849
- *Eristalis arvorum* (Fabricii, 1787)
- *Eristalis fulvipes* Macquart, 1846
- *Eristalis haileyburyi* Nayar, 1968

- *Eristalis okinawensis* Matsumura, 1916
- *Eristalomyia eunotata* Bigot, 1890
- *Eristalomyia spec* Bigot, 1880
- *Lathyrophthalmus arvorum* (Fabricius)
- *Musca arvorum* Gmelin, 1790
- *Musca tranquebarica* Gmelin, 1790
- *Syrphus aruorum* Fabricius, 1787
- *Syrphus arvorum* Fabricius, 1787
- *Syrphus quadrilineatus* Fabricius, 1787

Type Material: ♂**,** UZM, Copenhagen

Other material:

1♂: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00219); 2♂4♀: INDIA- Jammu and Kashmir, Baramulla, Kulgam, Aharbal; 33^{0}38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00220 to CUZM- A_Wachkoo00225); 1♂1♀: INDIA- Jammu and Kashmir, Baramulla, Limber, 34^{0}11'47"N 74^{0}09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00226 to A_Maqbool00227).

Type Locality: India (Tamil Nadu)

Diagnosis: Eyes golden marked with brownish spots; thorax yellow dusted, with 4 conspicuous black stripes, middle two not touching the posterior margin and turning brown apically; in males 1st and 2nd tergites with large pale-yellow stripes meeting in the middle leaving a faint brownish wide longitudinal stripe; 3rd abdominal tergite with wide yellowish brown spot in basolateral corners; 4th tergite with oblique dust bands; femora normally all orange or brownish orange; female (Ka-Lun 2022)

Distribution: Australia, China, Hawaii, India (Arunachal Pradesh, Jammu & Kashmir, Manipur, Meghalaya, Mizoram, Orissa, Sikkim, Tripura, West Bengal), Japan, Marianas, Micronesia, Pakistan, Seychelles, Southeast Asia (Brunetti 1923; Rahman 1940; Datta & Chakraborti 1984; Mitra et al. 2008; Ghorpade et al. 2011; Shah et al. 2014; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): Forest/freshwater; adjacent to streams; alongside rivers.

Floral host range: *Achillea millefolium, Heracleum candicans, Mentha longifolia, Spiraea bella* L.

Remarks: This was observed as the least dominant species among genus *Eristalinus.*

Eristalinus megacephalus (Rossi, 1794) (Figure 38)

- *Eristalinus laetus* (Wiedemann, 1830)
- *Eristalis convexifacies* Macquart, 1850
- *Eristalis fasciatus* Germar, 1844
- *Eristalis fasciatus* Meigen, 1835
- *Eristalis laetus* Wiedemann, 1830
- *Eristalis obscuritarsis* Meijere, 1908
- *Eristalis pallinevris* Macquart, 1842
- *Eristalis quinquefasciatus* Schiner, 1849
- *Eristalis quinquevittatus* Macquart, 1847
- *Eristalis ridens* Walker, 1849
- *Lathyrophthalmus ishigakiensis* Shiraki, 1968
- *Syrphus megacephalus* Rossi, 1794

Type material: ♂**,** [unknown]

Other material

6♂5♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00228 to CUZM-A_Maqbool00238); 3♂4♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00239 to CUZM- A_Wachkoo00245); 2♂3♀: INDIA- Jammu and Kashmir, Baramulla, Limber, 34^{0}11'47"N 74^{0}09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 2♂3♀: INDIA- Jammu and Kashmir, Srinagar, MA Road, 34^{0}04'27"N 74^{0}49'01"E, 1600m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 6♂2♀: INDIA- Jammu and Kashmir, Anantnag, Khanabal, 34°44'40"N 75°7'44"E, 1620m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123);

Type Locality: Italy (Toscana)

Diagnosis: eyes golden marked with pale purple spots; thorax yellow, with 4 conspicuous black stripes; in males abdomen black with large golden yellow to pale orange lateral stripes (smaller in females); in females the second tergite features a dust band that tapers laterally, with its widest section located centrally, and the band does not extend to the lateral boundary.

Distribution: worldwide including India (Andhra Pradesh, Bihar, Gujarat, Jammu & Kashmir, Karnataka, Kerala, Maharashtra, Meghalaya, Odisha, Rajasthan, Sikkim, Tamil Nadu, Tripura, Uttarakhand, West Bengal), Java, Guam, Southern Spain, Turkey, North Africa, Iran, and coastal regions of Italy. Brunetti 1923; Rahman 1940; Datta & Chakraborti 1984; Mitra et al. 2008; Peck 1988; Ghorpade et al. 2011; Shah et al. 2014; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): Open ground/freshwater; canal and riverbank environments in rural areas (Vujic et al. 2018)

Floral host range: *Achillea millefolium, Brassica spp., Conium maculatum, Dacus carota* L, *Sisymbrium loesli* L, *Foeniculum vulgare, Lathyrus oleraceus.*

Remarks: The larvae have been found in running water contaminated by animal manure (Vujic et al. 2018)

Eristalinus sepulchralis (Linnaeus, 1758)

- *Eristalinus ater* (Harris, 1776)
- *Eristalinus melanius* (Harris, 1776)
- *Eristalinus riki* Violovich, 1957
- *Eristalinus sepulcralis* (Linnaeus, 1758)
- *Eristalis impunctata* Strobl, 1910
- *Eristalis miki* Mutin & Barkalov, 1999
- *Eristalis sepulchralis* (Linnaeus, 1758)
- *Musca ater* Harris, 1778
- *Musca melanius* Harris, 1778

- *Musca sepulchralis* Linnaeus, 1758
- *Syrphus tristis* Fabricius, 1794

Other Material: ♀, NHMUK, London

2♂1♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 1♂1♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 1♂2♀: INDIA- Jammu and Kashmir, Baramulla, Limber, 34^{0}11'47"N 74^{0}09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 2♂3♀: INDIA- Jammu and Kashmir, Srinagar, MA Road, 34^{0}04'27"N 74^{0}49'01"E, 1600m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 1♂2♀: INDIA- Jammu and Kashmir, Anantnag, Khanabal, 34^{0}44'40"N 75^{0}7'44"E, 1620m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123);

Type Locality: Sweden (LSL)

Diagnosis: shiny, dark, slightly metallic and rather dumpy hoverflies; spotty eyes, dichoptic, eye pilosity stretching across the eye surface in a wide, indistinct stripe from the ventral margin of the eye to the dorsal margin, antero-laterally, and characterised by considerable length and density; notable dull spots extending along the central axis of the abdomen; reduced in size relative to other *Eristalinus* species (but the size is often variable) (Van Veen 2004; Bot and Meutter 2023)..

Distribution: The species is distributed over Europe, including the Baltic nations, Northern, Central, Southern, and Western Europe, and extends throughout the Palaearctic region to Afghanistan, Kamchatka, Japan, China, India (Jammu & Kashmir), Finland, Great Britain, Hungary, Ireland, Norway, and the Netherlands. Brunetti 1923; Aslamkhan et al. 1997; Shah et al. 2014; Sengupta et al. 2024; Evenhuis & Pape 2024).

Preferred habitat(s): River, fen, and pond margins; wetland; very anthropophilic; also found in areas where livestock is grazed, along contaminated ditches, and near slurry pits. (Vujic et al. 2018)

Floral host range: *Achillea millefolium, Heracleum candicans, Brassica spp., Conium maculatum, Sisymbrium loesli* L*, Foeniculum vulgare,*

Remarks: The larva occurs in rotting vegetation in ponds, pools, and marshes. It can also be found in dung heaps and slurry pits. (Vujic et al. 2018)

Eristalinus taeniops (Wiedemann, 1818)

- *Eristalis aegyptius* Walker, 1849
- *Eristalis communis* Adams, 1905
- *Eristalis completa Santos Abreu, 1924*
- *Eristalis concinna* Santos Abreu, 1924
- *Eristalis secretus* Walker, 1849
- *Eristalis taeniops* Wiedemann, 1818
- *Eristalis torridus* Walker, 1849
- *Helophilus pulchriceps* Meigen & Wiedemann, 1822

Other Material: ♀, NHMUK, London

4♂5♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; $34^0$16'44"N $74^0$11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 3♂2♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; $33^0$38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 4♂5♀: INDIA- Jammu and Kashmir, Baramulla, Limber, $34^0$11'47"N $74^0$09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 3♂1♀: INDIA- Jammu and Kashmir, Srinagar, MA Road, $34^0$04'27"N $74^0$49'01"E, 1600m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 3♂2♀: INDIA- Jammu and Kashmir, Anantnag, Khanabal, $34^0$44'40"N $75^0$7'44"E, 1620m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123);

Type Locality: South Africa (Cape of Good Hope)

Diagnosis: eyes with five to six slender bands; scutum either with longitudinal dust bands abdomen dark with yellow spots from T1-T3.

Distribution: Palaearctic and Afrotropical regions, India (Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Meghalaya, Sikkim, West Bengal), Nepal, Yemen, and the United Arab Emirates. Brunetti 1923; Rahman 1940; Knutson et al. 1975; Mitra et al. 2008; Shah et al. 2014; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): forest/open terrain/freshwater; adjacent to streams in *Quercus ilex* forests and maquis; alongside rivers, especially ephemeral rivers (Vujic et al. 2018).

Floral host range: *Achillea millefolium, Heracleum candicans, Brassica spp., Conium maculatum, Foeniculum vulgare, Mentha longifolia, Sisymbrium loesli* L, *Ranunculus repens, Spiraea bella* L.

Remarks: The larvae of *E. taeniops* inhabit stagnant water with decomposing plant matter (e.g., pine needles) or decaying animal remains, as well as flowing water tainted by swine excrement**.** (Haffaressas et al. 2017; Speight 2020).

Eristalinus tarsalis (Macquart, 1855)

- *Eristalis ocularius* Coquillett, 1898
- *Eristalis tarsalis* Macquart, 1855

Type Material: ♀, USNM, Washington, DC

Other Material:

2♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 1♂1♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^{0} 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 1♂1♀: INDIA- Jammu and Kashmir, Baramulla, Limber, 34^{0}11'47"N 74^{0}09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 1♂: INDIA- Jammu and Kashmir, Srinagar, MA Road, 34^{0}04'27"N 74^{0}49'01"E, 1600m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123);

Type Locality: China ("Chine Boreale")

Diagnosis: The body is largely black (including the scutum, tergites and legs) and covered with whitish hairs, except for the two pairs of creamy white fasciae on tergites 3 and 4, the creamy white basal one-fourth of the tibiae, and two thin white lines sometimes visible on the scutum.

Distribution: East China, Japan, India, Korea, Nepal, Russia and Taiwan (Sengupta et al. 2024; Evenhuis & Pape 2024).

Preferred habitat(s): River margins

Floral host range: *Achillea millefolium, Heracleum candicans, Brassica spp., Conium maculatum, Foeniculum vulgare, Mentha longifolia, Sisymbrium loesli* L,

Remarks: This is a new record for J&K

Key to the species of genus *Eristalinus* for Jammu and Kashmir

1a. Eyes with numerous small spots……………………………………………….…. **2**

1b. Eyes with vertical bands………. **…………………*E. taeniops*** (Wiedemann, 1818)

2a. Pale (orange) lateral marks on abdominal tergite II ………………….…………. **3**

2b. Abdominal tergite 2 black and mostly unmarked ……………………………….**4**

3a. Antennal basoflagellomere uniformly brownish orange**;** femora brownish orange ……………………………………..……………. ***E. arvorum*** (Fabricius, 1787)

3b. Antennal basoflagellomere brownish orange with a black dorsal stripe; femora black…..………..………………………………..…. ***E. megacephalus*** (Rossi, 1794)

4a. Tergites III and IV with creamy white fasciae …..……. ***E. tarsalis*** (Macquart, 1855)

4b. Tergites III and IV without creamy white fasciae…..……………………………. **5**

5a. Eyes with dense pilosity. In male eyes dichoptic; a broad hourglass shaped patch on the abdomen which is dull…………….………… ***E. sepulchralis*** (Linnaeus, 1758)

5b. Pilosity confined to only upper third of eyes; In male: eyes holoptic; entire abdomen glossy ………………………………………………. ***E. aeneus*** (Scopoli, 1763)

Genus *Eristalis* Latreille, 1804

Diagnosis:

Eyes unicolorous, without brown spots or stripes; arista rarely bare, mostly feathery or finely pubescent; abdomen varying in markings and appearance, frequently exhibiting a pair of orange or yellow lateral spots on the tergite II and/or a pale-yellow band on the posterior margin of each tergite; in general appearance similar to *Apis* or *Bombus* (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Eristalis arbustorum (Linnaeus, 1758)

- *Eoseristalis arbustorum* De Geer, 1776
- *Eristalis bulgarica* Szilády, 1934
- *Eristalis lyra* (Harris, 1776)
- *Eristalis paralleli* (Harris, 1776)
- *Eristalis parrelleli* (Harris, 1776)
- *Eristalis polonica* Szilády, 1934
- *Eristalis sachalinensis* Matsumura, 1916
- *Eristalis strandi* Duda, 1940
- *Eristalomya distincta* Shiraki, 1968
- *Musca arbustorum* Linnaeus, 1758
- *Musca horticola* De Geer, 1776
- *Musca lyra* Harris, 1778
- *Musca paralleli* Harris, 1778
- *Musca parrelleli* Harris, 1776
- *Syrphus deflagratus* Preyssler, 1793
- *Syrphus succinctus* Panzer, 1804
- *Volucella tricincta* Müller, 1776

Type material: ♀, NHMUK, London

Other Material:

8♂7♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 4♂4♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 9♂12♀: INDIA- Jammu and Kashmir, Baramulla, Limber, 34^{0}11'47"N 74^{0}09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 9♂7♀: INDIA- Jammu and Kashmir, Srinagar, MA Road, 34^{0}04'27"N 74^{0}49'01"E, 1600m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 10♂12♀: INDIA- Jammu and Kashmir, Anantnag, Khanabal, 34^{0}44'40"N 75^{0}7'44"E, 1620m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123);

Type Locality: Sweden (LSL)

Diagnosis:

Completely yellow dusted face with no entirely yellow-dusted face without a medial shining black stripe; pale mid tibiae and heavily darkened close to the metatarsal joint strongly darkened near the metatarsal joint, basal tarsomere of mesoleg usually bright yellow; scutum with a notably blotchy pattern - with a wide blotch in the centre that may or may not reach the front of the scutum; in males the second tergite consists of a pointed lateral marking that is not triangular because it meets the hind margin of T2 broadly and overflows into a significant anterolateral marking on T3 forming a black hourglass shape, in females a similar marking on T2, (pointed, and meeting the hind margin broadly) but there is no marking on T3; abdomen always has white bands at the tergite margins.

Distribution: Afghanistan, Africa, Canada, China, Europe, India (Arunachal Pradesh, Jammu & Kashmir, Meghalaya, Sikkim, West Bengal), Iran, Pakistan, Siberia, United States (Brunetti 1923; Doesburg 1955; Rahman 1940; Knutson et al. 1975; Datta & Chakraborti 1984; Peck 1988; Aslamkhan et al. 1997; Mitra et al. 2008; Shah et al. 2014; Sengupta et al. 2024; Evenhuis & Pape 2024).

Preferred habitat(s): A species that thrives in human-altered environments, commonly found in agricultural areas, urban parks, gardens, and other wetlands (Vujic et al. 2018)

Floral host range: *Achillea millefolium, Heracleum candicans, Brassica spp., Conium maculatum, Foeniculum vulgare, Mentha longifolia, Sisymbrium loesli* L, *Ranunculus repens, Spiraea bella* L.

Remarks: most widespread and common species in Kashmir. The larva is found in several shallow, stagnant water environments, as well as in cow dung, silage pits, and manure heaps (Vujic et al. 2018).

Eristalis brevifacies Coe, 1964

Other Material:

2♂1♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 1♂1♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^{0} 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 1♂: INDIA- Jammu and Kashmir, Baramullah, Gulmarg, 34^{0}03'50"N 74^{0}23'20"E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123);

Diagnosis:

face comparatively less descending with almost linear, much narrower, black, shining median stripe; fore femora black with a dark ring posteriorly, rather than being totally yellow (as in *E. himalayensis*); absence of a thick antero-ventral border with elongated dark brown and black pilosity on hind femora (present in *E. himalayensis*); thorax is finely and evenly punctate, finer on the anterior portion, significantly rougher in a central gleaming grey region beyond the midpoint; in males, the eye contiguity roughly double the length of vertex (almost equal to length of vertex in *E. himalayensis*). (Coe 1964)

Distribution: India (Jammu & Kashmir), Nepal (Coe 1964; Shah et al. 2014; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): Mesophilic coniferous forests.

Floral host range: *Heracleum candicans, Mentha longifolia, Spiraea bella* L.

Remarks: Very similar to and often misidentified as *E. himalayensis*

Eristalis cerealis Fabricius, 180

- *Eristalis barbatus* Bigot, 1880
- *Eristalis incisuralis* Loew, 1858
- *Eristalis solitus* Walker, 1849

Scutum grey dusted in middle and posteriorly; in males T2 with large yellowish trangular spots, T3 with almost rectangular wide spots not reaching the apex of T3 but sometimes meeting along the basal margin; tergite II spots in female abruptly constrict at the base and extend as a slender band in the middle; T3 bands much reduced and confined to the basolateral region

Distribution: Buma, China, India (Arunachal Pradesh, Assam, Himachal Pradesh, Jammu & Kashmir, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tamil Nadu, Uttarakhand, West Bengal), Japan, Nepal, Russia (Brunetti 1923; Nayar 1968b; Knutson et al. 1975; Datta & Chakraborti 1984; Mitra et al. 2008; Shah et al. 2014; Sengupta et al. 2024; Evenhuis & Pape 2024).

Preferred habitat(s): Thrives in human-altered environments, commonly found in agricultural areas, urban parks, gardens, and wetlands (Vujic et al. 2018)

Floral host range: *Achillea millefolium, Brassica spp., Chaerophyllum reflexum, Conium maculatum, Convolvulus arvensis* L, *Dacus carota* L, *Sisymbrium loesli* L, *Foeniculum vulgare, Melisa officinalis, Mentha piperita, Lathyrus oleraceus, Prunus avium, Heracleum candicans, Mentha longifolia, Ranunculus repens, Spiraea bella* L.

Remarks: One of the widespread and common species in Kashmir.

Eristalis himalayensis Brunetti, 1908 (Figure 39)

Eristalis ursinus Bigot, 1880

Other Material:

4♂2♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; $34^0$16'44"N $74^0$11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 2♂3♀: INDIA- Jammu and Kashmir, Baramullah, Gulmarg, $34^0$03'50"N $74^0$23'20"E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123);

Diagnosis:

Wings featuring a prominent brownish band centrally; hind femora exhibiting a dense fringe of elongated, dark brown and black hairs on the antero-ventral aspect (absent in *E. brevifacies)*; thorax with numerous small dark punctations on disc (evenly and finely punctate in *E. brevifacies)*; in males the eyes touch for about length of vertex (eyes touching for almost twice the length of vertex in *E. brevifacies*) (Brunetti 1923; Coe 1964).

Distribution: Myanmar, China, India (Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Sikkim, Uttarakhand, West Bengal), Nepal (Brunetti 1923; Coe 1964; Nayar 1968b; Knutson et al. 1975; Mitra et al. 2008; Shah et al. 2014; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): mesophilic coniferous forests

Floral host range: *Achillea millefolium, Heracleum candicans, Mentha longifolia, Ranunculus repens, Spiraea bella* L.

Remarks: Very similar to and often misidentified as *E. brevifascies.*

Eristalis tenax (Linnaeus, 1758) (Figure 40)

- *Conops vulgaris* Scopoli, 1763
- *Eristalis alpina* Strobl, 1893
- *Eristalis campestris* Meigen, 1822
- *Eristalis claripes* Santos Abreu, 1924
- *Eristalis cognatus* Wiedemann, 1824
- *Eristalis columbicus* Macquart, 1855
- *Eristalis hortorum* Meigen, 1822
- *Eristalis rubix* Violovich, 1977
- *Eristalis sinensis* Wiedemann, 1824
- *Eristalis sylvaticus* Meigen, 1822
- *Eristalis tenax subsp. campestris* Meigen, 1822
- *Eristalis ventralis* Thomson, 1869
- *Eristalis vulpinus* Meigen, 1822
- *Eristalomya tenax* (Linnaeus, 1758)
- *Musca porcina* De Geer, 1776
- *Musca tenax* Linnaeus, 1758

Other Material:

4♂2♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 3♂4♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^{0} 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 2♂3♀: INDIA- Jammu and Kashmir, Baramulla, Limber, 34^{0}11'47"N 74^{0}09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 2♂3♀: INDIA- Jammu and Kashmir, Srinagar, MA Road, 34^{0}04'27"N 74^{0}49'01"E, 1600m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 6♂2♀: INDIA- Jammu and Kashmir, Anantnag, Khanabal, $34^0$44'40''N $75^0$7'44''E, 1620m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 1♂3♀: INDIA- Jammu and Kashmir, Baramullah, Gulmarg, $34^0$03'50''N $74^0$23'20''E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123);

Diagnosis: Eyes featuring a vertical band of elongated, dark hairs; a broad black face stripe; and notably larger and bent hind tibia. (Van Veen 2004).

Distribution: Afghanistan, Australia, Burma, China, Easter Island, Hawaii, India (Arunachal Pradesh, Jammu and Kashmir, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Uttarakhand, West Bengal), Japan, New Zealand, Pakistan, Sri Lanka (Brunetti 1923; Rahman 1940; Lambeck and Brink 1973; Mitra et al. 2008; Shah et al. 2014; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): Anthropophilic and almost ubiquitous.

Floral host range: *Achillea millefolium, Heracleum candicans, Brassica spp., Conium maculatum, Foeniculum vulgare, Mentha longifolia, Sisymbrium loesli* L, *Ranunculus repens, Spiraea bella* L.

Remarks: The larvae inhabit nutrient-rich aquatic settings such as slurry tank and silage clamps, where they may occasionally exist in large quantities (Vujic et al. 2018)

Key to the species of genus *Eristalis* for Jammu and Kashmir

1a. Yellowish or brownish orange fascia or bands absent on tergites III-V…………. **2**

1b. Yellowish or brownish orange bands or fascia present on tergites III-V………….**3**

2a. basoflagellomere and arista black; in males the eyes touch for about length of vertex; descending face with a wide median black stripe; thorax covered in dense golden yellow and orange yellow pilosity; hind femora with the dense antero-ventral fringe of longish dark brown and black hairs ………..…………………………………..…. ***Eristalis himalayensis*** Brunetti, 1908

2b. basoflagellomere and arista brownish orange; eyes in male touching for almost double the length of vertex; less descending face with a narrow median black stripe; thorax pilosity less denser, brownish yellow and brownish black; hind femora

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without the dense antero-ventral fringe of longish dark brown and black hairs ……………………………………………. ….. ***Eristalis brevifacies*** Coe, 1964

3a. Eyes with two distinct bands of hair …..……………..…. ***E. tenax*** (Linnaeus, 1758)

3b. Eyes without bands of hair Yellowish bands or fascia absent on tergites III-V…. **4**

4a. face without a central shining black stripe; scutellum blakish brown; scutum pruinose with longitudinal dark bands…..………. ***E. arbustorum*** (Linnaeus, 1758)

4b. face with a narrow central shining black stripe; scutellum brownish orange; scutum pruinose with a wide black horizontal band towards posterior half ……………..……………………………………………. ***E. cerealis*** Fabricius, 180

Genus *Ferdinandea* Rondani, 1844

Diagnosis: Crossvein r-m extending to or beyond the midpoint of the discal cell; antennal sockets confluent; face yellow and pruinose with a black median stripe; legs yellow; prominent, grey pruinose stripes on scutum; Scutum and scutellum having strong black bristles (Hull 1942; Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Ferdinandea isabella Hull, 1942

Type Material: India (‘Gulmarg, 8500 ft., Kashmir, India’) [Holotype ♀; BMNH, London, examined]

Diagnosis: Wing without trace of clouds anywhere; only stigmal base brownish and wing uniformly pale yellowish brown. Four notopleural bristles, four scutellars, and four prescutellars; radial sector with two microbristles.

Distribution: India (Kashmir) (Hull 1942; Coe 1964; Knutson et al. 1975; Shah et al. 2014; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): High altitude sub alpine coniferous forest.

Floral host range: Data insufficient.

Remarks: This species is known from a single female specimen.

Ferdinandea montana Hull, 1942

Type Material: India (‘Gulmarg, 8500 ft., Kashmir, India’) [Holotype ♂; BMNH, London, examined].

Other Material:

7♂: INDIA- Jammu and Kashmir, Baramullah, Botapathri, $34^0$05'06"N $74^0$18'40"E, 2900m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 2♂3♀: same as above except Gulmarg, $34^0$03'50"N $74^0$23'20"E, 2700m (amsl), 5 oct 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Diagnosis: The face is yellow pruinose, featuring a broad black median stripe, with antennae comprising a black scape, pedicel, and arista, brown basoflagellomere, arista black; thorax with three pairs of notopleurals, five scutellars, and one pair of prescutellars; abdomen nonmetallic, yellowish brown, black, wedgelike spots on at least second and third segments.

Distribution: India (Kashmir) (Hull 1942; Coe 1964; Knutson et al. 1975; Shah et al. 2014; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): High altitude sub alpine coniferous forest.

Floral host range: *Geranium wallichianum*

Remarks: This species collected and photographed first time since its first description in 1942.

Key to the species of genus *Ferdinandea* for Jammu and Kashmir

1a. Thorax shining brownish-black with 4 notopleural bristles on each side**;** abdominal segments bright orange brown…………………………..…. ***F. isabella*** Hull, 1942

1b. Thorax dull grey with 2-3 notopleural bristles on each side; abdomen dark brown metallic……………………………………..…………..……. ***F. montana*** Hull, 1942

Genus *Graptomyza* Wiedemann, 1820

Diagnosis:

Dichoptic eyes in both sexes, head broader than thorax; somewhat depressed frons beneath antennae; elongated antennal flagellomere, longer than its width; wings featuring an open marginal cell and an obscure spurious vein; distinct depression on scutellum with a row of bristles on the side margin; abdomenal margins conspicuously convex laterally (Brunetti, 1923).

Graptomyza brevirostris Wiedemann, 1820

Type locality: Indonesia (‘Batavia, Djakarta, Java’)

Type material: ♀;UZM, Copenhagen [Examined]

Diagnosis: Face with a dark median stripe reaching upto the base of antennae; antennae brownish black, arista bare yellow; wings with dark crossbands; scutum shinning black; scutellum black with yellowish margins; tergites II and III with a posterior black stripe with forward extending anterior margins in forming three black obtuse triangles (Brunetti 1923).

Distribution: Pakistan? India (CH, Jammu and Kashmir, Punjab) Nepal

Floral host range: Data insufficient

Remarks: Although the species, as per literature has a wider distribution in India, yet it’s rarely collected.

Graptomyza flavonotata Brunetti, 1917 (Figure 41)

Type Locality: India (‘between Kufri and Phagu, Simla District’)

Type material: [♀, ZSI, Calcutta - examined]

Other Material:

1♂2♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 1♂1♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 2♂3♀: INDIA- Jammu and Kashmir, Srinagar, MA Road, 34^{0}04'27"N 74^{0}49'01"E, 1600m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Diagnosis:

face and frons and completely yellow with yellowish pilosity; antennae brownish black, arista yellowish, bare; scutum black shining, yellowish lateral margins with two circular pilose yellow spots near posterior margin; scutellum yellowish; wings clear without any dark bands tergites II, III and IV with distinct three black spots; scutellum yellow (Brunetti 1923).

Distribution: India (Himachal Pradesh, J&K) Pakistan (Hull 1942; Coe 1964; Knutson et al. 1975: Hassan et al. 2013; Shah et al. 2014; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): forested localities, city gardens on white Compositae flowers.

Floral host range: *Chaerophyllum reflexum*, *Spiraea bella* L.

Remarks: Certain species have been identified as saprophagous, developing in fruits and pods.

Key to the species of genus *Graptomyza* for Jammu and Kashmir

1a. Wings with dark cross bands; scutellum black with yellow margins yellow; tergites II and III with a posterior black stripe with forward extending anterior margins in forming three black obtuse triangles……….…. ***G. brevirostris*** Wiedemann, 1820

1b. Wings without any marks; scutellum yellowish; tergites II, III and IV with distinct three black spots……………………….….……….. ***G. flavonotata*** Brunetti, 1917

Genus *Helophilus* Meigen, 1822

Diagnosis:

Antenna entirely black (sometimes with a narrow orange border at the base of the basoflagellomere) or blackish brown; face with a vertical median stripe, glabrous and shiny, yellow or black; facial tubercle present; vein R_{4+5} with a strong to moderate loop; a patch of black setulae on hind femur basolaterally, lacking a ventroapical tubercle or carina; thorax with pale, longitudinal stripes on the top (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Helophilus trivittatus (fabricius, 1805) (Figure 42)

- *Eristalis trivittatus* Fabricius, 1805: 235.
- *Musca parallelus* Harris, 1778.
- *Helophilus camporum* Meigen, 1822.
- *Helophilus solitarius* Rondani, 1857.

Type material: ZMUC, Copenhagen

Other Material:

1♂1♀: INDIA- Jammu and Kashmir, Srinagar, MA Road, $34^0$04'27"N $74^0$49'01"E, 1600m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 7♂8♀: INDIA- Jammu and Kashmir, Anantnag, Khanabal, $34^0$44'40"N $75^0$7'44"E, 1620m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: Austria

Diagnosis:

The R_{4+5} wing vein has a pronounced sinuation into cell r_{4+5}, but cell r_1 remains open; the thorax is characterised by a velvet black pruinosity adorned with off-white fasciae along the lateral margin and two extra mediolateral fasciae. Protibia exceedingly short and pilose; posterobasal region of metafemur thickly covered with black setulae; eyes devoid of pilosity; male exhibits widely dichoptic eyes; face characterised by a medial bare vitta extending from the facial tubercle downward; face concave with a distinctly protruding ventral section. (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Distribution: Palaerctic and Eurasian regions, India (Jammu and Kashmir) (Van steenis et. al. 2013; Riyaz and Khan 2017; Speight 2020; Wachkoo et al. 2021).

Preferred habitat(s): Significantly anthropophilic, Wetland/open terrain; riverbanks, periodically inundated damp grasslands, and salt marshes (Vujic et al. 2018)

Floral host range: *Achillea millefolium, Brassica spp., Sisymbrium loesli* L, *Lathyrus oleraceus*

Remarks: Dolezil (1972) raised larvae from eggs deposited in a hay infusion in water. The larvae have been inhabiting mud characterised by a high organic content derived from animal excrement and decomposing plant matter (Speight 2017).

Genus *Lejogaster* Rondani, 1857

Diagnosis:

Ventral surface of the hind femur without black spinose hairs; Tergites 2 – 5 entirely shining and undusted, the central part of each tergite not appearing matt from any angle, metallic bronze or gold along the lateral margins and either the same colours or metallic blue, centrally; male: eyes separate on the frons (metasternum hairy) (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

***Lejogaster tarsata* (Meigen, 1822)** (Figure 43)

Type material: NMW, Vienna

Other Material

5♂7♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 5♂5♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 2♂3♀: INDIA- Jammu and Kashmir, Baramulla, Limber, 34^{0}11'47"N 74^{0}09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 2♂3♀: INDIA- Jammu and Kashmir, Srinagar, MA Road, 34^{0}04'27"N 74^{0}49'01"E, 1600m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 6♂2♀: INDIA- Jammu and Kashmir, Anantnag, Khanabal, 34^{0}44'40"N 75^{0}7'44"E, 1620m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 1♂3♀: INDIA- Jammu and Kashmir, Baramullah, Gulmarg, 34^{0}03'50"N 74^{0}23'20"E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123);

Type Locality: Austria

Diagnosis:

Abdomen metallic with bluish reflections; marginally smaller and more slender than *L. metallina*; The antennae are somewhat rounded and yellow in male, while in female, more elongated compared to those of *L. metallina*. (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Distribution: Central Asia, Western Palaerctic, European Russia, Pacific Coast, India (Speight 2020; Wachkoo et al. 2021; Sengupta et al. 2024; Evenhuis & Pape 2024).

Preferred habitat(s): Wetland/freshwater; streams, springs in fens, spring-fed pons, and with pure water (Speight 2017)

Floral host range: *Achillea millefolium, Chaerophyllum reflexum, Conium maculatum, Heracleum candicans, Spiraea bella* L.

Remarks: Aquatic larvae are, reproducing in moist decomposing plant matter around the peripheries of ponds and ditches (Vujic et al. 2018).

Genus *Myathropa* Rondani, 1845

Diagnosis:

eyes pilose, arista bare, open cell R_1, non-metallic bodywithout any vittae on thorax; pruinose scutum with two anterior and a large posterior macula resembling a skull marking, though, scutum pruinosity maybe reduced in darker specimens; male holoptic (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Myathropa seminovi (Smirnov, 1925) (Figure 44)

Myiatropa semenovi Smirnov, 1925

Type material: Syntype ♂ ZMMU, examined

Other Material:

2♂3♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 1♂: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 1♂2♀: INDIA- Jammu and Kashmir, Baramulla, Limber, 34^{0}11'47"N 74^{0}09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 1♂3♀: INDIA- Jammu and Kashmir, Baramullah, Gulmarg, 34^{0}03'50"N 74^{0}23'20"E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123);

Type Locality: Uzbekistan (Tashkent)

Diagnosis:

Entirely yellow pilose scutum and scutellum; males and females with yellow abdominal maculae that are diminished in size on tergites III and IV and are medially smaller on tergite II; a medial pruinose fascia on tergites III and IV (Maqbool et al. 2023)

Distribution: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and India (Jammu and Kashmir) (Maqbool et al. 2023)

Preferred habitat(s): Various types of deciduous forests; to a certain degree anthropophilic, found in humid pastures and residential gardens (Vujic et al. 2018).

Floral host range: *Achillea millefolium, Heracleum candicans, Mentha longifolia, Ranunculus repens, Spiraea bella* L.

Remarks: Saprophagous larvae, including aquatic or semi-aquatic forms, inhabit sap runs, shallow rot holes, beneath bark, decaying heartwood and decomposing vegetation (Stubbs & Falk 1983; Rotheray 1993; van Steenis 2023).

Genus *Rhingia* Scopoli, 1763

Diagnosis: Face strongly projected forward in the form of a long snout; wing veins C and R_{4+5} terminate after the wing apex; thorax with bristles (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Rhingia laticincta Brunetti, 1907 (Figure 45)

Rhingia fasciata brunetti, 1908

Type material: ♂, ZSI, Calcutta, examined

Other Material:

2♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; $34^0$16'44"N $74^0$11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096).

Type Locality: India (Darjiling)

Diagnosis: thorax yellowish grey pruinose with four blackish longitudinal stripes, lateral ones interrupted at the suture, the inner ones running closely and diverging posteriorly, diffusing in front of scutellum; scutellum with fine black pilosity and stiff black hairs on apical margin; legs brownish orange; posterior margin of tergite II-IV with a broad black band, narrowing considerably in the centre and widening laterally, reaching margins; somewhat oval vertical black spot, medially, on tergite II-IV, closer to anterior margins (Brunetti, 1907; 1923)

Distribution: China, India (Himachal Pradesh, J&K, Punjab, Uttarakhand, West Bengal) (Brunetti 1923; Shah et al. 2014; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): Forest/wetland, predominantly found in areas utilised for cattle grazing.

Floral host range: *Barbarea vulgaris, Taraxacum parvulum*

Remarks: New state record.

Rhingia sexmaculata Brunetti, 1913 (Figure 46)

Type material: ♂, ZSI, Calcutta, examined

Other Material:

1♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096).

Type Locality: India (Darjiling)

Diagnosis: antennae brownish orange, arista black; thorax ground-colour aeneous, brownish yellow pruinosity with two central and two lateral dark longitudinal stripes, lateral ones interrupted at suture, inner ones diverging posteriorly and reaching margin of scutellum; scutellum concolourous with yellowish apical margin bearing long stiff hairs; abdomen black with wide yellowish fascia, on tergite II-IV reaching but not touching in the middle; coxae and base of femora, hind tarsi black, rest of the legs brownish yellow (Brunetti, 1913; 1923).

Distribution: India (Assam & J&K) (Sengupta et al. 2024; Evenhuis & Pape 2024

Preferred habitat(s): Forest/wetland, predominantly found in areas utilised for cattle grazing.

Floral host range: *Barbarea vulgaris, Impatiens glandulifera,*

Remarks: New state record.

Key to the species of *Rhingia* for Jammu and Kashmir

1a. Tergites II-IV mainly black : a pair of distinct orange yellow bands in middle of side margin of each, all subequal, their inner ends not touching…………………………………………….…. ***R. sexmaculata*** Brunetti, 1913

1b. Tergites II-IV mainly yellowish, with black spots towards each side on hind margin…………………………………….………..….. ***R. laticincta*** Brunetti, 1907

Genus *Sphegina* Meigen, 1822

Diagnosis: small or medium-sized slender Syrphidae with aface is markedly concave and glabrous in both genders; the eyes are glabrous and dichoptic in both genders; The antennal basoflagellomere is oval in shape, featuring a lengthy pilose arista attached dorsally. Postpronotum pilose; metasternum and katepisternum glabrous; wing vein R_{4+5} straight, cross vein tm rounded, cross vein dm-cu joining vein M_{1+2} perpendicularly; postmetacoxal bridge broad and complete; hindleg longer than pro and mesolegs, enlarged hind femora; petiolate abdomen (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Sphegina bispinosa Brunetti, 1915 (Figure 47)

Other material: 5♂1♀: INDIA- Jammu and Kashmir, Baramulla, Limber, $34^0$11'47"N $74^0$09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); same as above except Rafiabad $34^0$16'44"N $74^0$11'32"E 1800m (amsl), 2 sept 2024, swipe net, Suhaib Yatoo leg., (CUZM-S_Yatoo00124)

Diagnosis: strong posterior setae on left side on sternum IV with much longer and stronger than on right side; a large conical and setose tubercle present on sternum VII medially; genitalia with strongly asymmetrical surstyli (Brunetti, 1915).

Distribution: India (Assam, J&K, Uttarakhand, West Bengal) (Brunetti 1923; Mitra et al. 2008; Shah et al. 2014; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): shady, damp places with flowing water (streams etc)

Floral host range: *Heracleum candicans, Impatiens glandulifera, Mentha longifolia,*

Remarks: New state record.

Sphegina conifera **n.sp** (Figure 48)

Type material: Holotype ♂: INDIA- Jammu and Kashmir, Baramulla, Limber, $34^0$11'47"N $74^0$09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00110)

Paratypes:2♂: same as holotype except (CUZM-A_Maqbool00111 to CUZM-A_Maqbool00112)

Etymology: The species epithet refers to

Type locality: India (Jammu & Kashmir: Kashmir: Baramulla: Limber)

TD: CUZM

Diagnosis: similar to *S. bispinosa* but differs in having a uniformly black legs (yellow fore and mid legs in *S. bispinosa)*, antennae dark brown (brownish orange in *S. bispinosa)*, absence of strong posterior setae on sternum IV; tergite III completely black without a fascia (brown-yellow sub-anterior fascia present in *S. bispinosa*); genitalia symmetrical (asymmetrical in *S. bispinosa)*

Description: Face strongly concave, projected antero-ventrally; large frontal prominence, antennae dark brown, arista brownish; occiput dull black wings transparent grey in basal half, with a light brownish hue in apical half; scutum dark grey, pruinose without any markings, covered with short pilosity; thorax laterally grey with sparse greyish white pilosity; scutellum semi-triangular with short black pilosity; uniformly black legs, with dark brown tibia and brownish tarsi; metafemur strong with rows of strong ventral bristles; andomen shinning black, sternum IV without posterior setae on; tergite III completely black without any fascia; genitalia symmetrical with short surstyli.

Distribution: India (J&K)

Preferred habitat(s): shady, damp places with flowing water (streams etc)

Floral host range: *Heracleum candicans, Mentha longifolia,*

Remarks: New species

***Sphegina robusta* n.sp** (Figure 49)

Type material: Holotype ♂: INDIA- Jammu and Kashmir, Baramulla, Limber, 34^{0}11'47"N 74^{0}09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00113)

Paratypes:1♂: same as holotype except (CUZM-A_Maqbool00111 to CUZM-A_Maqbool00114)

Etymology: The species epithet refers to

Type locality: India (Jammu & Kashmir: Kashmir: Baramulla: Limber)

TD: CUZM

Diagnosis: similar to *S. tricoloripes* but differs in having long greyish black pile on head covering frons to occiput (only fine and sparse greyish white hairs in *S. tri coloripes*); yellow fore and mid legs (black in *S. tricoloripes)*; scutellum with black hairs (whitish in *S. tricoloripes*); tergite III completely black without a fascia (brown-yellow sub-anterior fascia present in *S. tricoloripes*); genetalia with normal unmodified cerci (dentate cerci *S. tricoloripes*).

Description: Face strongly concave, projected antero-ventrally; large frontal prominence, antennae brownish, arista brownish and hairy, Frons exhibiting extensive black pilosity along the ocellar triangle, extending to the occiput; wings are transparent with a pale yellowish tint; fore and mid legs are yellowish-brown, featuring dark brown apical tarsal segments, metafemur strong, black, yellowish white in basal 4th with rows of short black ventral bristles; abdomen moderately elongated, sternite VII with a uniform apical margin, tergite-III slightly longer than tergite-IV; genitalia with narrow and elongated surstyli

Distribution: India (J&K)

Preferred habitat(s): shady, damp places with flowing water (streams etc)

Floral host range: *Heracleum candicans, Mentha longifolia,*

Remarks: New species

***Sphegina baccha* n.sp** (Figure 50)

Diagnosis: very similar to *S. tricoloripes* however differs in having no fascia on tergite III (brown-yellow fascia present in *S. tricoloripes*), hind tibia black in basal half (white in *S. tricoloripes*); genetalia with normal small cerci (dentate cerci *S. tricoloripes*).

Description: Face concave, slightly projected antero-ventrally; large frontal prominence, antennae dark brown, basoflagellomere brownish orange, arista light brownish; wings transparent grey basally with very light yellowish hue in apical ¾ ; scutum black, shiny, with bluish hue, very light pruinosity, without any markings, covered with small black and grayish-white pilosity; scutellum is black, pruinose, featuring short black and grayish-white pilosity along with elongated dark grey apical setae; Fore and mid femora are black, tibia is brownish, and tarsi are yellow with a dark apical tarsal segment; metafemur strong, black, yellowish white in basal 4th with rows of short ventral bristles and greyish white pilosity along the ventral margin; hind tibia brown with yellowish white ring in middle, hind tibia light brownish; abdomen shinning black with fine black pilosity and greyish white pilosity towards basal segments, sternite VII with an irregular apical margin without posterior setae; tergite III completely black without any fascia; genitalia with short and pointed surstyli.

Type Material: Holotype♂: INDIA-Jammu and Kashmir, Baramulla, Limber, $34^0$12'50"N $74^0$09'46"E, 2500m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00114)

Paratypes:2♂: same as holotype except (CUZM-A_Maqbool00115 to CUZM-A_Maqbool00116)

Etymology: The species epithet '*baccha*' refers to it close morphological similarity with *Baccha* species.

Type locality: India (Jammu & Kashmir: Kashmir: Baramulla: Limber)

TD: CUZM

Distribution: India (J&K)

Preferred habitat(s): shady, damp places with flowing water (streams etc)

Floral host range: *Dipsacus inermis*, *Mentha longifolia*,

Remarks: New species

Sphegina parbati **n.sp** (Figure 51)

Type material: Holotype ♂: INDIA- Jammu and Kashmir, Baramulla, Limber, $34^0$12'50"N $74^0$09'46"E, 2500m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00117)

Etymology: The species epithet refers to

Type locality: India (Jammu & Kashmir: Kashmir: Baramulla: Limber)

TD: CUZM

Diagnosis: very similar to *S. tricoloripes* however differs in having no fascia on tergite III (brown-yellow fascia present in *S. tricoloripes*), tergite III significantly longer than tergite IV (equall in tricoloripes), tergite III 1.7 times longer than tergite IV (2.3 times longer in *S. tricoloripes*). It's also similar to *S. baccha* but varies in having a dull densely pruinose scutum (shinning black in *S. baccha*), fore and mid legs primarily yellow (primarily black in *S. baccha*), rear and mid tibia light brown in the Basal half (black in *S. baccha*);

Description: Face whitish yellow with a dark wide brownish black medial stripe, concave, slightly projected antero-ventrally; small frontal prominence, antennae dark brown, basoflagellomere brownish orange, arista light brownish; wings transparent basally with light brownish hue more so towards apical region than basally; scutum dark dull with greyish white pruinosity, without any markings, covered with short black and greyish white pilosity; scutellum black, marginally pruinose with long yellowish apical setae; fore leg whitish yellow with dark brown apical tarsomeres, mid femur and tibia light brownish, basitarsus yellowish white with dark apical tarsomeres, hind femur strong, black, covered with sparse greyish white pilosity, yellowish white in basal 3rd with rows of short ventral bristles and along the ventral margin; hind tibia light brown with dark brown apical 3rd, hind tarsi light brown; abdomen shinning black with fine black pilosity and greyish white pilosity, sternite VII with an irregular apical margin without a prominent lobe; genitalia with narrow and elongated surstyli.

Distribution: India (J&K)

Preferred habitat(s): shady, damp places with flowing water (streams etc)

Floral host range: *Dipsacus inermis,*

Remarks: New species

Sphegina tricoloripes Brunetti, 1915 (Figure 52)

Other material: 3♂: INDIA- Jammu and Kashmir, Baramulla, Limber, $34^0$11'47"N $74^0$09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00125 to A_Maqbool00127); 6♂: same as above except Kulgam, Aharbal $33^0$38'39"N 74^0 46'37"E 2270m (amsl), 10 Aug 2021, swipe net, A. Wachkoo leg., (CUZM-A_Wachkoo00125 to CUZM-A_Wachkoo00130).

Diagnosis: basal ¼ of arista rather short and pilose; frons along eye-margin widely pollinose, dull medially; fascia on tergum III pale, almost connected to the anterior margin of its tergum; genitalia having dentate cerci (Brunetti, 1915).

Distribution: China, India (Himachal Pradesh, Uttarakhand) (Brunetti 1923; Knutson et al. 1975; Shah et al. 2014; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): shady, damp places with flowing water (streams etc)

Floral host range: *Heracleum candicans, Impatiens glandulifera, Mentha longifolia,*

Remarks: New state record.

Key to the species of *Sphegina* for Jammu and Kashmir

1a. Brown-yellow sub-anterior fascia present on tergite III…………………….........**2**

1b. Tergite III without any fascia…... **3**

2a. Antennal basoflagellomere brownish orange; wings light brownish with diffused dark bands; fore and mid femora yellowish brown; sternum IV with strong posterior setae on left side on, sternum VII with a large conical and setose tubercle present medially; genitalia with small cerci and strongly asymmetrical surstyli ………………………………………..……….…..... ***S. bispinosa*** Brunetti, 1915

2b. Antennal basoflagellomere brown; wing greyish without any dark bands; fore and mid femora black; sternum IV without strong posterior setae, sternum VII without a setose tubercle; genetalia having dentate cerci .... ***S. tricoloripes*** Brunetti, 1915

3a. Fore and mid legs predominantly brownish yellow ..………..…………..……... **4**

3b. Fore and mid legs predominantly black**…………………………….…………...5**

4a. hind tibia black basally; sternite VII with a prominent left apical lobe; genitalia with short surstyli..…………………………………………….……….. ***S. conifera*** **n. sp**

4b. Hind tibia brownish yellow basally; sternite VII with an irregular apical margin without a prominent lobe; genitalia with narrow and elongated surstyli…………..…………………………………………………….. ***S. parbati*** **n. sp**

5a. frons with long black pilosity; sternite VII with a uniform apical margin; genitalia with narrow and elongated surstyli.……………………………….…….. ***S. robusta*** **n. sp**

5b. Frons with short grey pilosity; sternite VII with an irregular apical margin; genitalia with short and pointed surstyli…………..…………………..……… ***S. baccha*** **n. sp**

Genus Spilomyia **Meigen, 1803**

Diagnosis: Eyes with small dark spots and a dark vertical band with irregular contours; ventral surface of the hind femur with an isolated, spinose, tubercle, in the apical half of its

length; abdominal tergites with transverse yellow bands (mimicking wasps of genus *Polistes*) (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Spilomyia recta Van Steenis, Maqbool & Wachkoo, 2024

Type material: Holotype ♂: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E, 2184 m a.s.l., 5^{th} Sept 2021, leg. Amir Maqbool (CUZM-A_Maqbool00018)

Paratypes:7♂♂ ♀:INDIA- with same data as holotype, except: 26. vi.2022, leg. Suhaib Yatoo 1♂, 1♀ (CUZM-S_Yatool00005 to S_Yatool00006); Jammu and Kashmir, Srinagar, 34.1456^{0}N 74.8775^{0}E, 1800m (amsl)., 15^{th} oct 2015 1♀ (CNC (on long term loan from CUZM)-Jeff_Skevington_Specimen45211; BOLD ID CNCFF851-16; Afghanistan: "Afghanistan // Nouristan // 18-VIII-1977 // G. Meur-gues, G. Ledoux", "Vall´ee du Pech // (1800–2400 m.)" 1♂ (MNHN, id no PaAf-18877).

Additional Material: India: Himachal Pradesh, Naggar Castle, 32.1144^{0}N, 77.1747^{0}E, 1887 m a.s.l., 13^{th} July 2013 leg. D. Banerjee, 1♀.

Type locality: India (Jammu & Kashmir: Kashmir: Baramulla: Rafiabad)

TD: CUZM

Diagnosis: A wasp-mimicking species with contrasting black and yellow coloured body pattern; scutum with yellow pattern on postpronotum, a macula medially from the postpronotum, on the notopleuron and an inverted V anterior to the scutellum; pile on scutum and scutellum long, almost 1/3 of the length of the scutellum; pile on anterior half of scutum mixed black and white; posterior margin of scutellum broadly yellow; pleurae with 4

yellow maculae; Wing completely microtrichose; legs predominantly yellow, with the exception of the antero-apical three-quarters of the protibia and tarsomere 1–4 of protarsus black; terga II–IV each with an uninterrupted antero-medial yellow fascia and a straight posterior yellow fascia (Maqbool et al. 2024).

Distribution: Afghanistan, India (Himachal Pradesh, J&K), Pakistan (Maqbool et al. 2024)

Preferred habitat(s): Deciduous forest; Coniferous forest with over-mature trees.

Floral host range: *Achillea millefolium, Dipsacus inermis, Heracleum candicans, Mentha longifolia, Spiraea bella* L.,

Remarks: New species described (only representative species of this genus found in India)

Genus *Syritta* Lepeletier & Serville, 1828

Diagnosis:

Ventral surface of the hind femur without black spinose hairs; Tergites 2 – 5 entirely shining and undusted, the central part of each tergite not appearing matt from any angle, metallic bronze or gold along the lateral margins and either the same colours or metallic blue, centrally; male: eyes separate on the frons (metasternum hairy) (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Syritta pipiens (Linnaeus, 1758) (Figure 53)

- *Musca pipiens* Linnaeus, 1758
- *Musca pipines* Geoffroy, 1785
- *Spheginoides tenofemorus* Dzhafarova, 1974
- *Syritta albicincta* Santos Abreu, 1924
- *Syritta flavicans* Szilády, 1940
- *Syritta obscuripes* Strobl, 1899
- *Syritta vicina* Szilády, 1940
- *Xylota proxima* Say, 1824

Type material: NHMUK, London

Other Material:

5♂7♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 3♂3♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^{0} 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 6♂9♀: INDIA- Jammu and Kashmir, Baramulla, Limber, 34^{0}11'47"N 74^{0}09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 2♂3♀: INDIA- Jammu and Kashmir, Srinagar, MA Road, 34^{0}04'27"N 74^{0}49'01"E, 1600m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 3♂4♀: INDIA- Jammu and Kashmir, Anantnag, Khanabal, 34^{0}44'40"N 75^{0}7'44"E, 1620m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 5♂7♀: INDIA- Jammu and

Kashmir, Baramullah, Gulmarg, 34^{0}03'50"N 74^{0}23'20"E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: Sweden

Diagnosis:

Wing bare on basal two third; mesoscutum and scutellum with fine punctuation; no pruinosity along the lateral margins of the mesoscutum, except for anteriorly, where the humeral callus is sometimes densely grey polinose; enlarged hind femur with spinose anteroventral edge (Van Veen 2004; Bot and Meutter 2023).

Distribution: Afghanistan, Africa Countries, British Columbia, Canada, Europe, India (Himachal Pradesh, J&K, Uttarakhand, Uttar Pradesh, West Bengal), Nepal, Pakistan, United States. (Brunetti, 1923; Shah et al. 2014; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): wetland; the periphery of nearly any freshwater body, encompassing ponds, lakes, rivers, canals, brooks and ditches; anthropophilic, prevalent in many types of agricultural land, suburban gardens and urban parks (Vujic et al. 2018).

Floral host range: *Achillea millefolium*, *Brassica spp.*, *Chaerophyllum reflexum, Conium maculatum*, *Dacus carota* L, *Sisymbrium loesli* L, *Foeniculum vulgare, Lathyrus oleraceus*, *Delphinium ajacis*, *Heracleum candicans*, *Barbarea vulgaris, Mentha longifolia, Myosotis arvensis, Ranunculus repens, Spiraea bella* L.,

Remarks: Larvae residing in diverse forms of damp, decomposing organic material, such as garden compost and piles of cow dung (Speight 2017).

Genus *Volucella* Geoffroy, 1762

Diagnosis: robust species mimicking bumblebees or hornets, featuring a hairy arista, anteroventrally protruding face, and a highly curved M1 vein directed towards the wing base (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Volucella linearis Walker, 1852 (Figure 54)

Volucella nitobei Matsumura, 1916

Type material: ♀, NHMUK, London

Other material:

2♂1♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; $34^0$16'44"N $74^0$11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 1♂3♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; $33^0$38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 6♂9♀: INDIA- Jammu and Kashmir, Baramulla, Limber, $34^0$11'47"N $74^0$09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 2♂1♀: INDIA- Jammu and Kashmir, Baramullah, Gulmarg, $34^0$03'50"N $74^0$23'20"E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: Japan

Diagnosis: Head orange-yellow, male compound eyes covered with orange-yellow hair on the upper part; antennae orange-yellow, basoflagellomere almost twice as long as wide, wide at the base; mesothorax brownish orange, with a pair of black middle longitudinal stripes in the middle, which reach the front edge of the dorsal plate, but not the rear edge; notopleuron, postalar callus and anterior anepisternum with long black bristles; scutellum orange yellow with 8-10 long black bristles apically; wings yellow basally and along costal margin, lower half transparent, with wide brown longitudinal bands on the upper half; legs brownish orange with femora little darker; abdomen ground colour black and shiny, covered with black hair; The front margin of the second tergite features a pair of inconspicuous tiny triangular yellow lateral dots, which are less discernible in males, anterior margin of the second and third dorsal tergites with narrow yellowish white horizontal fascia (Matsumura, 1916).

Distribution: Japan (Evenhuis & Pape 2024)

Preferred habitat(s): mesophilous woodland, open aresa within diverse deciduous forest types .

Floral host range: *Dipsacus inermis, Heracleum candicans, Mentha longifolia, Spiraea bella* L.

Remarks: New country record

Volucella peletrii Macquart, 1834 (Figure 55)

Volucella signata Brunetti, 1923

Type material: ♂, MNHN, Paris

Other Material:

2♂2♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 3♂3♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^{0} 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 1♀: INDIA- Jammu and Kashmir, Baramulla, Limber, 34^{0}11'47"N 74^{0}09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 1♂: INDIA- Jammu and Kashmir, Baramullah, Gulmarg, 34^{0}03'50"N 74^{0}23'20"E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: Indonesia (Java)

Diagnosis: Body pubescence is often sparse and brief. Antennal and cephalic regions entirely orange; epistome elongated, exhibiting a short yellowish hue with sparse black hairs, and a prominent central protuberance; thorax brownish-orange; scutellum orange interspersed with golden and black hairs, long black bristles along apical margin; wings yellowish; legs orange yellow to brownish orange with short orange pubescence, femora darker; tergite 1 and II black, tergite I with yellowish white band medio-apically, anterior margin of tergite II with greyish white horizontal fascia, tergite III orange red with a large central triangular spot, tergite IV with a faded sub-apical brown (Macquart 1834; Brunetti, 1923).

Distribution: India, Pakistan (Brunetti 1923; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): Pinus forest, mesophilous forest

Floral host range: *Heracleum candicans, Anthriscus nemorosa, Dipsacus inermis, Mentha longifolia, Spiraea bella* L.,

Remarks: Brunetti (1923: 146) described *V. signata* as a new species, but on examining the type specimen it came out as *V. peletrii* and hereby is synonymised.

Volucella pellucens (Linnaeus, 1758) (Figure 56)

- *Conops dryaphilus* Scopoli, 1763
- *Musca fera* Harris, 1776
- *Musca pellucens* Linnaeus, 1758
- *Syrphus putescens* Schellenberg, 1803
- *Volucella fera* (Harris, 1776)
- *Volucella matsumurai* Han & Choi, 2001

Type material: ♀, NHMUK, London

Other Material:

7♂6♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 4♂6♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 2♂: INDIA- Jammu and Kashmir, Baramulla, Limber, 34^{0}11'47"N 74^{0}09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 2♂3♀: INDIA- Jammu and Kashmir, Baramullah, Gulmarg, 34^{0}03'50"N 74^{0}23'20"E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: Sweden

Diagnosis: Body pubescence is often sparse and brief; head orange-brown, antennae orange; thorax glossy black, dark brown at the humeri and lateral borders; scutellum orange-brown with elongated black bristles along the margin; wings with veins on the basal half exhibiting a pale orange hue, conspicuous black markings present in the middle and at the tip, hind margin veins appearing blackish, squamae brownish with orange margins and fringed legs in black; tergite II pale, while the remaining tergites are black; abdominal pubescence is black, save for a white margin near the base of the second abdominal segment. (Van Veen 2004; Bot and Meutter 2023);

Distribution: China, Europe, India (Uttarakhand), Japan, Korea, Malaysia, Mongolia, Russia, Tunisia (Brunetti, 1923; Shah et al. 2014; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): Pinus forest, mesophilous forest

Floral host range: *Heracleum candicans, Barbarea vulgaris, Dipsacus inermis, Mentha longifolia, Spiraea bella* L.,

Remarks: The larva is characterised as a scavenger and larval predator within wasp nests (Vujic et al. 2018).

Volucella ruficauda Brunetti, 1907 (Figure 57)

Type material: ♂, ZSI, Calcutta, examined

Other Material:

2♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 5♀: INDIA- Jammu and Kashmir, Baramulla, Limber, 34^{0}11'47"N 74^{0}09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 2♀: INDIA- Jammu and Kashmir, Baramullah, Gulmarg, 34^{0}03'50"N 74^{0}23'20"E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: India (Sikkim)

Diagnosis: Head black, epistome shining black, well produced; eyes densely pilose, antennae brownish; thorax black covered with dense long golden red pilosity also covering the orange red scutellum; wings pale yellowish grey with an irregular rather large brown spot in the centre, a sub apicall brownish duffused band, halteres black; abdomen black with rather thick black pilosity; posterior margin of tergite III and tergite IV-V covered with dense long golden red pilosity (Brunetti 1907; 1923);

Distribution: India (J&K, Sikkim), Pakistan (Herve-Bazin, 1923e; Coe 1964; Knutson et al. 1975; Aslamkhan et al. 1997; Ghorpade & Shehzad, 2013; Shah et al. 2014; Mitra et al. 2008; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): Pinus forest, mesophilous forest

Floral host range: *Heracleum candicans, Anthriscus nemorosa, Dipsacus inermis, Mentha longifolia, Spiraea bella* L.,

Remarks: New state record, previously known from Sikkim only.

Key to the genus *Volucella* for Jammu and Kashmir

1a. Body covered in dense pilosity; face black…………..….***V. ruficauda*** Brunetti, 1907

1b. Body bare or minimally pilose; face yellowish or brownish orange..………………**2**

2a. Abdominal tergite 2 entirely yellowish-white; thoracic dorsum lustrous black.. ***V. pellucens*** (Linnaeus, 1758)

2b. Abdominal tergite 2 predominantly black; thoracic dorsum brownish-orange..........**3**

3a. Abdominal tergites III orange red with black triangular spot; wing yellowish without a wide brown longitudinal band on the upper half …… ***V. peleterii*** Macquart, 1834

3a. Abdominal tergites III completely black; wing greyish with wide brown longitudinal band on the upper half**…**………………..…***V. linearis*** Walker, 1852

Genus Xylota **Meigen, 1822**

Diagnosis: *Xylota* species can be diagnosed based on the following traits: face concave in lateral view; short, drooping antennae with aristas longer than the face's width short, pubescent metasternum without a lengthy pile; enlarged metafemur with short, spiny ventral setae; male metatrochanter with variable-length ventral calcar (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Xylota nursei Brunetti, 1923 (Figure 58)

Type material: ♂, NHMUK, examined

Other Material:

2♂2♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 3♂3♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 6♂9♀: INDIA- Jammu and Kashmir, Baramulla, Limber, 34^{0}11'47"N 74^{0}09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 2♂3♀: INDIA- Jammu and Kashmir, Srinagar, MA Road, 34^{0}04'27"N 74^{0}49'01"E, 1600m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 3♂4♀: INDIA- Jammu and Kashmir, Anantnag, Khanabal, 34^{0}44'40"N 75^{0}7'44"E, 1620m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 5♂7♀: INDIA- Jammu and

Kashmir, Baramullah, Gulmarg, 34^{0}03'50"N 74^{0}23'20"E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: India (Shimla)

Diagnosis: The hind trochanters bear a short blunt tooth; completely yellow metatibia with no anteroventral setae at the proximal one third; a double row of very small spines on the outer under side of hind femora (Brunetti 1923).

Distribution: India (Himachal Pradesh state, West Bengal state, Darjeeling district, J&K) (Brunetti, 1923; Knutson et al. 1975; Mitra et al. 2008; Ghorpade & Shehzad, 2013; Shah et al. 2014; Mitra et al. 2008; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): Deciduous forest; Coniferous forest with over-mature trees.

Floral host range: *Heracleum candicans,*

Remarks: New state record

Figure 33: ***Brachyopa himalayensis n.sp***

Figure 34: ***Ceriana dimidiatipennis*** **(Brunetti, 1923)**

Figure 35: ***Chrysogaster himalayensis*** **n. sp**

Figure 36: ***Criorhina vivida*** **Brunetti, 1923**

Figure 37: *Eristalinus arvorum* (Fabricius, 1787)

Figure 38: *Eristalinus megacephalus* (Rossi, 1794)

Figure 39: ***Eristalis himalayensis*** **Brunetti, 1908**

Figure 40: ***Eristalis tenax***

Figure 41: *Graptomyza flavonotata* Brunetti, 1917

Figure 42: *Helophilus trivittatus* (Fabricius, 1805)

Figure 43: ***Lejogaster tarsata*** **(Meigen, 1822)**

Figure 44: ***Myathropa semenovi*** **(Smirnov, 1925)**

Figure 45: *Rhingia laticincta* Brunetti, 1907

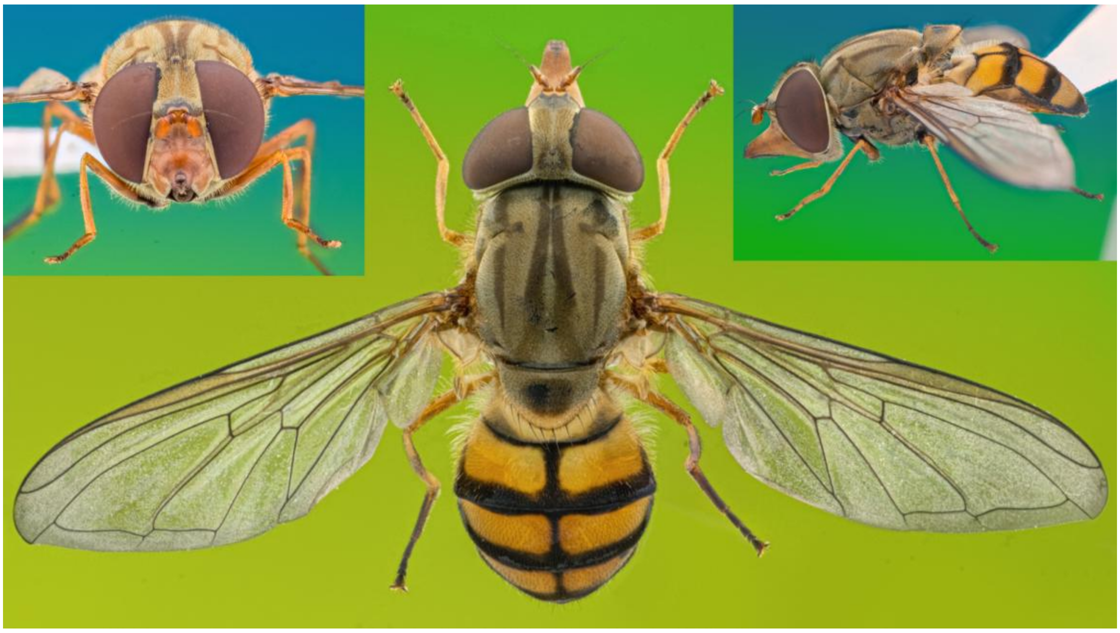

Figure 46: *Rhingia sexmaculata* Brunetti, 1913

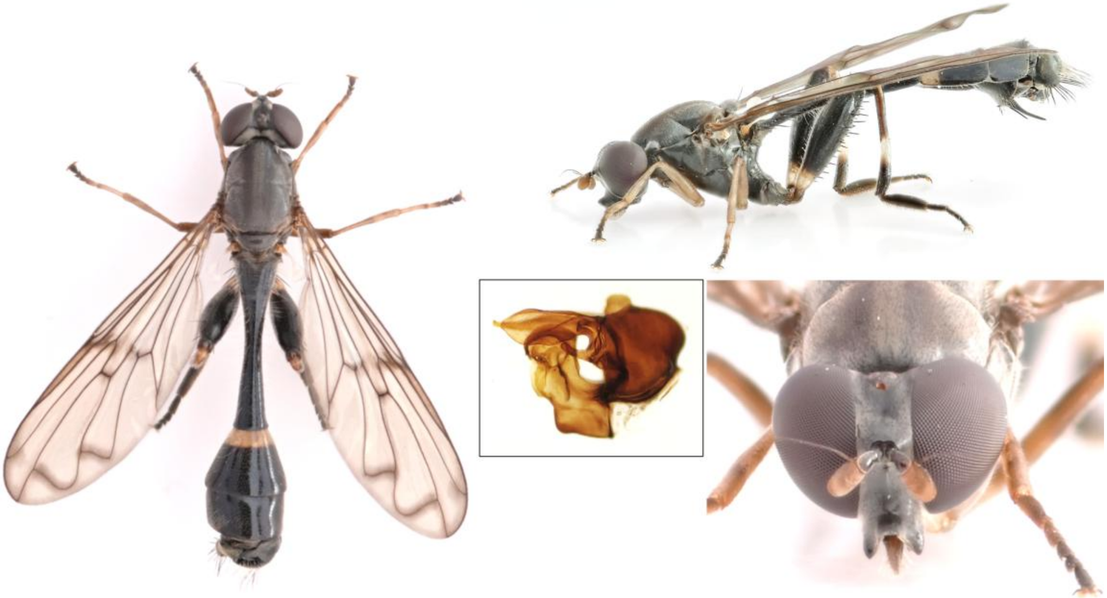

Figure 47: ***Sphegina bispinosa*** **Brunetti, 1915**

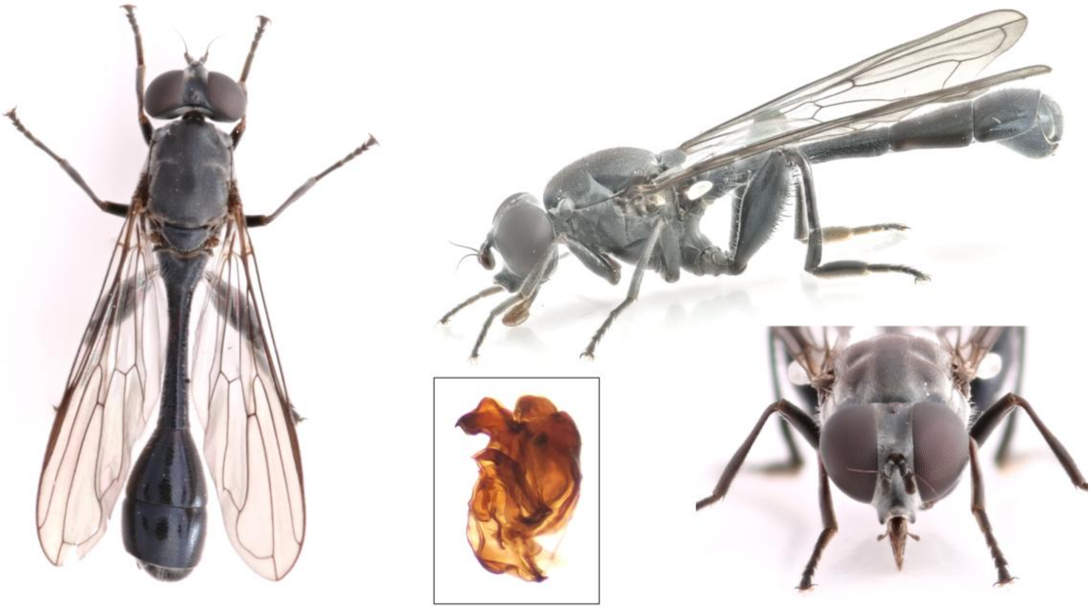

Figure 48: ***Sphegina conifera n.sp***

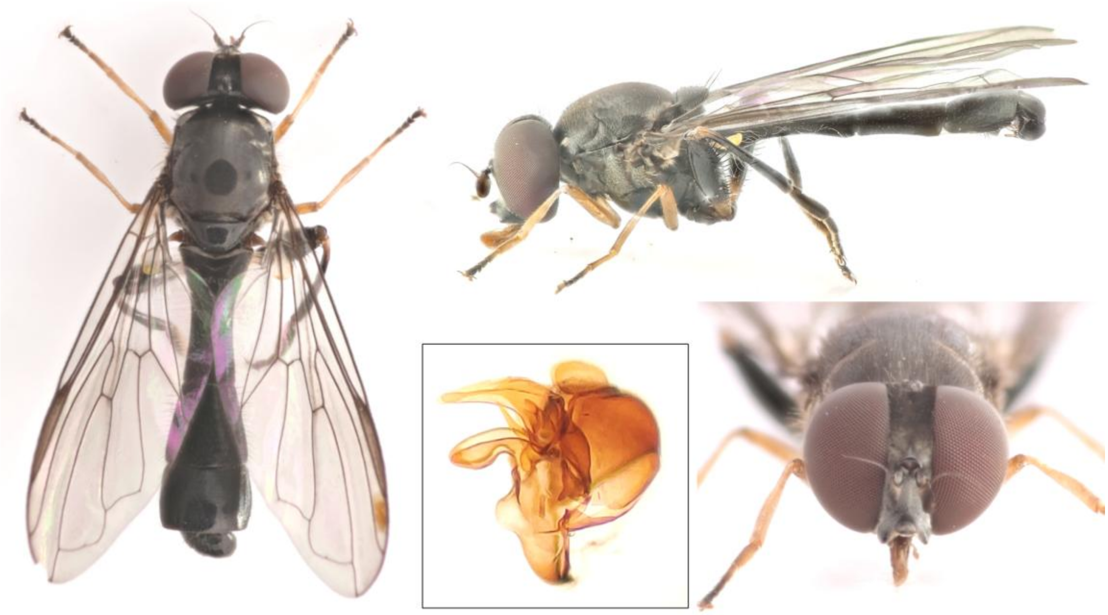

Figure 49: ***Sphegina robusta n.sp***

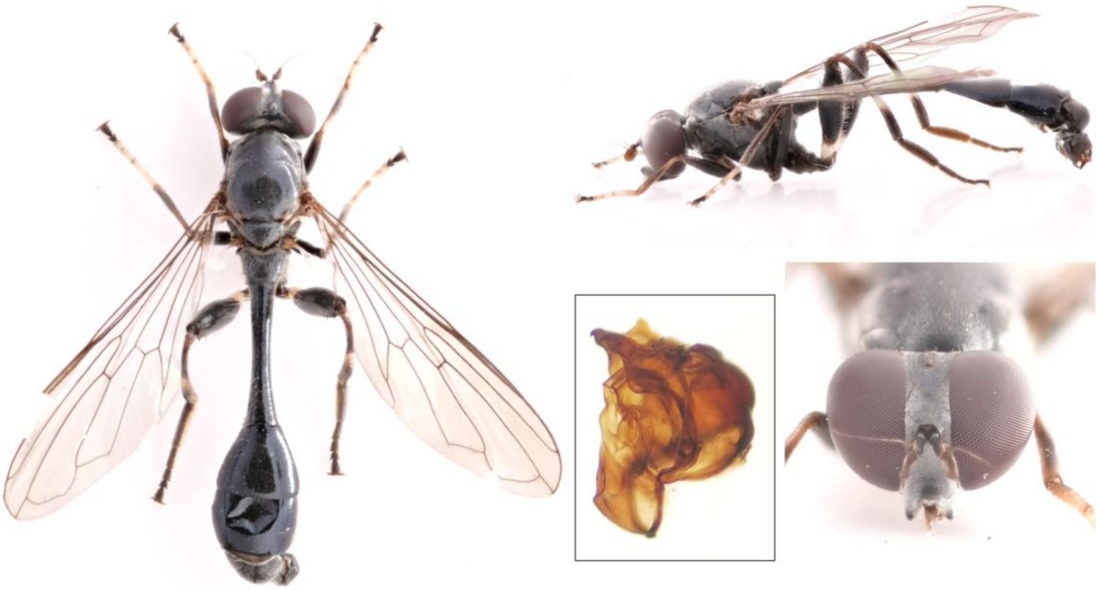

Figure 50: ***Sphegina baccha n.sp***

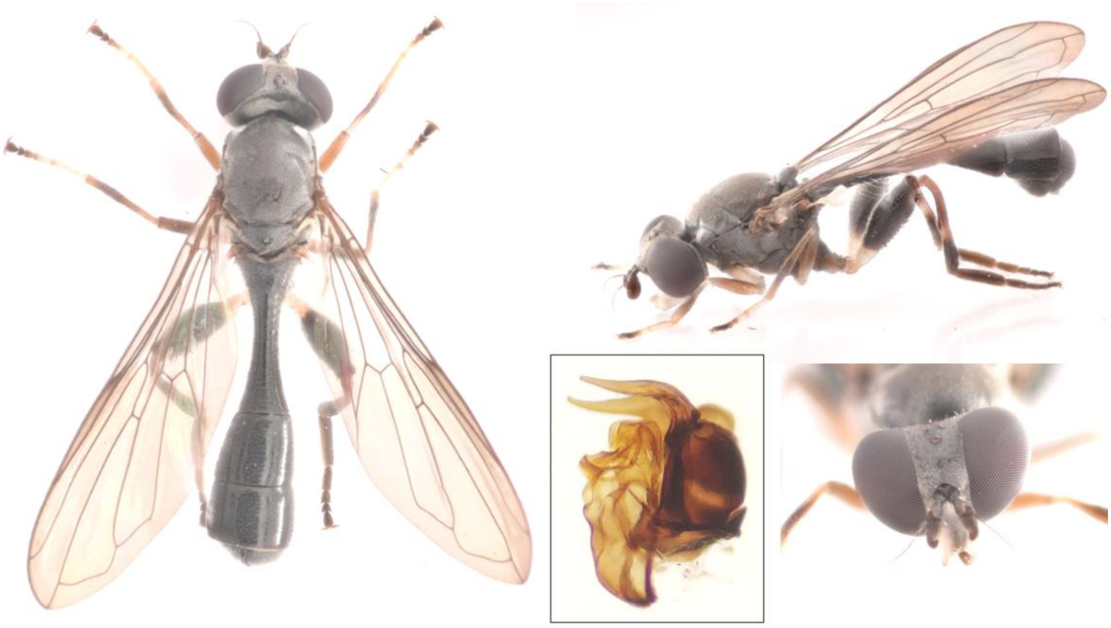

Figure 51: ***Sphegina parbati*** **n.sp**

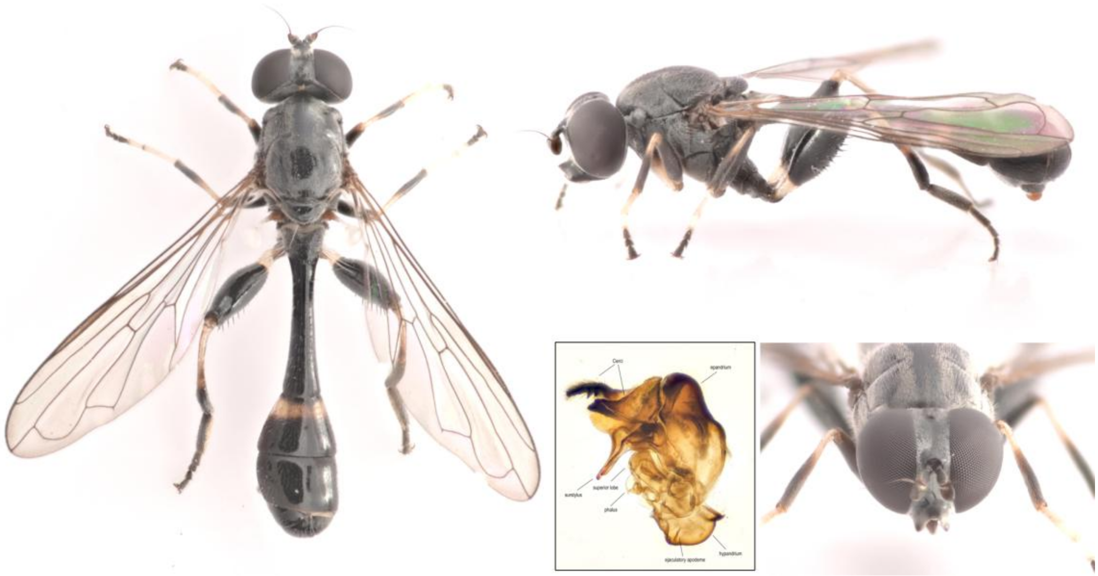

Figure 52: ***Sphegina tricoloripes***

Figure 53: ***Syritta pipiens*** **(Linnaeus, 1758)**

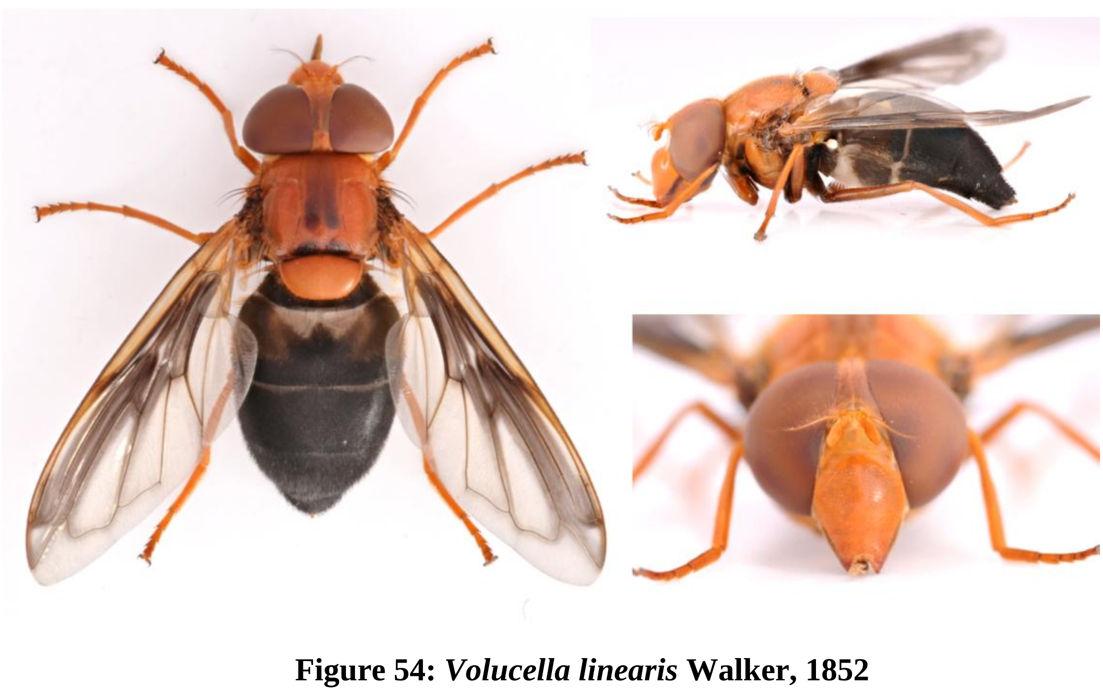

Figure 54: ***Volucella linearis*** **Walker, 1852**

Figure 55: ***Volucella peletrii*** **Macquart, 1834**

Figure 56: ***Volucella pellucens*** (Linnaeus, 1758)

Figure 57: ***Volucella ruficauda*** **Brunetti, 1907**

Figure 58: ***Xylota nursei*** **Brunetti, 1923**

Subfamily Pipizinae

This subfamily is represented by a single species of genus *Neocnemodon* Goffe, 1944 in India.

Genus *Neocnemodon* Goffe, 1944

Diagnosis:

Straight face with evenly rounded oral margin; Vein Sc ending beyond crossvein r-m; vein M1 and R_{4+5} making an angle <90 at the apex of M_1; antennal basoflagellomere < 1.5 times as long as wide; male hind trochanters exhibiting a pronounced spur-like protrusion (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Distribution: Holarctic, palearctic (Van Veen 2004; Vujic et al. 2018; Evenhuis & Pape 2024)

Preferred habitat(s): Adults occur in deciduous, broadleaved evergreen and coniferous forests, including degraded formations and phrygana. The known larvae feed on Homoptera occurring on a range of trees and shrubs. (Vujic et al. 2018)

***Neocnemodon indiana* n. sp** (Figure 59-60)

Type material: Holotype ♂: **INDIA**- Jammu and Kashmir, Baramulla, Rafiabad; $34^0$16'44"N $74^0$11'32"E; 2000m (amsl)., 25 Aug 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00100).

Paratypes:2♂2♀: INDIA- Jammu and Kashmir, Baramulla, Limber, $34^0$11'47"N $74^0$09'55"E, 2200m (amsl), 10 Sept 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00101 to CUZM-A_Maqbool00104)

Other Material: 1♂1♀: INDIA- Jammu and Kashmir, Baramulla, Kulgam, Aharbal; $33^0$38'39"N 74^0 46'37"E, 2270m (amsl), 09 Sept 2024, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00105 to CUZM- A_Wachkoo00106)

Etymology: The species epithet refers to the country of origin where it was collected (India).

Type locality: India (Jammu & Kashmir: Kashmir: Baramulla: Rafiabad)

Diagnosis:

Face black wings transparent with light yellowish brown hue, legs black, fore and mid basitarsi brownish yellow, tergite-II with long brownish yellow hairs along apico-lateral region; males with a long spine on hind trochanter; tergites black (shiny and with coarse punctuations in female).

Description: eyes densely pilose, frons black covered with dense black pilosisty, ocellar triangle black; scutum dark brown, shiny, covered with long brownish pilosity (bluish purple hue in females); scutellum shiny with metallic hue apically with long brownish white hairs (shorter yellowish white hairs in female); wings transparent with light yellowish brown hue (no hue in females); legs black, fore and mid basitarsi brownish yellow, mid and fore tibia basally, mid and fore femora apically brownish yellow, males with a long spine on hind trochanter; abdomen dull black (shiny black in females), with fine punctuations (rough punctuations in female), long greyish white pilosity along lateral margins (shorter pilosity in female), tergite-II with long brownish yellow hairs along apico-lateral region (very short yellowish white hairs in female); genitalia with very long epandrium and elongated hypandrium.

Floral host Range: *Achillea millefolium, Heracleum candicans, Anthriscus nemorosa, Barbarea vulgaris, Dipsacus inermis, Mentha longifolia,*

Remarks: This is the first confirmed genus record from India. *Neocnemodon* was previously classified as a subgenus of *Heringia*, however, the molecular phylogeny shown by Vujic et al. (2013b) substantiated the recognition of *Neocnemodon* as a valid genus.

Figure 59: ***Neocnemodon Indiana*** **n. sp male**

Figure 60: ***Neocnemodon Indiana*** **n. sp female**

Subfamily Syrphinae

This subfamily is represented by 28 species in 20 genera in Jammu and Kashmir

Key to the genera of Syrphinae for Jammu and Kashmir

1a. Antenna rounded and short, measuring less than the length of the head…………..**2**

1b. Antennae significantly enlarged, exceeding the length of the head……………….. …..……………………………………………………...….***Chrysotoxum*** Meigen

2a. The area under the antennae features a face bump and a somewhat projecting mouth edge……………………………………………………………………………**3**

2b. The area under the antennae extends forward in a semicircular manner, lacking a distinct facial tubercle and protruding mouth edge…………..….***Paragus*** Latreille

3a. 2nd tergite broader than scutellum…………………………………………………**4**

3b. 2nd tergite is exceedingly elongated and narrow, smaller than the scutellum……..**5**

4a. Face and scutellum black, frequently with a greenish lustre ..……..…….…..…... **6**

4b. Face or scutellum, typically both, predominantly yellow…….……………….....…**7**

5a. postpronotum bare…………………………...……..…. ***Baccha*** Fabricius, 1805

5b. postpronotum pilose…………………………………. ***Allobaccha*** Curran,1928

6a. Metasternum complete, broadly covering its whole length; fore basal tarsomeres widened in many and or an apico-lateral curled hairy tuft on fore femur……………………………………….***Platycheirus*** Lepeletier & Serville

6b. Metasternum highly reduced (postero-lateral decrease, resulting in a median diamond-shaped sclerotized section); fore basal tarsomeres not widened and fore femur without tufts of curled hair……..………………..…..***Melanostoma*** Schiner

7a. Pilose anterior anepisternum…………..……………………………………………..**8**

7b. Bare anterior anepisternum………..……………………………..…………**10**

8a. Bare metasternum; black tergites with yellow spots or a yellow band…....………**9**

8b. Pilose metasternum; tergite typically dark orange with a black "moustache" like pattern on the front half and a black band along the back edges…………………………………………………...…***Episyrphus*** Matsumura

9a. Eyes bare or pilose; hind margin of wing lacking, tiny, closely spaced, black maculae……………………………………...………….. ***Parasyrphus*** Matsumura

9b. Eyes bare; hind margin of wing with very small, closely spaced, blackl maculae near hind margin…………….……………………..…………….***Meliscaeva*** Frey

10a. The thoracic dorsum exhibits lateral edges characterised by a distinctly defined yellow band, typically running from the humerus to the suture, frequently reaching the postalar knob……………………………………….……………..………**11**

10b. Lateral margins of thoracic dorsum without a distinctly defined band, exhibiting black or, at most, a muted yellow band that does not sharply contrast with the median sections…………………………………………………………………….**12**

11a. basoflagellomere brownish yellow; scutellum completely yellow; hind femur yellow without a dark band ………………..….. ***Sphaerophoria*** Lepeletier & Serville

11b. basoflagellomere dark brown; scutellum completely yellow; hind femur yellow without a dark band ……..…………………………………… ***Ischiodon*** Sack, 1913

12a. Tegites III-IV lightly pilose with aple markings………………………………..**13**

12b. Tegites III-IV densely pilose and black……..………………….***Eriozona*** Schiner

13a. Wing vein R_{4+5} distinctly sinuate………..……….…………………………..**14**

13b. Wing vein R_{4+5} straight or almost so………..…………….………………….**17**

14a. Metasternum bare……………..…………………………….………………..**15**

14b. Metasternum pilose……………..……………………….……..………….**16**

15a. Eyes bare; wings with dense layer of microtrichia on the upper two-thirds……… **………………..……………………………...………..*Eupeodes*** Osten Sacken

15b. Eyes pilose; wings bare barely covered with microtrichia, featuring substantial bare regions in the upper two thirds…………………………..…***Scaeva*** Fabricius

16a. Abdomen widely oval, adorned with interconnected 'sunglasses' like spots ……………………………………….…………………..***Didea*** Macquart

16b. Abdomen wide yet elongated, tergites III-IVfeaturing rectangular yellow spots.……………………………………………………. ***Megasyrphus*** Schiner

17a. Eyes glabrous orbarely pilose; lower lobe of calypter pilose, especially on posteromedian region………….………………………….***Syrphus*** Fabricius

17b. Eyes densely pilose; calypter bare…………………...…………………..**18**

18a. Wing with obvious long, black stigma; tergite II with wide yellow fascia…….………………………………..……..……….. ***Dasysyrphus*** Enderlein

18b. Wing with brownish or light brown stigma; tergite II with narrow yellow or grey fascia …………………………………………… ***Betasyrphus*** Matsumura, 1917

Genus *Allobaccha* Curran,1928

Diagnosis: Humerus pilose posteriorly; metasternum bare; laterotergite pilose; lower face not produced (Ghorpade 1994)

Allobaccha apicalis (Loew, 1858)

- *Baccha apicalis* Loew, 1858
- *Baccha apicenotata* Brunetti, 1915
- *Baccha nigricosta* Brunetti, 1907

Type material: ♀, MCZ, Cambridge

Other Material:

1♂2♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 1♂1♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^{0} 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 1♀: INDIA- Jammu and Kashmir, Baramullah, Gulmarg, 34^{0}03'50"N 74^{0}23'20"E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: Japan

Diagnosis: Frons exhibiting a lustrous aeneous black hue, accented by a dark blue tinge; scutum displaying a gleaming dark blue colouration, adorned with sparse, short brownish-grey pubescence; apical margin of the scutellum characterised by long yellowish-grey pubescence; wings are transparent; subcostal cell entirely blackish-brown, with colouration extending beyond the cell's tip into an apical wing spot, adjacent to the front margin and constrained posteriorly by the third longitudinal vein. ; tergite 1 bluish black with yellow basolateral spots; tergite II-III bluish black with dark brownish posterior margin, yellow bands in the middle of tergite-II, tergite 3 with basolateral yellow spots; hind legs yellowish with a subapical light brownish ring on femora and a wide apical band on tibia (Ghorpade 1994;

Distribution: Myanmar, China, India (Assam, Bihar, Goa, Himachal Pradesh, Karnataka, Kerala, Meghalaya, Mizoram, Tamil Nadu, Uttarakhand, W Bengal), Japan, Nepal, Sri Lanka (Brunetti 1915, 1923; Coe 1964; Ghorpade, 1994; Mitra et al. 2008; Shah et al. 2014; Mitra et al. 2008; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): shady areas of forests

Floral host range: *Anthriscus nemorosa,*

Remarks: New species for J&K

Genus *Asarkina* Macquart, 1842

Diagnosis: Bare postpronotum, the antennae are typically short, bare anterior anepisternum, the abdomen is oval, face and scutellum are partially yellow, margined abdomen, pilose metasternum, hind coxa features a tuft of hair posterolaterally, a dense subscutellar fringe is present, and anterior tuft of pile on the katepisternum (Vockeroth 1969; Ghorpade 1994).

Asarkina porcina (Coquillett, 1898) (Figure 61)

Syrphus porcinus Coquillett, 1898

Type material: ♂, USNM, Washington DC

Other Material:

3♂1♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; $34^0$16'44"N $74^0$11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 2♂3♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; $33^0$38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 6♂7♀: INDIA- Jammu and Kashmir, Baramulla, Limber, $34^0$11'47"N $74^0$09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: Japan (Mitsukuri)

Diagnosis: The scutum is black, featuring a broad lateral yellow vitta extending from the notopleuron to the scutellum, and is yellow pollinose, the anterior anepisternum bare; metasternum pilose, the legs are yellow, with the metatarsi yellow except for the apical 3-4 tarsi, which are brown, the III-IV tergites are vaguely margined, the 1st tergum is yellow, adorned with a medial black fascia in the shape of an arrow on the posterior margin, which does not extend to the lateral margins, the tergite II is yellow, featuring a narrow medial black fascia on the posterior margin that does not reach the lateral margins, along with a very diffuse medial black vitta, the 3rd and 4th terga are yellow, each displaying a narrow medial black fascia on the anterior margin that does not extend to the lateral margins, and a black fascia on the posterior margin that reaches the lateral margins (Ghorpade 1994).

Distribution: Myanmar, China, India (Assam, Meghalaya, Sikkim, Uttarakhand, W Bengal), Japan, Nepal, Sri Lanka Burma, China, India (Assam, Meghalaya, Sikkim, Uttarakhand, West Bengal), Japan, Nepal, Sri Lanka (Ghorpade, 1994; Shah et al. 2014; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): larvae feed on aphids (Nawa 1917)

Floral host range: *Anthriscus nemorosa*, *Barbarea vulgaris, Impatiens glandulifera, Mentha longifolia,*

Remarks: New record for J&K

Genus *Baccha* Fabricius, 1805

Diagnosis: Abdomen strongly petiolate; extremely elongated and narrow tergite-II, smaller than scutellum; metepisternum bare (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Baccha maculata (Walker, 1852) (Figure 62)

- *Baccha austeni* Meijere, 1908
- *Baccha eoa* Violovich, 1976
- *Baccha eronis* Curran, 1928
- *Baccha pulla* Violovitsh, 1976
- *Baccha tenera* Meijere, 1910
- *Baccha tinctipennis* Brunetti, 1907

Type material: [♂, NHMUK, examined]

Other Material:

1♂3♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33⁰38'39"N 74⁰ 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-

A_Wachkoo00091 to CUZM- A_Wachkoo00092); 1♂1♀: INDIA- Jammu and Kashmir, Baramullah, Gulmarg, $34^0$03'50"N $74^0$23'20"E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: East Indies

Diagnosis: club-shaped abdomen and predominantly black colored body; wing medially with two black infuscated maculae (Brunetti 1907; 1908)

Distribution: Borneo, India, Java, Peninsular Malaysia and Taiwan Pakistan? (Brunetti 1923; Knutson et al. 1975; Mitra et al. 2008; Shah et al. 2014; Mitra et al. 2008; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): wet forests, shady forest patches near streams

Floral host Range: *Anthriscus nemorosa*,

Remarks: New species for J&K

Genus *Betasyrphus* Matsumura, 1917

Diagnosis: eyes densely haired; the upper and lower sternopleural pilose patches are clearly divided in the posterior region; tergite II features a short yellow or greyish fascia, consistently exhibiting extensive pruinosity; face thickly covered with grey pruinosity; eye evenly and densely pilose (Ghorpade 1994).

Betasyrphus isaaci (Bhatia, 1933)

Syrphus isaaci Bhatia, 1933

Type material: ♂, ZSI, Calcutta, examined

Other Material:

3♂1♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; $34^0$16'44"N $74^0$11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 4♂2♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; $33^0$38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 1♂1♀: INDIA- Jammu and Kashmir, Baramulla, Limber, $34^0$11'47"N $74^0$09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: India (Bihar)

Diagnosis: yellow or grey fascia on tergite 2 confluent with lateral margins; male with suture of eyes longer than length of ocellar triangle; anterior angle of eye junction less than 90^0; female with face having black pilosity except for lower margin around oral cavity below tubercle having white pilosity (Bhatia 1993).

Distribution: Myanmar, India (arunachal Pradesh, Assam, Bihar, Himachal Pradesh, Jammu and Kashmir, Meghalaya, Punjab, Uttarakhand, W Bengal), Nepal (Bhatia & Shafi 1933;

Datta & Chakraborti 1984; Ghorpade, 1994; Mitra et al. 2008; Shah et al. 2014; Mitra et al. 2008; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): wet forests, shady forest patches near streams

Floral host Range: *Achillea millefolium, Brassica spp., Chaerophyllum reflexum, Conium maculatum, Sisymbrium loesli* L, *Foeniculum vulgare, Heracleum candicans, Anthriscus nemorosa*,

Remarks: Brunetti reported this new species but was described by Bhatia (1993).

Genus *Chrysotoxum* Meigen, 1803

Diagnosis:

Antennae elongated, occasionally exceeding the length of the head; antennal basoflagellomere is at least three times longer than it is wide, while scape and pedicel are frequently longer than wide. scutellum more or less orange yellow, with or without a darker central spot (which varies in colour from yellow brown to black); the abdomen is prominently convex dorsally, distinctly margined, typically featuring projecting posterolateral angles of the tergites. (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Chrysotoxum antiquum Walker, 1952

Chrysotoxum violaceum Brunetti, 1923

Type material: ♂, NHMUK, examined

Other Material:

1♂: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092).

Type Locality: East Indies

Diagnosis: femora yellow with basal 1/4th black; lateral margins of abdomen black; antennae with 3rd segment longer than first two combined; yellow spots in the middle of tergite 2 forming an elongated isosceles triangle gradually tapering towards centre; yellow spots on tergite 3 close to anterior margin, narrow and forming an almost parallel band; spots on tergite IV reduced to small oval spots (Brunetti, 1923; Ghorpade 1994).

Distribution: Myanmar, India (Himachal Pradesh, Uttarakhand, W Bengal), Nepal (Brunetti 1923; Ghorpade, 1994; Shah et al. 2014; Mitra et al. 2008; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): high altitude undisturbed forests, unimproved grassland

Floral host Range: *Mentha longifolia,*

Remarks: This is first species record for J&K

Chrysotoxum baphyrum Walker, 1849 (Figure 63)

- *Chrysotoxum coloradense* Greene, 1918
- *Chrysotoxum fasciata* Kohli, 1987
- *Chrysotoxum testaceum* Sack, 1913

Type material: ♂, NHMUK, examined]

Other Material:

1♂1♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 1♂: INDIA- Jammu and Kashmir, Baramulla, Limber, 34^{0}11'47"N 74^{0}09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: India (North Bengal)

Diagnosis: Basoflagellomere as long as or longer tha scape and pedicel combined; frons yellow; facial black vitta present; mesonotum with lateral yellow vitta complete abdomen with on terga II-IV one medially interrupted fascia (Brunetti, 1923; Ghorpade 1994).

Distribution: Myanmar, China, India (Arunachal Pradesh, Chandigarh, Himachal Pradesh, Jammu and Kashmir, Karnataka, Meghalaya, Tamil Nadu, Uttarakhand, Uttar Pradesh, W Bengal), Indonesia, Nepal, Sri lanka (Brunetti 1923; Datta & Chakraborti 1984; Ghorpade, 1994; Kohli et al. 1998; Mitra et al. 2008; Shah et al. 2014; Mitra et al. 2008; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): high altitude undisturbed forests, unimproved grassland

Floral host Range: *Mentha longifolia,*

Remarks: This species matches the description of *C. baphyrum* except for black frons and wider facial black vitta.

Chrysotoxum corbetti Ghorpade, 1994 (Figure 64)

Type material: ♂, UZM, Copenhagen.

Other Material:

3♂2♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; $33^0$38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 4♂1♀: INDIA- Jammu and Kashmir, Baramulla, Limber, $34^0$11'47"N $74^0$09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: India (Uttarakhand)

Diagnosis: abdomen with yellow and black lateral margin; Tergite II posteriomedially brownish yellow or with narrow posterior margin brownish yellow (Ghorpade 1994).

Distribution: India (Uttrakhand, Jammu & Kashmir) (Brunetti 1923; Ghorpade 1994; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): high altitude undisturbed forests, unimproved grassland

Floral host Range: *Mentha longifolia,*

Remarks: First species record from J&K

Key to the species of genus *Chrysotoxum* for Jammu and Kashmir

1a. mesonotum with complete or interrupted lateral yellow vitta; abdominal yellow fascia on tergites II-IV prominent and oblique…………………………………….… ***2***

1b. mesonotum without or very reduced lateral yellow fascia; abdominal yellow fascia on tergites II-III narrow and parallel to anterior margin, on tergite IV reduced two oval spots ……………………………………………., ***C. antiquum*** Walker, 1852

2a. mesonotum with complete uninterrupted lateral yellow vitta; scutum with two, wide, prominent longitudinal pruinose stripes reaching ipto the margin of scutellum; tergites brownish orange with yellow and black fascia ……………………………………………………. ***C. baphyrum*** Walker, 1849

2b. mesonotum with lateral yellow vitta interrupted at suture; scutum with two, narrow, faint longitudinal pruinose stripes reaching just post midway …. ***C. corbetti*** Ghorpade, 1994

Genus *Dasysyrphus* Enderlein, 1938

Diagnosis: pilose eyes; prominent centre black stripe on the face; wing featuring a distinct elongated black stigma; abdomen featuring a lateral groove, adorned with yellow, orange, or creamy-yellow curved to straight bands, occasionally exhibiting strong constriction and sometimes converging at the centre; a pair of grey stripes present on the thorax; tergite II displaying a small pair of spots; tergites III-IV characterised by oblique yellow markings that typically converge in the centre (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Dasysyrphus orsua (Walker, 1852) (Figure 65)

- *Syrphus brunettii* Herve-Bazin, 1923
- *Syrphus orsua* Walker, 1852

Type material: ♀, NHMUK, examined

Other Material:

1♂1♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 2♂2♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 1♂: INDIA- Jammu and Kashmir, Baramullah, Gulmarg, 34^{0}03'50"N 74^{0}23'20"E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: East Indies

Diagnosis: yellow spots on tergite III-IV usually meeting in centre and forming a fascia; tergite V yellow only on posterior margin; black facial vitta not reaching antennal base; fore femur yellow haired (Hervé-Bazin, 1923; Ghorpade 1994).

Distribution: India (Himachal Pradesh, Jammu and Kashmir, Sikkim, Uttarakhand, W Bengal), Nepal, Sri Lanka, Indonesia (Brunetti 1923; Ghorpade, 1994; Mitra et al. 2008; Ghorpade & Shehzad, 2013; Shah et al. 2014; Mitra et al. 2008; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): Conifer forest (*Abies, Picea* and *Pinus*)

Floral host Range: *Anthriscus nemorosa*, *Barbarea vulgaris, Dipsacus inermis, Sambucus wightiana*, *Spiraea bella* L.,

Remarks: Brunetti (1923) misidentified this species as *albostriatus* (Fallén) and was renamed as brunettii by Hervé-Bazin (1924: 290).

Genus *Didea* Macquart, 1834

Diagnosis: Wing vein R_{4+5} strongly curved into cell r_5, which is consequently narrowed at about the middle of its length; a tuft of fine pilosity on metapleural episternum, ventral to spiracle; first segment of hind tarsus (basitarsus) black; the pale yellow markings on abdominal tergite II are equidistant from both the anterior (at lateral part) and posterior margins (at median part) of the tergite; tergites III and IV each with a yellow band that has a concave posterior margin (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Didea vockerothi Ghorpade, 1994 (Figure 66)

Type material: ♂, UZM,Copenhagen

Other Material:

1♂1♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; $34^0$16'44"N $74^0$11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 1♂1♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; $33^0$38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 1♂1♀: INDIA- Jammu and Kashmir, Baramullah, Gulmarg, $34^{0}03'50''$N $74^{0}23'20''$E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: India (Jammu and Kashmir: Gulmarg)

Diagnosis: face yellow with a narrow black median vitta; scutellum with only yellow hairs; hind tibia black with basal $1/3^{rd}$ yellow; sternite IV black (Ghorpade, 1994).

Distribution: India (Jammu & Kashmir) (Nayar 1968a; Ghorpade, 1994; Shah et al. 2014; Mitra et al. 2008; Sengupta et al. 2024; Evenhuis & Pape 2024

Preferred habitat(s): Conifer forest (*Abies, Picea* and *Pinus*)

Floral host Range: *Anthriscus nemorosa*, *Barbarea vulgaris, Dipsacus inermis, Mentha longifolia, Spiraea bella* L.,

Remarks: Mostly arboreal but will descend to visit flowers. The larvae are aphidophagous and arboreal

Genus *Episyrphus* Matsumura

Diagnosis:

Wing border featuring a a series of minute, closely spaced black spots along the posterior edge; metasternum pilose; hind coxa lacking an apical tuft of pile at the posteromedial angle; eyes glabrous; abdomen suboval to petiolate (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Episysphus balteatus (de Geer, 1776) (Figure 67)

- Epistrophe balteata (De Geer, 1776)
- *Episyrphus cannabinus* (Scopoli, 1763)
- *Episyrphus fallaciosus* Matsumura, 1917
- *Episyrphus hirayamae* Matsumura, 1918
- *Episyrphus scitule* (Harris, 1780)
- *Episyrphus scitulus* (Harris, 1780)
- *Musca alternata* Schrank, 1781
- *Musca balteata* De Geer, 1776
- *Musca cannabina* Scopoli, 1763
- *Musca elegans* Villers, 1789
- *Musca nectarina* Gmelin, 1790

- *Musca palustris* Scopoli, 1763
- *Musca scitule* Harris, 1780
- *Musca scitulus* Harris, 1780
- *Syrphus alternatus* Rossi, 1790
- *Syrphus andalusiacus* Strobl, 1899
- *Syrphus balteatus* De Geer
- *Syrphus cretensis* Becker, 1921
- *Syrphus nectareus* Fabricius, 1787
- *Syrphus pleuralis* Thomson, 1869

Syrphus signatus Santos Abreu, 1924

Type material: ♂♀, NRS, Stockholm

Other Material:

6♂8♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 3♂3♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 5♂7♀: INDIA- Jammu and Kashmir, Baramulla, Limber, 34^{0}11'47"N 74^{0}09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 2♂2♀: INDIA- Jammu and Kashmir, Srinagar, MA Road, 34^{0}04'27"N 74^{0}49'01"E, 1600m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 7♂9♀: INDIA- Jammu and Kashmir, Anantnag, Khanabal, 34^{0}44'40"N 75^{0}7'44"E, 1620m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 2♂4♀: INDIA- Jammu and Kashmir, Baramullah, Gulmarg, 34^{0}03'50"N 74^{0}23'20"E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: Sweden

Diagnosis:

Metasternum with distinct, rather long hairs; tergites 3 and 4 each usually with two black transverse bands, which may merge laterally in melanistic individuals; the anterior black band may be reduced to a narrow streak not reaching the lateral margins of the tergite, or further reduced into two almost linear streaks, separated in the mid-line (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Distribution: Widespread in the Palaerctic region, Oriental and Australia. Afghanistan, Africa, Australia, China, Europe, India (Arunachal Pradesh, Assam, Himachal Pradesh, Jammu and Kashmir, Karnataka, Kerala, Manipur, Meghalaya, Mizoram, Nagaland, Orissa, Punjab, Sikkim, Tamil nadu, Tripura, Uttarakhand, W Bengal), Japan, Pakistan. (Brunetti 1923; Nayar 1968b; Datta & Chakraborti 1984; Ghorpade, 1994; Shah et al. 2014; Mitra et al. 2008; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat: highly anthropophilic and almost ubiquitous (Vujic et al. 2018)

Floral host Range: *Achillea millefolium*, *Brassica spp.*, *Chaerophyllum reflexum*, *Conium maculatum*, *Convolvulus arvensis* L, *Dacus carota* L, *Sisymbrium loesli* L, *Foeniculum vulgare*, *Melisa officinalis*, *Mentha piperita*, *Lathyrus oleraceus*, *Prunus avium*,*Delphinium ajacis*, *Heracleum candicans*, *Anthriscus nemorosa*, *Barbarea vulgaris*, *Dipsacus inermis*, *Impatiens glandulifera*, *Mentha longifolia*, *Myosotis arvensis*, *Ranunculus repens*, *Spiraea bella* L., *Taraxacum parvulum*

Remarks: 2^{nd} most dominant species in J&K. This species is one of the commonest and most widespread hoverflies and can be found throughout the year in various habitats, including urban gardens and cultivated crops. Adults show overwintering. The larva is aphidophagous on a diverse array of plants including many crops and trees (speight 2017).

Genus *Eriozona* Schiner, 1860

Diagnosis:

Bumblebee mimic; face yellow; pterostigma dark brown; thoracic dorsum mostly black; basal segments of abdomen black ground colour with black or white pubescence (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

***Eriozona bombylans* n. sp** (Figure 68)

Type material: Holotype ♂: INDIA-Jammu and Kashmir, Baramulla, Botapathri; 34^{0}05'06"N 74^{0}18'40"E; 3000m (amsl)., 25 Aug 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00071).

Paratypes:7♂♂:INDIA-with same data as holotype except Suhaib Yatoo leg., (CUZM-A_Maqbool00072 to CUZM-A_Maqbool00078).

Type locality: India (Jammu & Kashmir: Kashmir: Baramulla: botapathri)

Etymology: The species epithet '*bombylans*' referes to the morphological appearance similar to a bumble bee (*Bombus*)

Diagnosis: This species is very similar to european *Eriozona syrphoides* (Fallén, 1817) however it differs in having the ground colour of tergite IV-V red.

Description: Face yellow without dark median stripe, antennae black; frons with long black pilosity and pruinose; Eyes pilose; ocellar triangle black with long black pilosity; wide, oblique black band across gena; thorax black, pilose; Wings transparent grey, dark brown patches basally and across the mid-section; mesocutum with two longitudinal grey pruinose stripes reaching just past midline and fading out; scutellum pale with long yellowish white pilosity on the margin and short hairs all over; tergites I-III ground colour black, rest of the tergite orange red; tergites I-II with dense long greyish white pilosity, tergite-III covered with black pilosity, rest with orange red pilosity and very few black hairs.

World distribution: India (Jammu and Kashmir)

Preferred habitat(s): arboreal, hovering high among aphid infested *Picea* trees**.**

Floral host Range: Data insufficient

Remarks: This is new genus record for J&K and 2nd species from India. The only known species from India is *Eriozona analis* Kertész, 1901.

Genus *Eupeodes* Osten-Sacken, 1877

Diagnosis: wings densely microtrichose; the margins of the tergites have a distinct longitudinal groove that extends conspicuously from the centre of tergite II to the apex of tergite V; the dorsal and ventral pile patches on the sternopleuron are nearly confluent anteriorly and sharply separated posteriorly.; tergites III and IV each with either a yellow transverse band more or less lacking pruinosity, or a pair of curved, transverse, yellow marks, more or less lacking pruinosity, the marks or band varying considerably in width between their outer and inner ends (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Eupeodes corollae (Fabricius, 1794) (Figure 69)

- *Dasysyrphus pyrorum* (Schrank, 1803)
- *Metasyrphus corollae* (Fabricius, 1794)
- *Metasyrphus libyensis* Nayar, 1978
- *Musca pyrorum* Schrank, 1803
- *Musca vorax* Geoffroy, 1785
- *Scaeva annularis* Curtis, 1837
- *Scaeva octomaculata* Curtis, 1837
- *Scaeva olitoria* Fallén, 1817
- *Syrphus algirus* Macquart, 1847
- *Syrphus berber* Bigot, 1884
- *Syrphus cognatus* Loew, 1858
- *Syrphus corollae* Fabricius, 1794
- *Syrphus corolloides* Macquart, 1850
- *Syrphus crenatus* Macquart, 1829
- *Syrphus dentatus* Walker, 1852
- *Syrphus disjunctus* Macquart, 1842
- *Syrphus flaviventris* Macquart, 1829
- *Syrphus fulvifrons* Macquart, 1829
- *Syrphus lacerus* Meigen, 1822
- *Syrphus nigrifemoratus* Macquart, 1829

Syrphus terminalis Wiedemann, 1830

Type Material:

Other Material:

2♂2♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 3♂3♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^{0} 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 6♂9♀: INDIA- Jammu and Kashmir, Baramulla, Limber, 34^{0}11'47"N 74^{0}09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 2♂3♀:

INDIA- Jammu and Kashmir, Srinagar, MA Road, 34⁰04'27"N 74⁰49'01"E, 1600m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 3♂4♀: INDIA- Jammu and Kashmir, Anantnag, Khanabal, 34⁰44'40"N 75⁰7'44"E, 1620m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 5♂7♀: INDIA- Jammu and Kashmir, Baramullah, Gulmarg, 34⁰03'50"N 74⁰23'20"E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: Germany (Kiel)

Diagnosis:

Scutellum is adorned with yellow hairs, occasionally interspersed with a few black hairs; bare wing alula is devoid of hair at the base; the abdominal bands in males exhibit variability, with yellow spots on tergites III and IV being either broad or, on rare occasions, narrow; side margin of tergite V yellow entirely; sternites II–IV exhibit somewhat rounded spots that do not extend to the lateral margin; male genitalia are significantly larger than those of other species. (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Distribution: Afghanistan, Africa, China, Europe, Germany, India (Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Meghalaya, Punjab, Uttarakhand, W Bengal), Japan, Pakistan (Brunetti 1923; Nayar 1968b; Ghorpade, 1994; Ghorpade & Shehzad, 2013; Shah et al. 2014; Mitra et al. 2008; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): open ground; grasslands, arid riverbeds, predominantly anthropophilic, found in suburban gardens, orchards, parks, and other types of agricultural land (including arable crops), alpine grassland (Speight 2017)

Floral host Range: *Brassica spp., Chaerophyllum reflexum, Conium maculatum, Convolvulus arvensis* L, *Dacus carota* L, *Sisymbrium loesli* L, *Melisa officinalis, Mentha piperita, Lathyrus oleraceus, Prunus avium,*

Remarks: One of the first species that emerge in early spring.

Eupeodes latifasciatus (Macquart, 1829) (Figure 70)

- *Eupeodes chillotti* (Fluke, 1952)
- *Eupeodes depressus* (Fluke, 1933)

- *Metasyrphus chillcotti* Fluke, 1952
- *Metasyrphus chillotti* Fluke, 1952
- *Metasyrphus depressus* Fluke, 1933
- *Metasyrphus latifasciatus* (Macquart, 1829)
- *Scaeva abbreviata* Zetterstedt, 1849
- *Syrphus affinis* Loew, 1840
- *Syrphus affinis* Palma, 1864
- *Syrphus latifasciatus* Macquart, 182
- *Syrphus pallifrons* Curran, 1925
- *Syrphus submaculatus* Frey, 1918

Type material: ♂, MNHN, Paris

Other Material:

2♂2♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 3♂3♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^{0} 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 6♂9♀: INDIA- Jammu and Kashmir, Baramulla, Limber, 34^{0}11'47"N 74^{0}09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 2♂3♀: INDIA- Jammu and Kashmir, Srinagar, MA Road, 34^{0}04'27"N 74^{0}49'01"E, 1600m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 3♂4♀: INDIA- Jammu and Kashmir, Anantnag, Khanabal, 34^{0}44'40"N 75^{0}7'44"E, 1620m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 5♂7♀: INDIA- Jammu and Kashmir, Baramullah, Gulmarg, 34^{0}03'50"N 74^{0}23'20"E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: France (Arras)

Diagnosis: Scutellum predominantly or entirely adorned with yellowish pilosity; anterior edge of yellow bands or pairs of spots on tergites III-IV nearly linear, save for a shallow central indentation; genitalia not markedly enlarged; frons in females black superiorly, yellow inferiorly, with a distinct demarcation and a subtly undulating black margin; entirely lustrous frons, devoid of pruinose markings; bands on tergites III-IV extending to the lateral margin.

(Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Distribution: Afghanistan, China, Europe, India (Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Nagaland, Uttarakhand, Nepal, Pakistan, United States (Brunetti 1923; Coe 1964; Nayar 1968b; Knutson et al. 1975; Datta & Chakraborti 1984; Ghorpade, 1994; Mitra et al. 2008; Ghorpade & Shehzad, 2013; Shah et al. 2014; Mitra et al. 2008; Sengupta et al. 2024; Evenhuis & Pape 2024)

Floral host Range: *Chaerophyllum reflexum, Conium maculatum, Sisymbrium loesli* L, *Foeniculum vulgare, Heracleum candicans, Anthriscus nemorosa*, *Barbarea vulgaris,*

Remarks:

Key to the species of genus *Eupeodes* for Jammu and Kashmir

1a. Male genitalia prominently large, extending to the posterior margin of sternite IV, resulting in a constricted centre of sternite V at the anterior margin; bands or pairs of spots on tergites III-IV exhibit an undulating anterior margin**……………………………………..……………*E. corollae*** (Fabricius, 1794)

1b. Male genitalia small; bands or pairs of spots on tergites III-IV with almost straight anterior margin…..…………………………….. ***E. latifasciatus*** (Macquart, 1829)

Genus *Ischiodon* Sack, 1913

Diagnosis:

Antennal basoflagellomere elongate, upto to 2.0 times as long as broad; a ventral spur present on male hind trochanter; hyaline wing, largely devoid of microtrichia on the basal two thirds and sparsely microtrichose on the apical one-third; scutellum totally yellow. (Ghorpade 1994; Vujic et al. 2018).

Ischiodon scutellaris (Fabricius, 1805) (Figure 71)

- *Epistrophe magnicornis* Shiraki, 1963
- *Epistrophe platychiroides* Frey, 1946

- *Ischiodon boninensis* Matsumura, 1919
- *Ischiodon penicillatus* Hardy, 1952
- *Ischiodon trochanterica* Sack, 1913
- *Melithreptus novaeguineae* Kertész, 1899
- *Melithreptus ogasawarensis* Matsumura, 1916
- *Scaeva scutellaris* Fabricius, 1805
- *Sphaerophoria annulipes* Macquart, 1855
- *Sphaerophoria macquarti* Goot, 1964
- *Syrphus coromandelensis* Macquart, 1842
- *Syrphus erythropygus* Bigot, 1884
- *Syrphus nodalis* Thomson, 1869
- *Syrphus ruficauda* Bigot, 1884

Syrphus splendens Doleschall, 1856

Type material: ♂, UZM, Copenhagen

Other Material:

1♂: INDIA- Jammu and Kashmir, Srinagar, MA Road, $34^0$04'27"N $74^0$49'01"E, 1600m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: India (Tamil Nadu)

Diagnosis: bright yellow lateral mesonotal margin, demarcated distinctly from dark dorsum; posterior separation of sternopleural hair patches; abdominal tergite II with a medially interrupted yellow fascia (Ghorpade 1994) .

Distribution: Afghanistan, Africa, Australia, Myanmar, China, India (Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chandigarh, Delhi, Gujarat, Haryana, Himachal Pradesh, Jammu and Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Nagaland, Orissa, Pondicherry, Punjab, Rajasthan, Sikkim, Tamil Nadu, Tripura, Uttarakhand, West Bengal), Japan, Micronesia, Nepal, Pacific islands, Pakistan, Sri Lanka (Brunetti 1923; Datta & Chakraborti 1984; Ghorpade, 1994; Mitra et al. 2008; Shah et al. 2014; Mitra et al. 2008; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat: freshwater/open terrain; next to the peripheries of aquatic environments and wetlands (Vujic et al.2018)

Floral host Range: *Sisymbrium loesli* L, *Lathyrus oleraceus,*

Remarks: This is the only species of this genus found in India

Genus *Megasyrphus* Dusek & Laska.

Diagnosis:

The proximal part of the wing cell r5 has virtually parallel margins; first segment of hind tarsus (basitarsus) more or less dark yellow, but not black; the yellow marks on abdominal tergite 2 are distinctly closer to its anterior margin than to its posterior margin (space between marks and posterior margin about as wide as the marks themselves); The rear edge of the yellow band on tergite 3 is almost parallel to the posterior edge of the tergite; eyes distinctly hairy (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

***Megasyrphus kashmirensis* n. sp** (Figure 72)

Type material: Holotype ♂: INDIA- Jammu and Kashmir, Baramulla, Gulmarg; 34^{0}03'50"N 74^{0}23'20"E; 2700m (amsl)., 04 Sept 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00086).

Type locality: India (Jammu & Kashmir: Kashmir: Baramulla: Gulmarg)

Etymology: The species epithet '*kashmirensis'* refers to the type location (Kashmir).

Diagnosis: similar to *M. himalayensis* but differs in having hind femora brownish orange in apical 3^{rd} (apical half in *M. himalayensis*); tergite III and IV with orange yellow band narrowing in the middle and towards lateral margins, ending before reaching the margins (yellow bands of uniform width passing over lateral margins in *M. himalayensis*); a narrow yellowish white band on the posterior margin of sternite II-III (black in *M. himalayensis*);

Description: Face yellowish pruinose with a wide dark shiny medial stripe reaching upto antennal base; long yellow pilosity along eye margins and black pilosity around medial stripe; linule black on upper site with long black pilosity; frons yellowish with pruinosity; antennae completely black, arista black; ocellar triangle black with long black pilosity; legs predominantly brownish yellow with black tarsi; scutum shinning black with short brownish black pilosity, long brownish yellow pilosity laterally; scutellum light brownish with yellowish brown long pilosity; abdomen shinning black with black and yellowish brown pilosity, tergite III and IV with orange yellow band narrowing in the middle and towards lateral margins, ending before reaching the margins; posterior margin of sternite II-III with a narrow yellowish white band.

Distribution: India (Jammu and Kashmir)

Floral host Range: Data insufficient

Remarks: Arboreal, found hovering among *pinus* trees

Genus *Melanostoma* Schiner, 1860

Diagnosis: The metasternum is diminished, without lateral expansions, and features a sclerotised section including a median, diamond shaped region that tapers both anteriorly and posteriorly; facial structure featuring a small tubercle, not extending inferiorly; male legs thin, devoid of bristles, hairy tufts, or altered pile; abdominal tergites with orange-yellow markings, of more or-less triangular shape, rounded posteriorly, or completely black abdomen (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Melanostoma orientale (Wiedemann, 1824)

Type material: ♂, UZM, Copenhagen

Other Material:

2♂2♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 3♂3♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^{0} 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 6♂9♀: INDIA- Jammu and Kashmir, Baramulla, Limber, 34^{0}11'47"N 74^{0}09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 2♂3♀: INDIA- Jammu and Kashmir, Srinagar, MA Road, 34^{0}04'27"N 74^{0}49'01"E, 1600m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 3♂4♀: INDIA- Jammu and Kashmir, Anantnag, Khanabal, 34^{0}44'40"N 75^{0}7'44"E, 1620m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 5♂7♀: INDIA- Jammu and Kashmir, Baramullah, Gulmarg, 34^{0}03'50"N 74^{0}23'20"E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: Indes Orientales

Diagnosis: Rather elongate species; mesocutum black aeneus shining with fine greyish pilosity without any pruinosity; head covered in yellowish white pruinosity except at ocellar trangle, temple, base of antennae and facial tubercle, leaving these areas shinning; antennae yellowish orange with basoflaggelomere dark brown dorsally, arista long pilose; legs extensively yellow, especially femora almost entirely yellow; abdomen with relatively large yellow maculae in female, that appear like a drooping, rounded 'fishing net' attached to lateral side by a long narrow 'handle'. In males, markings are althoghh much squarer but they are still usually curved on the hind edge, especially along the lateral edge; maculae on tergite II almost as long as half length of the tergite; maculae on tergite III in female muxh elongated triangular, with concave postero-medial margin (Brunetti 1923; Ghorpade 1994).

Distribution: Oriental region, China, India (Arunachal Pradesh, Assam, Himachal Pradesh, Jammu and Kashmir, Karnataka, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tamil Nadu, Tripura, Uttarakhand, West Bengal), Pakistan, Sri Lanka, (Brunetti 1923; Datta & Chakraborti 1984; Shah et al. 2014; Mitra et al. 2008; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat: Moderately anthrophillic; Grasslands, open terrain, grassy clearings, and roadside areas, also present in various agricultural lands, parks, and suburban gardens. .

Floral host Range*Chaerophyllum reflexum, Conium maculatum, Heracleum candicans, Anthriscus nemorosa, Impatiens glandulifera, Mentha longifolia, Myosotis arvensis, Ranunculus repens, Spiraea bella* L., *Taraxacum parvulum*

Remarks: widespread oriental species

Genus *Meliscaeva* Frey, 1946

Diagnosis:

Wing margin featuring a series of minute, closely spaced black along the posterior edge; metasternum bare; hind coxa lacking an apical tuft of pile at the posteromedial angle;

eyes bare; abdomen suboval to petiolate (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Meliscaeva cinctelloides Ghorpade, 1994 (Figure 73)

Type material: ♂, Ghorpade collection

Other Material:

1♂: INDIA- Jammu and Kashmir, Baramulla, Limber, 34^{0}11'47"N 74^{0}09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: India (West Bengal: Darjeeling)

Diagnosis: Face completely yellow pruinose lacking median black vitta; Male tergite II with a median black vitta at its widest broader than the posterior black fascia; apical width of tergite II equall to basal width; tergite III equall to tergite II in length (Ghorpade 1994).

Distribution: India (west Bengal, Meghalaya, Kashmir) (Brunetti 1923; Ghorpade, 1994;

Shah et al. 2014; Mitra et al. 2008; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): Deciduous, broadleaf evergreen, coniferous forests, and conifer plantations.

Floral host Range: *Dipsacus inermis, Impatiens glandulifera, Mentha longifolia,*

Remarks: New state record

Meliscaeva strigifrons (Meijere, 1914) (Figure 74)

- *Meliscava strigifrons* (Meijere, 1914)
- *Syrphus strigifrons* Meijere, 1914

Type Material

Other Material:

1♂: INDIA- Jammu and Kashmir, Baramullah, Gulmarg, 34^{0}03'50"N 74^{0}23'20"E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: Indonesia (Java: Gunung Gede, Nongkodjadjar)

Diagnosis: face yellow pruinose with a narrow black median vitta; tergite II in male with a median black vitta at its widest narrower than the posterior black fascia; apical width of tergite II greater than the basal width; tergite III shorter than tergite II (Ghorpade 1994).

Distribution: Sri lanka, Malasia, Thailand, India (Ghorpade 1994; Evenhuis & Pape 2024)

Preferred habitat(s): coniferous forest

Floral host Range: *Mentha longifolia, Spiraea bella* L.,

Remarks: Indian presence was doubtful previously and this record confirms its presence in India

Key to the species of genus *Meliscaeva* for Jammu and Kashmir

1a. Face without a narrow black median vitta; apical width of tergite II equall to basal width; tergite III equall to tergite II in length………. ***M. cinctelloides*** Ghorpade, 1994

1b. Face with a narrow black median vitta; apical width of tergite II greater than the basal width; tergite III shorter than tergite II………….. ***M. strigifrons*** (Meijere, 1914)

Genus *Paragus* Latreille, 1804

Diagnosis:

Face in profile slightly convex or straight, thus without concavity between the antennae and the facial callus; facial callus almost indistinguishable; eyes with rather short pilosity; tergite I is well-developed, particularly on the disc, where it is often half the length of tergite II and consistently reaches beyond the scutellum; sublaterally, it is approximately three-quarters the length of tergite II; tergites are minutely punctate.; small species, body length 4-8mm (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Paragus bicolor (Fabricius, 1794) (Figure 75)

- *Musca cruentatus* Geoffroy, 1785
- *Paragus arcuatus* Meigen, 1822
- *Paragus ater* Meigen, 1822
- *Paragus ruficauda* Zetterstedt, 1843

- *Paragus tacchettii* Rondani, 1865
- *Paragus taeniatus* Meigen, 1822
- *Paragus testaceus* Meigen, 1822

  Syrphus bicolor Fabricius, 1794

Type Material:

Other material:

India: 1 ♂, 1 ♀, Jammu and Kashmir, ; Dist. Anantnag, GDC (boys) Botanical Garden; 34°44′38.89″ N, 75°07′43.13″ E; alt. 1620 m; 6 July 2024; A. Maqbool leg.; GDCA A_Maqbool00030- A_Maqbool00031; 2♀♀, Jammu and Kashmir, ; Dist. Srinagar, GCW MA Road Botanical Garden; 34°04′27.11″ N, 74°49′01805″ E; alt. 1600 m; 11 Aug. 2023; A. Maqbool leg.; CUZM A_Maqbool00055- A_Maqbool00056; 2♀♀, Jammu and Kashmir, Dist. Baramullah, Sopore; 34°22′44.8″ N, 74°13′43.5″ E; alt. 1680 m; 26 July. 2022; S.F. Yatoo leg.; CUZM S_Yatool00057 to S_Yatool00058.

Type Locality: Barbariae

Diagnosis: Eye exhibiting vertical alternating bands that reflect light variably, face somewhat protruding, and the antennal basoflagellomere elongated, measuring four times its width; apical margin of scutellum yellow with apical granulation; abdominal tergites variable, mostly orange red middle tergites between black basal and apical tergites (Sorokina 2007).

Distribution: Afghanistan, Barbaria, China, Europe, India (Jammu and Kashmir), Pakistan, United States (Brunetti 1923; Peck 1988; Thompson & Ghorpade 1992; Shah et al. 2014; Mitra et al. 2008; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): open ground; dry, unimproved, sparsely vegetated grassland (Vujic et al. 2018)

Floral host Range: *Sisymbrium loesli* L, *Foeniculum vulgare, Melisa officinalis, Mentha piperita, Lathyrus oleraceus,*

Remarks: larvae feed on aphids (Speight 2017)

Paragus (Pandasyopthalmus) karnaliensis, Claussen & Weipert (2004) (Figure 76)

Type Material: ♂, NHMUK, London

Other Material:

India: 1 ♂, 1 ♀, Jammu and Kashmir, ; Dist. Shopian; 34°22′44.8″ N, 74°13′43.5″ E; alt. 1680 m; 5 Aug. 2024; A.A. Wachkoo leg.; GDCK A_Wachkoo00045 to A_Wachkoo00046; 2 ♂♂, 2 ♀♀, Jammu and Kashmir, ; Dist. Baramullah, Rafiabad; 34°16′43.78″ N, 74°11′34.96″ E; alt. 2200 m; 10 Aug 2022; A. Maqbool leg.; CUZM A_Maqbool00057 to A_Maqbool00060.

Type Locality: Nepal (Prov. Karnali: Garpung-Tal E Hurikot.

Diagnosis: Face yellow, adorned with yellowish hairs and a black medial vitta that extends to the antennal pits or becomes indistinct above, the eyes are evenly pilose, basoflagellomere almost twice as long as it is wide, while vein M_1 is roughly twice the length of the apical part of vein M_2.; scutellum completely black; all tergites black with a variable reddish patch in some specimens that may vary between a faint presence on 3rd tergite (fig) to a bright orange red spot covering most of the 3rd tergite, basomedian area of 4th tergite and most of the 5th tergite reddish (Claussen & Weipert 2004)

Distribution: Nepal, India (Claussen and Weiport 2004)

Preferred habitat(s): Hovers low and perches on vegetation while also foraging flowers in subalpine grasslands

Floral host Range: *Brassica spp., Chaerophyllum reflexum, Sisymbrium loesli* L, *Foeniculum vulgare, Melisa officinalis, Mentha piperita, Lathyrus oleraceus,*

Remarks: previously misidentified as *Paragus (Pandasyopthalmus) rufocinctus* (Brunetti, 1908) by Thomson & Ghorpade (1988).

Paragus quadrifasciatus Meigen, 1822

- *Paragus bifasciatus* Macquart, 1834
- *Paragus niger* Šuster, 1959
- *Paragus pulcherrimus* Strobl, 1893
- *Paragus quadrivitatus* Macquart, 1829
- *Paragus sexnotatus* Szilády, 1940
- *Paragus variofasciatus* Becker, 1907
- *Syrphus concinnus* Meigen & Wiedemann, 1822

Type material: ♂, MNHN, Paris

Other Material:

India: 2 ♂♂, 1 ♀, Jammu and Kashmir; Dist. Baramullah, Sopore; 34°22′44.8″ N, 74°13′43.5″ E; alt. 1680 m; 5 May 2022; S.F. Yatoo leg.; CUZM S_Yatool00061 to S_Yatool00063; 2 ♀♀, Jammu and Kashmir, ; Dist. Srinagar, GCW MA Road Botanical Garden; 34°04′27.11″ N, 74°49′01805″ E; alt. 1600 m; 25 May 2021; A. Maqbool leg.; CUZM A_Maqbool00064 to A_Maqbool00065.

Type Locality: France

Diagnosis: The mesonotum is black with a metallic lustre, featuring prominent bands of light pruinosity that extend to the posterior margin of the notum and are interrupted in the centre; tergites black with distinctive pattern of four yellow fasciae, Tergite II with broad yellow fascia, sometimes interrupted medially; the posterior border of sternite IV features a rounded projection; abdominal tergite VII possesses distinct, two processes in female; surstylus elongated and curved (Sorokina 2007)

Distribution: Afghanistan, China, India, Iran, Kazakhstan, Kirghizia, Russia, Tajikistan, Turkmenistan (Datta & Chakraborti 1984; Peck 1988; Shah et al. 2014; Mitra et al. 2008; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): Open terrain/woodland; arid, unrefined, scarcely vegetated grassland, with or without desiccated scrub; may also be found in several farmed environments, such as cabbage fields, derelict land, hedge borders, and residential gardens. (Vujic et al. 2018; Speight 2017)

Floral host Range: *Brassica spp., Chaerophyllum reflexum, Conium maculatum, Sisymbrium loesli* L, *Foeniculum vulgare, Melisa officinalis, Mentha piperita, Lathyrus oleraceus, Mentha longifolia,*

Remarks: The larva is described, feeds on aphids and is found on many plants including

Centaurea, Cichorium, Leontodon, Onopordum, Rubus and *Sonchus.* (Vujic 2018)

Key to the species of genus *Paragus* for Jammu and Kashmir

1a. Eyes with 2 or 3 vertical vittae of pile (subgenus *Paragus*)……………………..… ***2***

1b. Eyes with uniformly distributed pile (subgenus *Pandasyopthalmus*) ……….……..……………………… ***P. karnaliensis,*** Claussen & Weipert (2004)

2a. Abdomen without bands or fascia having orange red middle tergites between black basal and apical tergites……..…………………..… ***P. bicolor*** (Fabricius, 1794)

2b. Abdomen mostly black with distinctive pattern of four yellow fasciae …………………………………………………..… ***P. bicolor*** (Fabricius, 1794)

Genus *Parasyrphus* Matsumura, 1917

Diagnosis:

Wing margin without black spots; Mesanepisternite with a few well-developed hairs; apical tuft of pilosity at posteromedial angle of hind coxa; eyes pilose or bare; bare metasternum; abdomen oval (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Parasyrphus kashmiricus Ghorpade, 1994 (Figure 77)

Type material: ♂, USNM, Washington, DC

Other Material:

1♂1♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00301 to CUZM-A_Maqbool00302); 1♂: INDIA- Jammu and Kashmir, Baramullah, Gulmarg, 34^{0}03'50"N 74^{0}23'20"E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00303).

Type Locality: India (Jammu and Kashmir: Kashmir: Pahalgam)

Diagnosis: facial tubercle yellow; no median vitta on face; at basal one fourth, fore and mid femora brownish black and completely yellow fore and mid tibia; undivided and complete yellow fascia on tergites III-IV (Ghorpade 1994).

Distribution: India (Jammu & Kashmir) (Ghorpade 1994; Evenhuis & Pape 2024).

Preferred habitat: forest; conifer forest (*Abies*, *Picea*, *Pinus*).

Floral host Range: *Dipsacus inermis, Mentha longifolia,*

Remarks: Found hovering at high altitude (2900m (amsl)) *Picea* dominated forest.

Parasyrphus thompsoni Ghorpade, 1994 (Figure 78)

Type material: ♂, USNM, Washington, DC

Other Material:

1♂: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 1♂: INDIA- Jammu and Kashmir, Baramullah, Gulmarg, 34^{0}03'50"N 74^{0}23'20"E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: India (Jammu and Kashmir: Kashmir: Gulmarg)

Diagnosis: Facial tubercle exhibiting a slender brownish-black median vitta; fore and mid femora yellow with brownish-black colouration restricted to the extreme base; fore and mid tibiae totally yellow; yellow fascia on tergite III-IV undivided and complete (Ghorpade, 1994).

Distribution: India (Himachal Pradesh, Jammu and Kashmir, Uttarakhand) (Ghorpade, 1994;

Shah et al. 2014; Mitra et al. 2008; Sengupta et al. 2024; Evenhuis).

Preferred habitat: forest; conifer forest (*Abies, Picea, Pinus*).

Floral host Range: *Mentha longifolia, Sambucus wightiana,*

Remarks: Found hovering among in *Pinus and Picea* dominated forest.

Key to the species of genus *Parasyrphus* for Jammu and Kashmir

1a. Dark facial vitta present; fore and mid femora yellow with brownish black towards extreme base ………………………………..…..***P. thompsoni*** Ghorpade, 1994

1b. Facial vitta absent; fore and mid femora brownish black at basal 1/4th ……………………………………………….… ***P. kashmiricus*** Ghorpade, 1994

Genus *Platycheirus* Lepeletier & Serville, 1828

Diagnosis: Face and scutellum black, face frequently anteroventrally produced; relatively slender abdomen, black usually with quadrate paired yellowish or gyeyish markings; non- excavated well developed metasternum (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023)..

***Platycheirus pseudoalbimanus* n. sp** (Figure 79)

Type material: Holotype ♂: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 25 Aug 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00090).

Paratypes:2♂4♀: INDIA- Jammu and Kashmir, Baramulla, Kulgam, Aharbal; $33^0$38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092)

Other Material: 2♂3♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; $34^0$16'44"N $74^0$11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096).

Etymology: The species epithet refers to its proximity to the European counterpart *Platycheirus albimanus* (Fabricius, 1781), to which it was previously misidentified.

Type locality: India (Jammu & Kashmir: Kashmir: Baramulla: Rafiabad)

Diagnosis: male protibia and tarsal segments, especially 1 &2 widened; abdomen dull black with greyish white spots; modified tufts of pilosity at the base of fore femur; females thorax steel blue shining with fine punctuations; with dull black abdomen with metallic bluish grey spots; legs predominantly black (yellow in *albimanus*)

Description: Face dark grey, pruinose with dark black tubercle, short greyish pilosity on face with dark longer pilosity on frons; antennae black with brownish arista; raised ocellar triangle, black with long yellowish pilosity; laterally occiput with short greyish white pilosity; thorax black with brownish gyey, sparse pilosity dorsally and dense greyish white pilosity along pleurae; legs predominantly black, male protibia and tarsal segments, especially 1 &2 widened, modified tufts of pilosity at the base of fore femur ; abdomen black with greyish white pruinose spots, lateral margins grey; in females thorax steel blue shining having fine punctuations; abdomen dull black with metallic bluish grey spots.

Distribution: India (Jammu and Kashmir)

Preferred habitat(s): scrub-invaded clearings in forest, unimproved grassland, hilltops and ridges.

Floral host Range: *Achillea millefolium, Chaerophyllum reflexum, Heracleum candicans, Anthriscus nemorosa, Barbarea vulgaris, Mentha longifolia, Ranunculus repens, Sambucus wightiana, Spiraea bella* L., *Taraxacum parvulum*

Remarks: New species. Previously misidentified as *P. albimanus* by Brunetti (1923) owing to its very close proximity to European *P. albimanus*.

Genus *Scaeva* Fabricius, 1805

Diagnosis: eyes pilose, dorsal well defined area of enlarged facets in male, wings bare or with very sparse microtrichosity, wing vein R_{4+5} curving up into r_{2+3} cell (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Scaeva pyrastri (Linnaeus, 1758) (Figure 80)

- *Musca mellina* Harris, 1780
- *Musca pyrastri* Linnaeus, 1758
- *Musca rosae* De Geer, 1776
- *Scaeva corrusca* Gravenhorst, 1807
- *Scaeva mellina* (Harris, 1780)
- *Scaeva unicolor* Curtis, 1834
- *Syrphus flavoscutellatus* Girschner, 1884

Type material: ♂, NHMUK, London

Other Material:

1♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; $34^0$16'44"N $74^0$11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 1♂1♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; $33^0$38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 6♂7♀: INDIA- Jammu and Kashmir, Srinagar, MA Road, $34^0$04'27"N $74^0$49'01"E, 1600m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 3♂4♀: INDIA- Jammu and Kashmir, Anantnag, Khanabal, $34^0$44'40"N $75^0$7'44"E, 1620m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: Sweden

Diagnosis: Frons distinctively swollen, especially in male; scutum shiny with yellowish white sides; wing vein R_{4+5} descending into cell r_{4+5}; fore femur with black hairs on the ventral surface; abdomen featuring pairs of bright white, curving, obliquely arranged spots on tergites III-IV in living specimens, which frequently transition to yellow in pinned specimens; wide rectangular black marks on sternites (Van Veen 2004; Bot and Meutter 2023).

Distribution: Afghanistan, Canada, China, Europe, India (Jammu and Kashmir, Punjab, Uttarakhand), Pakistan, United States (Dusek & Laska Dusek & Laska 1985; Peck 1988; Abrol, 1993; Ghorpade, 1994; Shah et al. 2014; Mitra et al. 2008; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat: significantly anthrophillic, found in areas with high aphid concentration; present in cultivated crops, hedgerows, orchards, gardens, and coniferous plantations. (Vujic et al. 2018).

Floral host Range: *Brassica spp., Conium maculatum, Sisymbrium loesli* L, *Lathyrus oleraceus, Prunus avium,*

Remarks: Collected from crops infested with aphids and aphid infested conifer trees.

Genus *Sphaerophoria* Lepeletier & Serville, 1828

Diagnosis:

Elongated black and yellow with yellow, including a yellow face and yellow scutellum; distinct yellow patterns laterally on the thorax; metasternum pilose; subscutellar fringe lacking or almost absent on at least the median one-third, present but sparse laterally; male genitalia globose and exceptionally large; tergite IX as wide as the abdomen (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

Sphaerophoria bengalensis Macqaurt

Sphaerophoria flavoabdominalis Brunetti, 1915

Type material: ♂, MNHN,Paris

Other material:

1♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00310); 1♂1♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00311 to CUZM- A_Wachkoo00312)

Type Locality: India (Bengal)

Diagnosis: Antennal basoflagellomere yellow, lunule yellow; scutellum with yellow pilosity only; fore femur with yellow pilosity only; tergite II exhibits a yellow fascia extending to the lateral edges without tapering; the female frons features a black median vitta that is narrower than the surrounding yellow regions; the yellow fascia on tergite II posteriorly emarginate in the centre, while tergite VI displays a yellow colouration with a vertical subtriangular black spot(Ghorpade 1994).

Distribution: Afghanistan, India (Bihar, Delhi, Himachal Pradesh, Jammu and Kashmir, Maharashtra, Punjab, Uttarakhand, W Bengal), Iran, Nepal, Pakistan, Turkmenistan (Abrol, 1993; Ghorpade, 1994; Shah et al. 2014; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat: Collected from common flowers and vegetable inflorescence like *Brassica, Dacus, Corianderum,* etc. (Abrol, 1993; Sajjad and Saeed 2010)

Floral host Range: *Chaerophyllum reflexum, Conium maculatum, Convolvulus arvensis* L, *Dacus carota* L, *Sisymbrium loesli* L, *Heracleum candicans, Anthriscus nemorosa*, *Barbarea vulgaris, Dipsacus inermis, Impatiens glandulifera, Mentha longifolia*, *Myosotis arvensis*, *Ranunculus repens, Sambucus wightiana*, *Spiraea bella* L., *Taraxacum parvulum*

Remarks: Larvae of *S. bengalensis* consume various species of Aphididae, Lepidoptera larvae and some Psyllidae (Rojo et al. 2003).

Sphaerophoria rueppellii (Wiedemann, 1830)

- *Ischiodon libycum* Nayar, 1978
- *Sphaerophoria calceolata* Macquart, 1842
- *Sphaerophoria flavicauda* Zetterstedt, 1843
- *Sphaerophoria insignita* Zetterstedt, 1859
- *Sphaerophoria montivaga* Violovich, 1985
- *Sphaerophoria (Sphaerophoria) multipunctata* Zetterstedt, 1859
- *Sphaerophoria nitidicollis* Zetterstedt, 1849
- *Sphaerophoria oleandri* Rondani, 1857
- *Sphaerophoria pictipes* Boheman, 1864
- *Sphaerophoria serpilli* Rondani, 1857
- *Syrphus incertus* Wiedemann, 1830
- *Syrphus rueppellii* Wiedemann, 1830

Type material: ♂, SMF, Frankfurt

Other material:

1♂1♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34⁰16'44"N 74⁰11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00313 to CUZM-A_Maqbool00314); 1♂1♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33⁰38'39"N 74⁰ 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00315 to CUZM- A_Wachkoo00316)

Type Locality: Sudan

Diagnosis: Face yellow or at most with a dark facial tubercle; thorax sides are yellow from the postpronotum to the transverse suture, subsequently black, although the postalar callus may be slightly yellowish; abdomen constricted at Tergites II and III, smaller than tergites V and VI; tergites III-V typically exhibiting yellow spots that taper towards the edges and frequently coalesce to create a wide band (Van Veen 2004: Bot and Meutter 2023)

Distribution: Abyssinia, Afghanistan, Algeria, Canary Islands, China, Egypt, Ethiopia, Europe, India (Jammu and Kashmir), Israel, Kenya, Korea , Mongolia, Morocco, Syria, Yemen (Datta & Chakraborti, 1984; Ghorpade, 1994; Shah et al. 2014; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat: Wetland/open ground; vegetated, exposed, riverine sand and gravel banks; irrigation channels and ephemeral riverbeds (Vujic et al. 2018).

Floral host Range: *Achillea millefolium, Chaerophyllum reflexum, Conium maculatum, Sisymbrium loesli* L, *Foeniculum vulgare, Heracleum candicans, Anthriscus nemorosa, Barbarea vulgaris,*

Remarks: Datta & Chakraborti's (1984) reported an unidentified *Sphaerophoria* from Kashmir which was later assigned as *rueppellii* by Ghorpade (2015).

Sphaerophoria scripta (Linnaeus, 1758) (Figure 81)

Diagnosis:

Type material: ♂, ZSI, NHMUK, London

Other Material:

2♂2♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34⁰16'44"N 74⁰11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 3♂3♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal;

$33^0$38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 6♂9♀: INDIA- Jammu and Kashmir, Baramulla, Limber, $34^0$11'47"N $74^0$09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 2♂3♀: INDIA- Jammu and Kashmir, Srinagar, MA Road, $34^0$04'27"N $74^0$49'01"E, 1600m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 3♂4♀: INDIA- Jammu and Kashmir, Anantnag, Khanabal, $34^0$44'40"N $75^0$7'44"E, 1620m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 5♂7♀: INDIA- Jammu and Kashmir, Baramullah, Gulmarg, $34^0$03'50"N $74^0$23'20"E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: Sweden (Uppsala)

Diagnosis: Scutum exhibiting continuous bright-yellow lateral margins, potentially less pronounced posterior to the transverse suture; male abdomen is elongated, extending well beyond the wing tips; variable markings on the abdomen, ranging from broad yellow bands to small bands or paired spots; genitalia large, pilose, and globose; female hind tarsus not clearly darkened; underside of hind femur along bare zone with one or more hairs producing small spines (Van Veen 2004; Bot and Meutter 2023).

Distribution: Afghanistan, China, Europe, Greenland, India (Jammu and Kashmir), Sweden (Datta & Chakraborti, 1984; Shah et al. 2014; Mitra et al. 2008; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat: anthropophilic, grassland; open ground; grassy clearings in dry woodland; suburban gardens; occuring in diverse crops, roadside verges, and along hedgerows (Vujic et al. 2018)

Floral host Range: *Achillea millefolium, Brassica spp., Chaerophyllum reflexum, Conium maculatum, Convolvulus arvensis* L, *Dacus carota* L, *Sisymbrium loesli* L, *Foeniculum vulgare, Melisa officinalis, Mentha piperita, Lathyrus oleraceus, Prunus avium,Delphinium ajacis, Heracleum candicans, Anthriscus nemorosa, Barbarea vulgaris, Dipsacus inermis, Impatiens glandulifera, Mentha longifolia, Myosotis arvensis, Ranunculus repens, Sambucus wightiana, Spiraea bella* L., *Taraxacum parvulum*

Remarks: Very widespread and occurring along a wide altitudinal range in Kashmir.

Key to the species of genus *Sphaerophoria* for Jammu and Kashmir

1a. Lateral yellow margins on mesonotum complete…………………………….……..…..**2**

1b. Lateral yellow margins on mesonotum incomplete, extending at most upto transverse suture……………………………….……. ***S. rueppellii*** (Wiedemann, 1830)

2a. Antennal basoflagellomere completely yellow; scutellum with only yellow pilosity; tergite II with a yellow fascia extending to the lateral borders without constriction. ……………………………………………………….. ***S. bengalensis*** Macqaurt

2b. Antennal basoflagellomere faintly brown dorsally; scutellum exhibiting yellow and at least some black pilosity. ; yellow fascia on tergite II narrowing to lateral margins…….…………………….……………………… ***S. scripta*** (Linnaeus, 1758)

Genus *Syrphus* Fabricius, 1775

Diagnosis: Lower lobe of calypterae with yellow long pilosity on on dorsal surface, near posterior margin; tergite III and IV each with a rather narrow, yellow band (Van Veen 2004; Vujic et al. 2018; Bot and Meutter 2023).

***Syrphus ribesii* (Linnaeus, 1758)**

- *Musca blandus* Harris, 1780
- *Musca ribesii* Linnaeus, 1758
- *Musca vacua* Scopoli, 1763
- *Scaeva concava* Say, 1823
- *Syrphus autumnalis* Fluke, 1954
- *Syrphus beringi* Violovich, 1975
- *Syrphus bigelowi* Curran, 1924
- *Syrphus blandus* (Harris, 1780)
- *Syrphus brevicinctus* Kanervo, 1938
- *Syrphus himalayanus* Nayar, 1968
- *Syrphus interruptus* Ringdahl, 1930
- *Syrphus japonicus* Matsumura, 1917
- *Syrphus jezoensis* Matsumura, 1917

- *Syrphus jonesii* Fluke, 1949
- *Syrphus maculifer* Matsumura, 1918
- *Syrphus moiwanus* Matsumura, 1917
- *Syrphus nigrigena* Enderlein, 1938
- *Syrphus philadelphicus* Macquart, 1842
- *Syrphus similis* Jones, 1917
- *Syrphus teshikaganus* Matsumura, 1918
- *Syrphus vittafrons* Shannon, 1916

  Syrphus yamahanensis Matsumura, 1917

Type material: ♀, NHMUK, London

Other Material:

3♂2♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; 34^{0}16'44"N 74^{0}11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 1♂3♀: INDIA- Jammu and Kashmir, Kulgam, Aharbal; 33^{0}38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 1♂1♀: INDIA- Jammu and Kashmir, Baramulla, Limber, 34^{0}11'47"N 74^{0}09'55"E, 2100m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 2♂1♀: INDIA- Jammu and Kashmir, Srinagar, MA Road, 34^{0}04'27"N 74^{0}49'01"E, 1600m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123); 2♂1♀: INDIA- Jammu and Kashmir, Baramulla, Gulmarg, 34^{0}03'50"N 74^{0}23'20"E, 2700m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123).

Type Locality: Sweden

Diagnosis:

Small to medium sized robust species; eye typically bare, though occasionally it may be sparsely or densely hairy; face is predominantly yellow, with rare instances of a very thin brown stripe down the middle; scutum exhibits a shiny or sub-shiny appearance, varying from bronze to black in colour; sometimes displaying faint, dark, narrow stripes along the centre and sides; mesonotum covered in yellowish or greyish pollen laterally; tergite II features a pair of yellow maculae, while T3 and T4 showcase well-defined, often slightly wavy, narrow or wide, continuous or split, bright yellow bands, these bands may or may not reach the side edges; sternites are yellow in coloration (Van Veen 2004).

Distribution: Afghanistan, China, Canada, England, Europe, India (Himachal Pradesh, Jammu and Kashmir, Uttarakhand), Japan, Mongolia, Russia, United States (Nayar, 1968b; Ghorpade, 1994; Shah et al. 2014; Mitra et al. 2008; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): Anthrophillic, present in agricultural fields, orchards, horticultural areas, residential gardens, and parks; also found in various deciduous and coniferous forests, along railway margins, and in clearings, on track-sides, clearings (Vujic et al. 2018).

Floral host Range: *Achillea millefolium, Brassica spp., Chaerophyllum reflexum, Conium maculatum, Convolvulus arvensis* L, *Dacus carota* L, *Sisymbrium loesli* L, *Foeniculum vulgare, Melisa officinalis, Mentha piperita, Lathyrus oleraceus, Prunus avium,Delphinium ajacis, Heracleum candicans, Anthriscus nemorosa, Barbarea vulgaris, Dipsacus inermis, Impatiens glandulifera, Mentha longifolia, Myosotis arvensis, Ranunculus repens, Sambucus wightiana, Spiraea bella* L., *Taraxacum parvulum*

Remarks: The larva feeds on aphids occurring on various herbaceous plants, bushes, shrubs and trees, including some crops (Speight 2017).

Syrphus dalhousiae Ghorpade, 1994 (Figure 82)

Type material: [♂, ZSI, Calcutta, examined]

Other Material:

1♂1♀: INDIA- Jammu and Kashmir, Baramulla, Rafiabad; $34^0$16'44"N $74^0$11'32"E; 2000m (amsl)., 5 Aug 2022, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00093 to CUZM-A_Maqbool00096); 1♂: INDIA- Jammu and Kashmir, Kulgam, Aharbal; $33^0$38'39"N 74^0 46'37"E, 2270m (amsl), 25 July 2021, Swipe net, Aijaz Wachkoo leg., (CUZM-A_Wachkoo00091 to CUZM- A_Wachkoo00092); 1♂: INDIA- Jammu and Kashmir, Srinagar, MA Road, $34^0$04'27"N $74^0$49'01"E, 1600m (amsl), 23 July 2024, Swipe net, A. Maqbool leg., (CUZM-A_Maqbool00118 to A_Maqbool00123);

Diagnosis: legs predominantly yellow with black fore and mid femora bases; Sternum II yellow with a median brownish black fascia; hind femur with an oblique posteromedian black fascia; tergite II black haired on black areas posterior to yellow maculae (Ghorpade, 1994)).

Distribution: India (Himachal Pradesh, Jammu and Kashmir, Uttarakhand) (Ghorpade 1994; Shah et al. 2014; Mitra et al. 2008; Sengupta et al. 2024; Evenhuis & Pape 2024)

Preferred habitat(s): Moderately anthrophillic, urban gardens, *pinus* plantations

Floral host Range: *Achillea millefolium, Heracleum candicans, Anthriscus nemorosa, Barbarea vulgaris, Dipsacus inermis, Impatiens glandulifera, Mentha longifolia, Myosotis arvensis, Ranunculus repens, Sambucus wightiana, Spiraea bella* L., *Taraxacum parvulum*

Remarks: Adults collected on blue pine infested with aphids in Srinagar

Key to the species of genus *Syrphus* for Jammu and Kashmir

1a. Tergite II exhibiting at least some black hairs on the apical half; fore and mid tibia, on at least basal 1/4th black in male.…………………..…***S. ribesii*** (Linnaeus, 1758)

1b. Tergite II black haired on black areas posterior to yellow maculae; male fore and mid tibia yellow……………………….………..…***S. dalhousiae*** Ghorpade, 1994

Figure 61: ***Asarkina porcina*** **(Coquillett, 1898)**

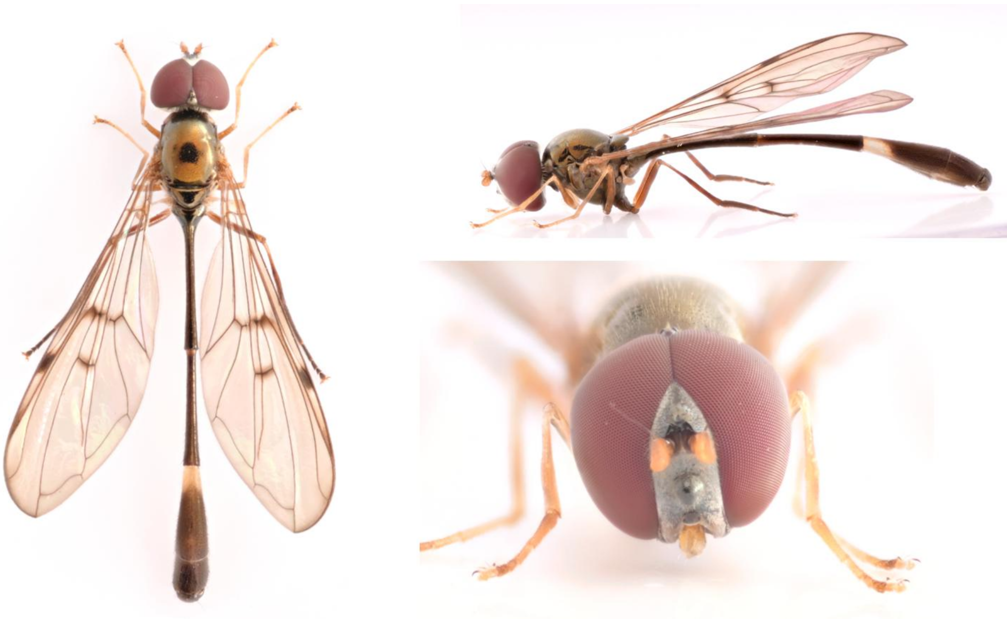

Figure 62: ***Baccha maculate*** **(Walker, 1852)**

Figure 63: ***Chrysotoxum baphyrum*** **Walker, 1849**

Figure 64: ***Chrysotoxum corbetti*** **Ghorpade, 1994**

Figure 65: ***Dasysyrphus orsua*** **(Walker, 1852)**

Figure 66: ***Didea vockerothi*** **Ghorpade, 1994**

Figure 67: ***Episyrphus balteatus*** **(de Geer, 1776)**

Figure 68: ***Eriozona bombylans*** **n. sp.**

Figure 69: ***Eupeodes Corollae*** (Fabricius, 1794)

Figure 70: ***Eupeodes latifasciatus*** (Macquart, 1829)

Figure 71: ***Ischiodon scutellaris*** **(Fabricius, 1805)**

Figure 72: ***Megasyrphus kashmirensis*** **n. sp.**

Figure 73: ***Meliscaeva cinctelloides*** **Ghorpade, 1994**

Figure 74: ***Meliscaeva strigifrons*** **(Meijere, 1914)**

Figure 75: ***Paragus bicolor*** **(Fabricius, 1794)**

Figure 76: ***Paragus karnaliensis,*** **Claussen & Weipert (2004)**

Figure 77: ***Parasyrphus kashmiricus*** **Ghorpade, 1994**

Figure 78: ***Parasyrphus thompsoni*** **Ghorpade, 1994**

Figure 79: *Platycheirus pseudoalbimanus* n. sp.

Figure 80: *Scaeva pyrastri* (Linnaeus, 1758)

Figure 81: ***Sphaerophoria scripta*** **(Linnaeus, 1758)**

Figure 82: ***Syrphus dalhousiae*** **Ghorpade, 1994**

Floral host range

In the present study 60 species of flowering plants across 21 families were documented for syrphid fly species. The floral host species were dominated by two families: Asteraceae (22%) and Apiaceae (17%). At high altitudes, Himalayan horsemint (*Mentha longifolia*) was the most favoured flowering plant with 39 species observed visiting, followed by white Himalayan hogweed (*Heracleum candicans*) with 34 species visitations and Japanese spirea (*Spiraea bella*) with 27 species visitations. At lower altitudes tall hedge mustard (*Sisymbrium loeselii*) was the most favoured flowering plant with 24 syrphid species visiting the flowers followed by Poison hemlock (*Conium maculatum*) with 22 species visiting the flowers.

Table 2: Floral host species visited by hoverflies in Jammu and Kashmir UT

S. No	Scientific Name	Family	Common Name	Altitude masl	No of Syrphid Species observed
1.	*Strobilanthes wallichii*	Acanthaceae	Kashmir Acanthus	1600-2500	2
2.	*Sambucus wightiana*	Adoxaceae	Kashmir Elder	1700-2700	12
3.	*Heracleum candicans*	Apiaceae	White Himalayan Hogweed	1850-2400	34
4.	*Anthriscus nemorosa*	Apiaceae	Forest Chervil	1800-2300	18
5.	*Asphodelus tenuifolius*	Apiaceae	onionweed	1600-1700	2
6.	*Chaerophyllum reflexum*	Apiaceae	Kashmir Chervil	1850-2400	18
7.	*Conium maculatum*	Apiaceae	poison hemlock	1600-1700	22
8.	*Coriandrum sativum*	Apiaceae	cilantro	1600-1700	8
9.	*Dacus carota*	Apiaceae	wild carrot	1600-1700	9
10.	*Foeniculum vulgare*	Apiaceae	Fennel	1600-1700	18
11.	*Tordylium apulum*	Apiaceae	Mediterranean Hartwort	1600-1750	1
12.	*Torilis bella*	Apiaceae	the erect hedgeparsley	1600-1800	3
13.	*Achillea millefolium*	Asteraceae	Common Yarrow	1600-2700	23
14.	*Ageratum conyzoides*	Asteraceae	White Weed	1800	1
15.	*Cirsium arvense*	Asteraceae	field thistle	1600-2200	4

16.	*Cirsium vulgare*	Asteraceae	Spear Thistle	1600-1700	4
17.	*Conyza bonariensis*	Asteraceae	hairy fleabane	1600-1700	2
18.	*Erigeron strigosus*	Asteraceae	Daisy Fleabane	1600	1
19.	*Helianthus annuus*	Asteraceae	Sunflower	1600-1700	4
20.	*Lactuca dissecta*	Asteraceae	split-leaf lettuce	1600	6
21.	*Leontopodium alpinum*	Asteraceae	Edelweiss	2300-2600	1
22.	*Senecillis jacquemontiana*	Asteraceae	Jacquemont's Ligularia	2500-2800	1
23.	*Senecio squalidus*	Asteraceae	Oxford Ragwort	1800	2
24.	*Sonchus asper*	Asteraceae	spiny-leaved sow thistle	1650	5
25.	*Taraxacum parvulum*	Asteraceae	Dendelion	1800-2300	8
26.	*Impatiens edgeworthii*	Balsaminaceae	Yellow Kashmir Balsam	2100-2500	7
27.	*Impatiens glandulifera*	Balsaminaceae	Himalayan Balsam	1800-2500	11
28.	*Sinopodophyllum hexandrum*	Berberidaceae	Himalayan May Apple	2500	1
29.	*Sinopodophyllum hexandrum*	Boraginaceae	Field Forget-Me-Not	2300-2400	7
30.	*Barbarea vulgaris*	Brassicaceae	Yellow Rocket	1650-1900	16
31.	*Brassica spp*	Brassicaceae	Mustard	1600-1700	19
32.	*Sisymbrium loeselii*	Brassicaceae	tall hedge mustard	1600-1700	24
33.	*Dipsacus inermis*	Caprifoliaceae	Himalayan Teasel	2200-2700	17
34.	*Valerian jatamansi*	Caprifoliaceae	Indian Valerian	1700	1
35.	*Cerastium cerastoides*	Caryophyllaceae	Mountain Chickweed	2100	1
36.	*Convolvulus arvensis* L	Convolvulaceae	Field Bindweed	1600-1700	6

37.	*Kalmia procumbens*	Ericaceae	Alpine Azalea	1600	1
38.	*Lathyrus oleraceus*	Fabaceae	Garden Pea	1600	14
39.	*Vicia bakeri*	Fabaceae	Wood Vetch	2150	1
40.	*Geranium wallichianum*	Geraniaceae	Purple-Vein Geranium	1600-2100	1
41.	*Iris kashmiriana*	Iridaceae	Kashmir Iris	1600-1700	3
42.	*Melisa officinalis*	Lamiaceae	Lemon balm	1600-1900	8
43.	*Mentha longifolia*	Lamiaceae	Himalayan Horsemint	1800-2600	39
44.	*Mentha piperita*	Lamiaceae	Peppermint	1600-1700	8
45.	*Stachys floccosa*	Lamiaceae	Woolly Woundwort	1600-2400	2
46.	*Thymus linearis*	Lamiaceae	Himalayan Thyme	1600-1700	1
47.	*Bistorta affinis*	Polygonaceae	Himalayan knotweed	1900	1
48.	*Persicaria orientalis*	Polygonaceae	Princess-feather	1600	1
49.	*Androsace sarmentosa*	Primulaceae	Common Rock Jasmine	2300-2500	3
50.	*Primula dendiculata*	Primulaceae	Drumstick Primrose	2900	2
51.	*Primula rosea*	Primulaceae	Rosy Primrose	2700	2
52.	*Primula vulagris*	Primulaceae	Dog Tooth Primose	1600	1
53.	*Anemone rupicola*	Ranunculaceae	Wood anemone	2600	1
54.	*Anemonoides sylvestris*	Ranunculaceae	Kashmir Snowdrop Anemone	2400	1
55.	*Delphinium ajacis*	Ranunculaceae	Larkspur	1600-1700	4
56.	*Ranunculus repens*	Ranunculaceae	Meadow Buttercup	1800-2500	14
57.	*Fragaria nubicola*	Rosaceae	Himalayan Strawberr	1800-2200	3
58.	*Potentilla argyrophylla*	Rosaceae	Silverleaf cinquefoil	2800	2
59.	*Spiraea bella* L	Rosaceae	Japanese Spirea	2100-2700	27
60.	*Saxifraga filicaulis*	Saxifragaceae	Slender Saxifrage	2700	1

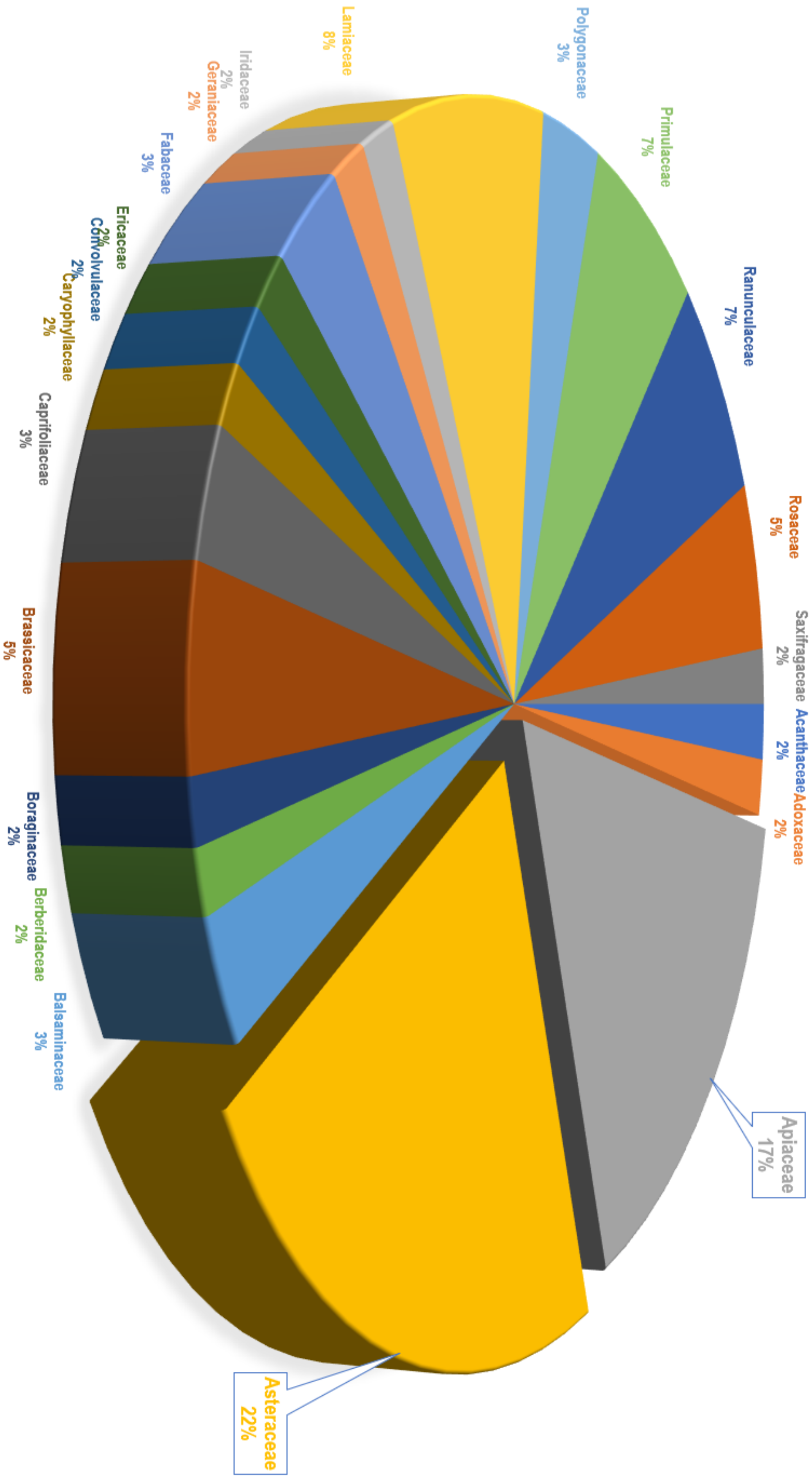

Figure 83: Family composition of Floral hosts

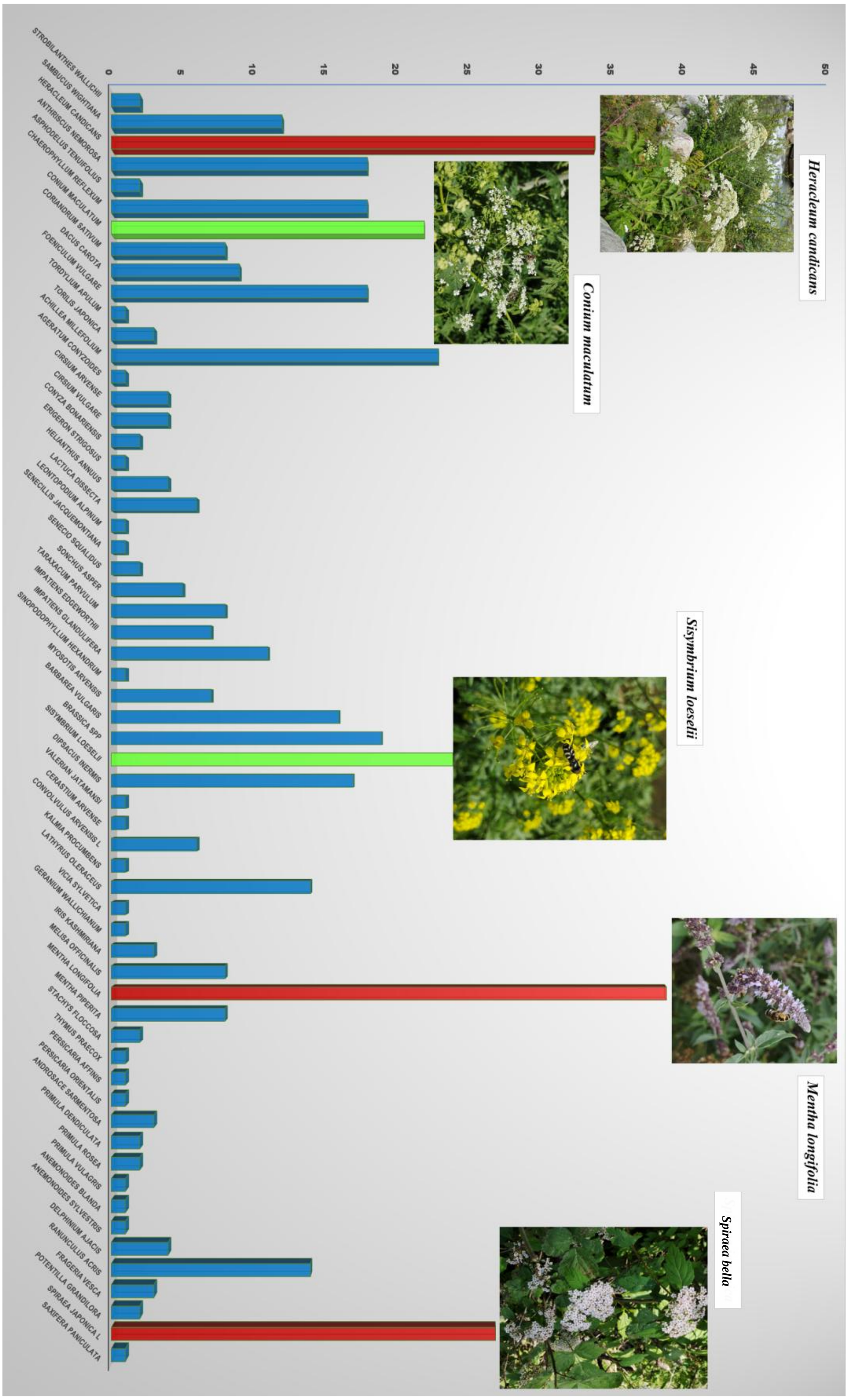

Figure 84: Floral host preference of hoverfly species observed in Jammu and Kashmir UT

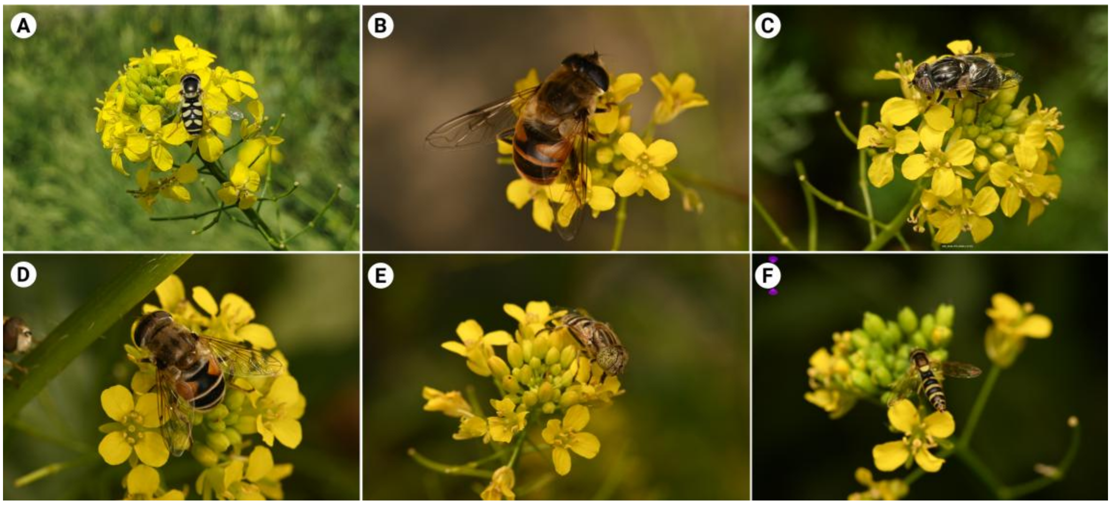

Figure 85: Hoverflies (A= *Ischiodon scutellaris*, B= *Eristalis tenex*, C= *Eristalinus tarsalis*, D= *E. arbistorum*, E=*E. megacephalus*, F=*S. scripta*) on *Sisymbrium loesli* L

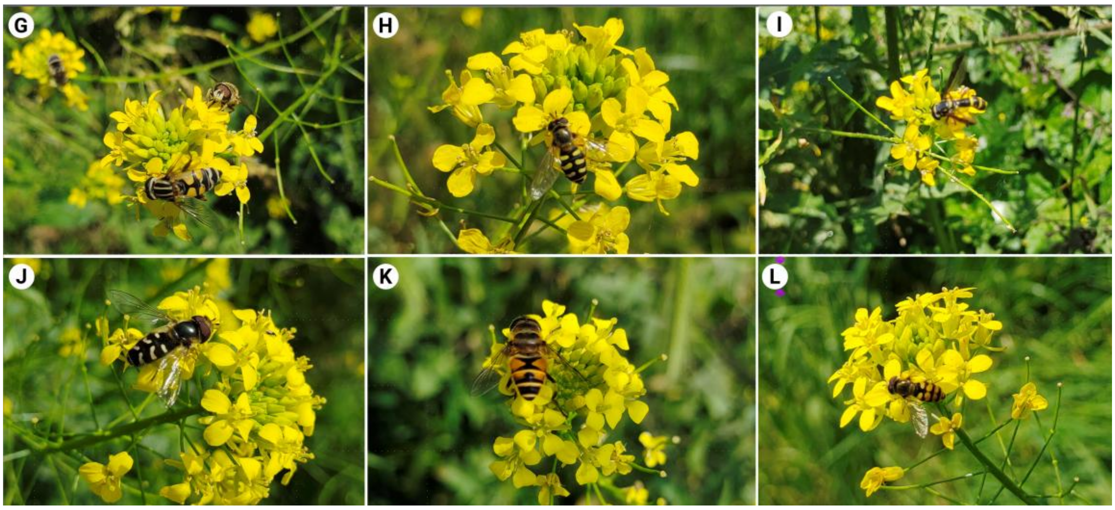

Figure 86: Hoverflies (A= *Ischiodon scutellaris*, B= *Eristalis tenex*, C= *Eristalinus tarsalis*, D= *E. arbistorum*, E=*E. megacephalus*, F=*S. scripta*) on *Sisymbrium loesli* L

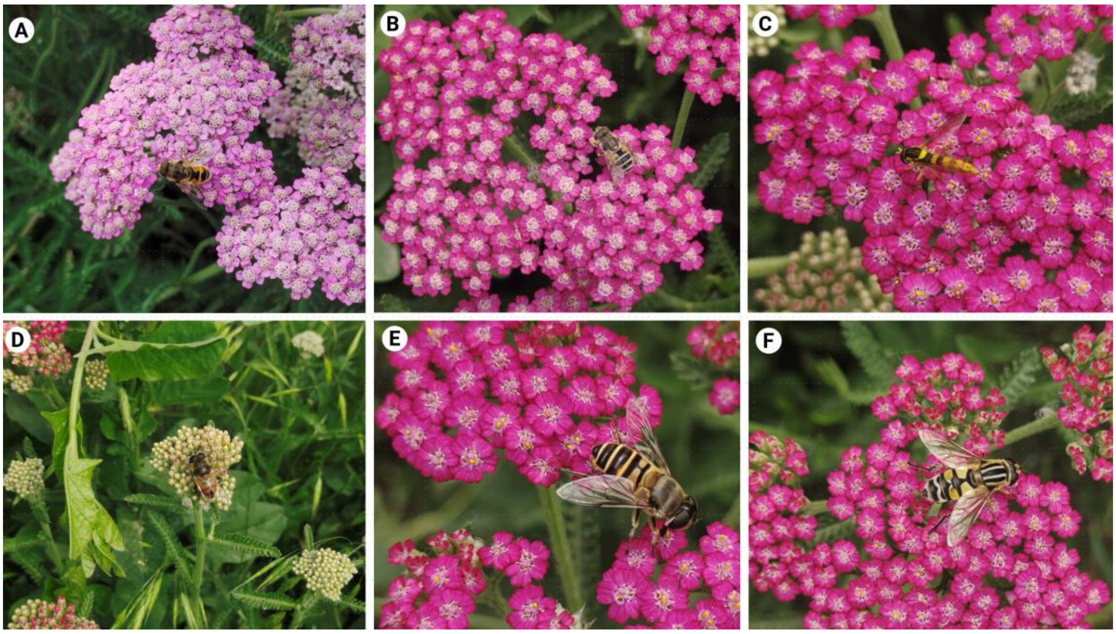

Figure 87: Hoverflies (A=*E. arbistorum,* B=E. *arbistorum,* C=S. *scripta* D= *E. tenax* E=*E. cerealis,* F= *H. trivitatus*) on *Achillea millefolium*

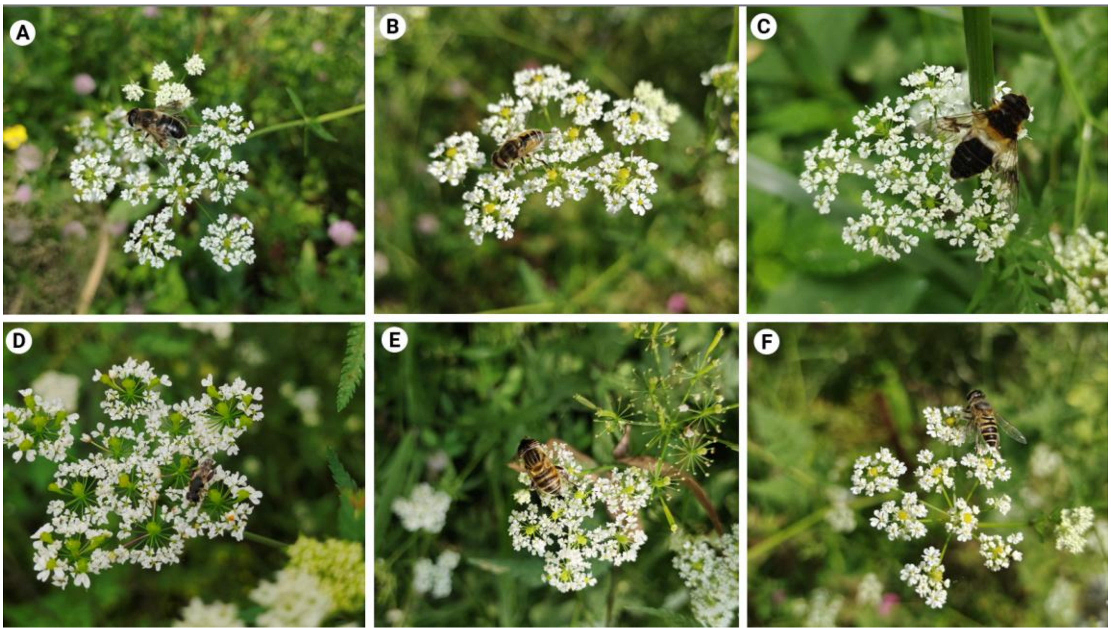

Figure 88: Hoverflies (A=*E. tenax,* B=*E. arbustorum,* C=*E. himalayensis* D= *S. pipiens,* E=, F= *E. taeniops,* F=*E. cerealis*) on *Chaerophyllum reflexum*

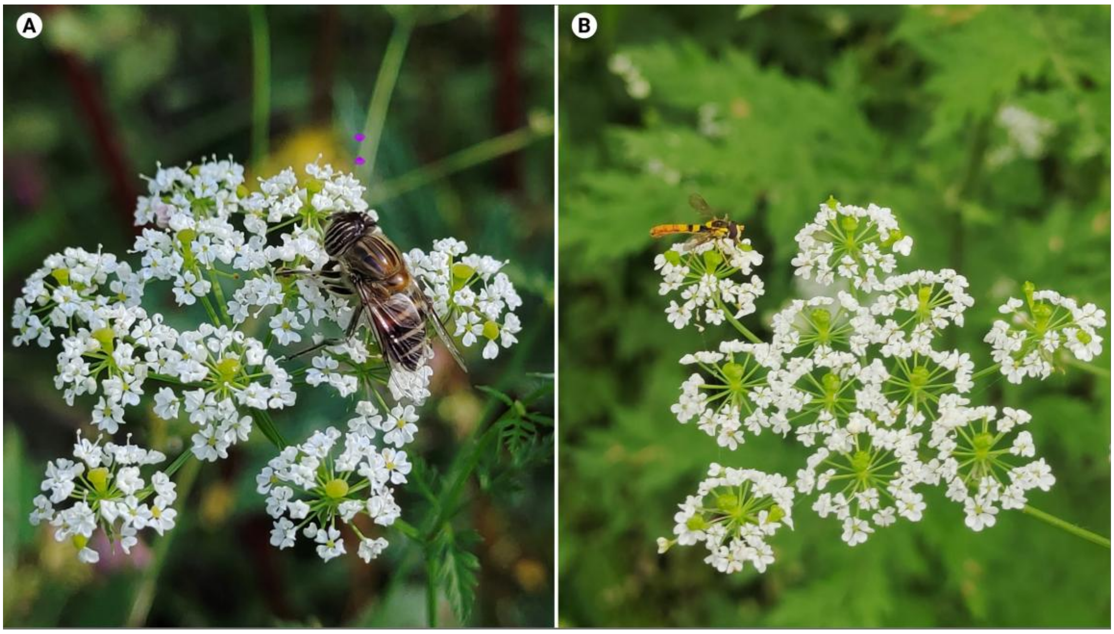

Figure 89: Hoverflies (A= *E. taeniops* B= *S. scripta*) on *Chaerophyllum reflexum*

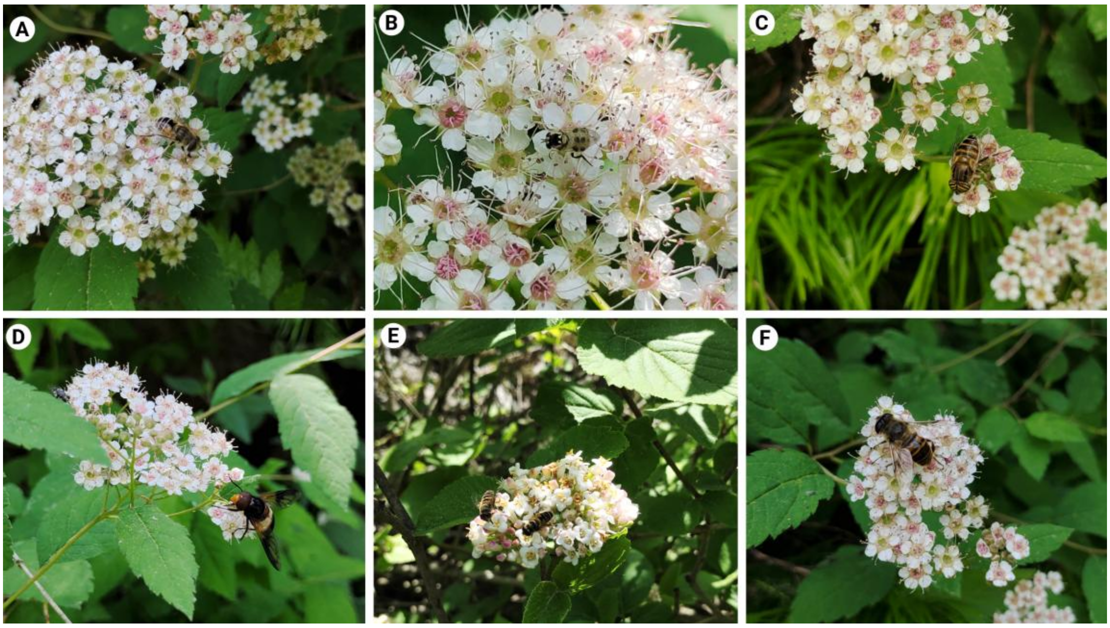

Figure 90: Hoverflies (A= *E. arbustorum* B= *G. flavonotata,* C= *E. taeniops,* D= *V. pellucens,* E=*E. cerealis* F= *E. taenax*) on *Spiraea bella* L.

Figure 91: Hoverflies (A= *E. balteatus*, B= *M. orientale*) on *Ranunculus repens*

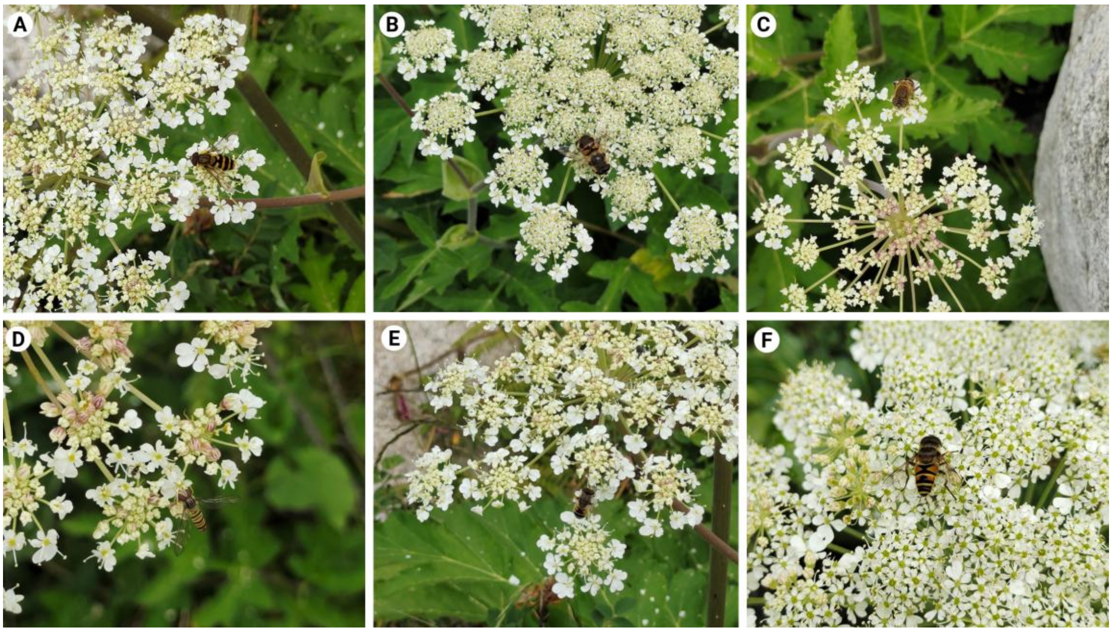

Figure 92: Hoverflies (A= *S. ribessi*, B= *E. tenax, C= E. taeniops, D= E. balteatus, E= E. arbustorum, F= E. cerealis*) on *Heracleum candicans*

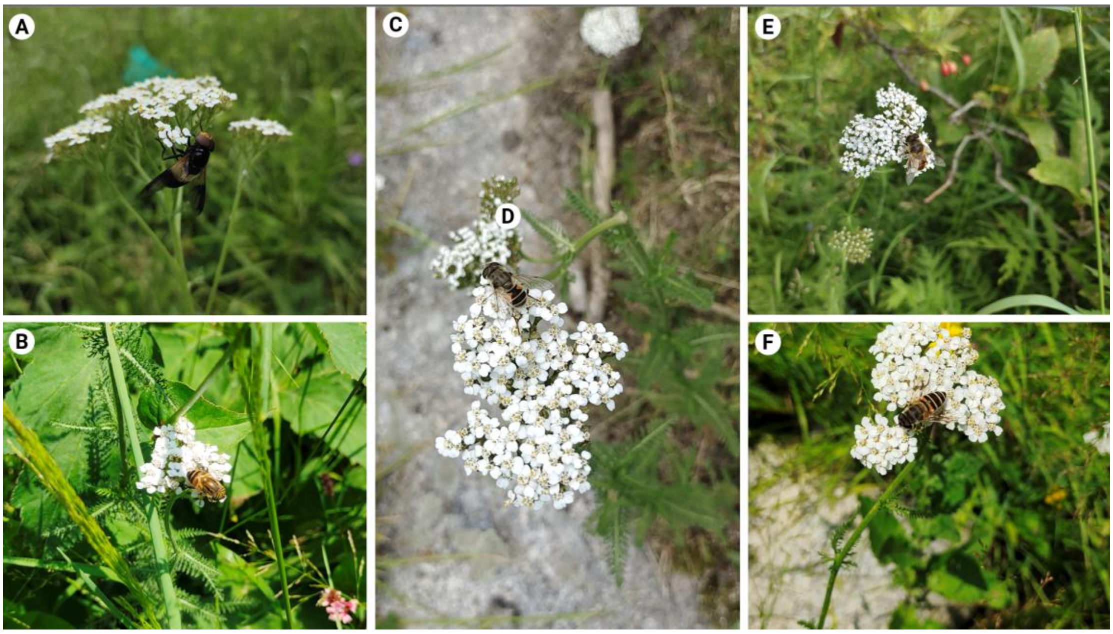

Figure 93: Hoverflies (A= ***V. pelucens*****, B=** ***E. taeniops, C= E. arbustorum D= E. tenax, E= E. cerealis*****) on** ***Achillea millefolium***

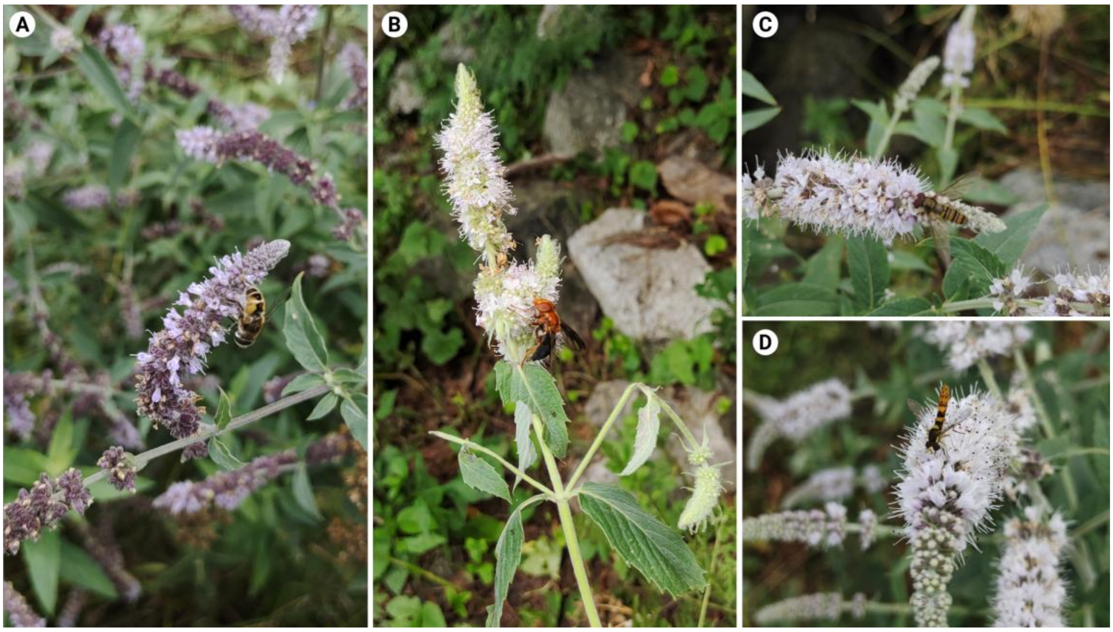

Figure 94: Hoverflies (A= ***E. arbustorum*****, B=** ***V. linearis, C= E. balteatus, D= S. scripta*****) on** ***Mentha longifolia***

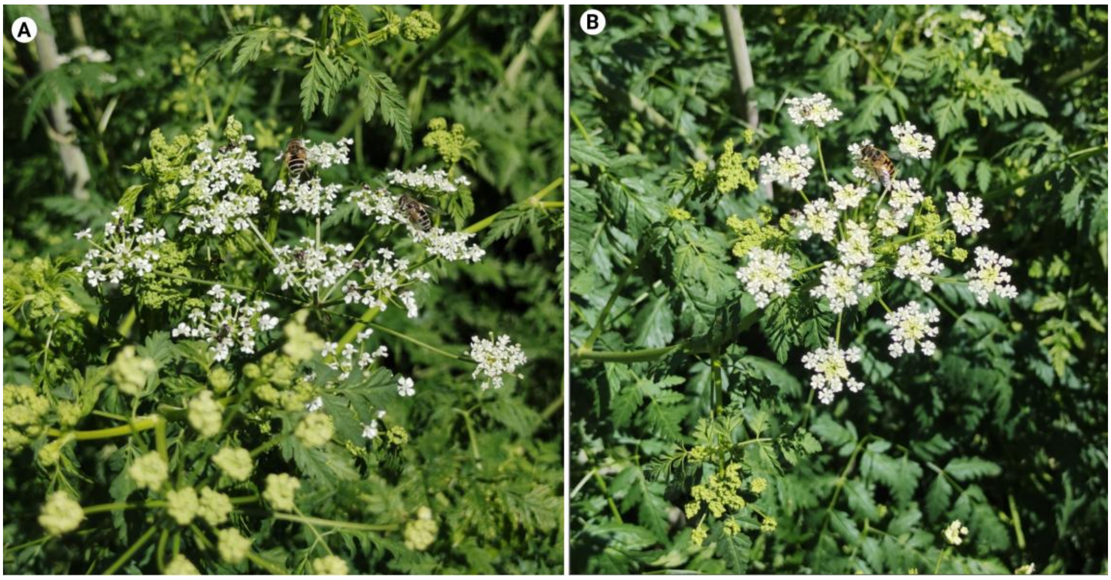

Figure 95: Hoverflies (A= *E. arbustorum*, B= *E. cerealis*) on *Conium maculatum*

Figure 96: Hoverflies (A= *E. arbustorum*, B= *H. trivitatus*) on *Convolvulus arvensis*

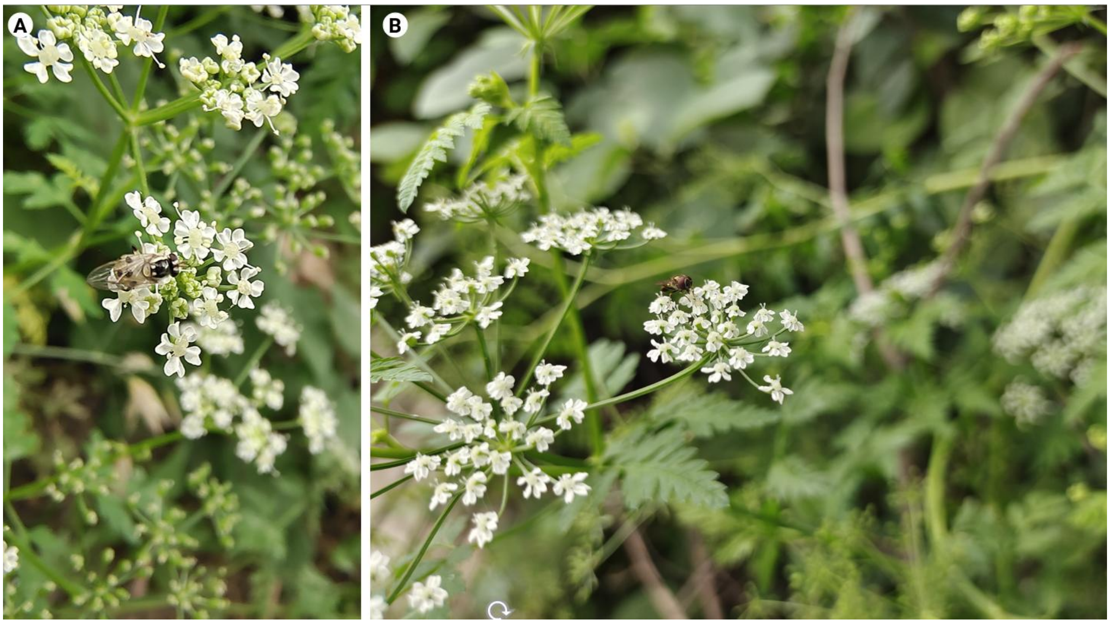

Figure 97: Hoverflies (A= *G. flavonotata*, B= *M. orientale*) on *Anthriscus nemorosa*

Figure 98: *P. Karnaliensis* on *Delphinium ajacis*

4.2 Hoverflies across altitudinal gradients

Hoverfly abundance and species richness were significantly affected by altitude. Both total abundance and species richness exhibited a significant curvilinear polynomial regression of the quadratic type with altitude as variable (Figure 98). The highest abundance and diversity of hoverflies were observed at medium altitudes, approximately 2300-2500 m. The regression analysis showed a moderate relationship between species richness and altitude ($R^2 = 0.420$, $p = 0.01658$), while the Kruskal-Wallis test indicates significant differences in abundance across altitudes ($H = 149.447$, $p < 0.01$) (Figure 100).

Most of the species showed dominance in the mid altitude range (2300-2500m (amsl)). *Eristalis* species (*E. arbustorum*, *E. cerealis*, *E. tenax*) and Eristalinus taeniops showed a dominance along the lower altitudes however were observed with a wide distributional range along the altitude. Other species with similar wide distributional range include *E. balteatus, S. scripta, S. rueppellii, X. nursei, S. pipiens, P. pseudoalbimanus*). Species restricted towards the lower altitudes include *E. sepulchralis, H. trivittatus, E. corollae, P. karnaliensis, S. pyrastri, P. bicolor, P. quadrifasciatus I.scutellaris* and *E. aeneus.*

Larger Species especially from genus *volucella* and *Spilomyia* were dominant in the mid-high-altitude region (2500-2700m (amsl)) although their range was observed quite wide (2000-2800m (amsl)).

Cluster analysis of distributional pattern of hoverfly species revealed some interesting results with genus *Chrysotoxum, Sphegina, Meliscaeva* and *Megasyrphus* forming a single clade (Figure 99). These genera especially *Chrysotoxum* were distributed along a very restricted altitudnal range (2500-2700m (amsl)). Anpther clade with a very restricted altitudnal range include *Eriozona bombylans* and *Ferdanandea montana* (2700-3000m (amsl)), the only species dominant at the highest observed altitude (3000m (amsl)).

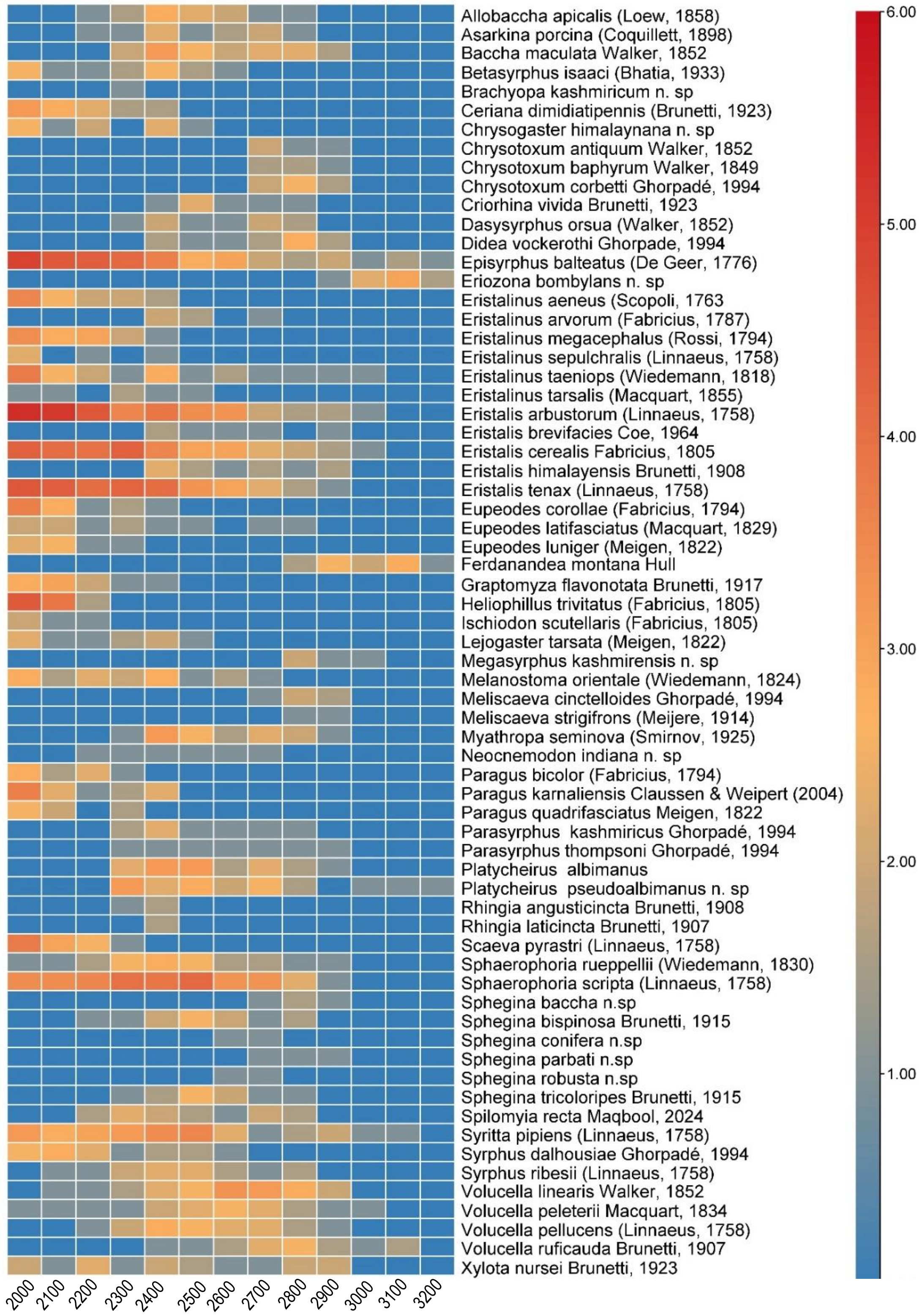

Figure: 99 Heatmap of hoverfly species abundance along the altitudinal gradient.

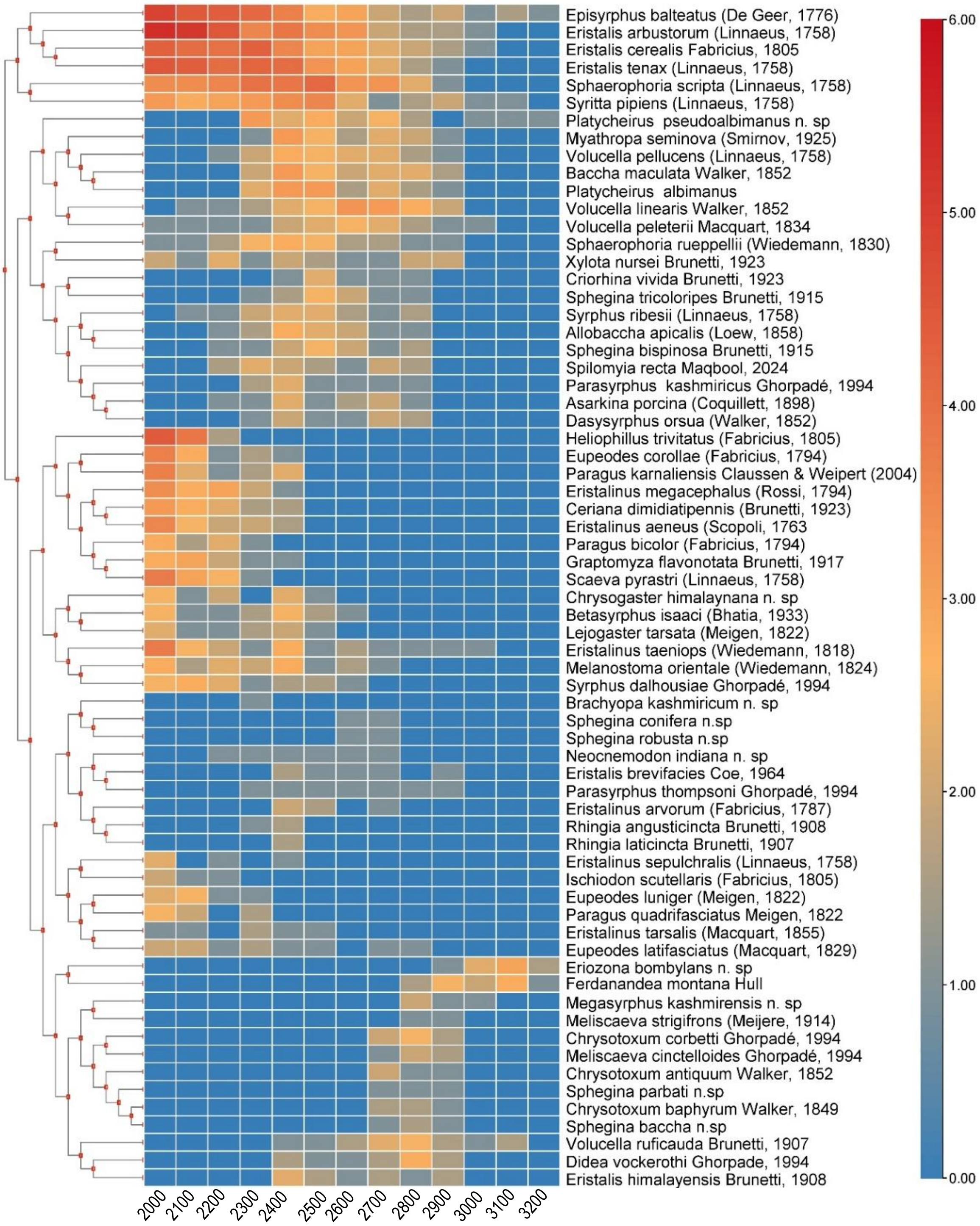

Figure: 100 Cluster Analysis of hoverfly species distribution along the

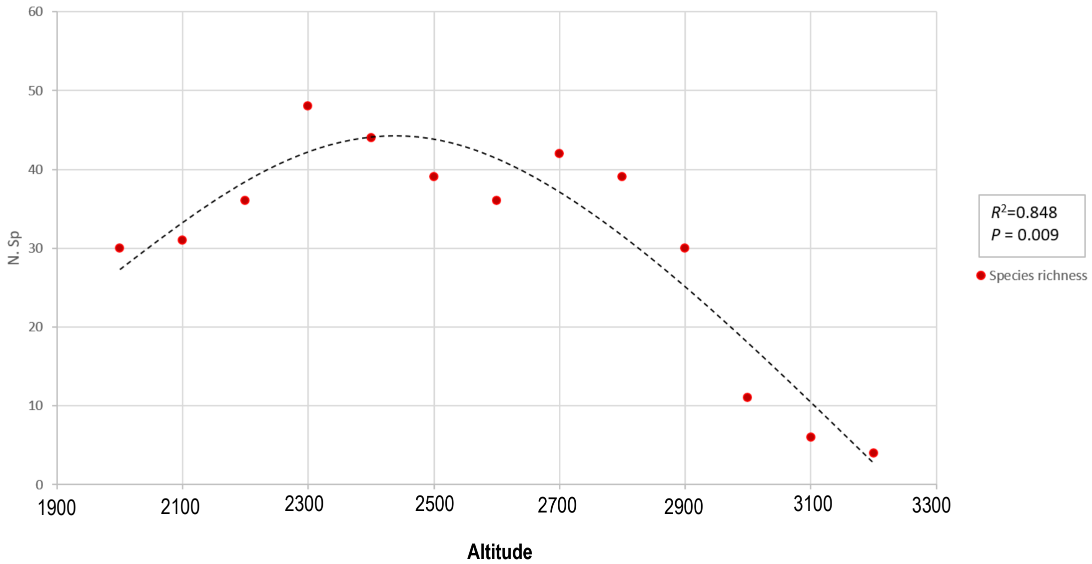

Figure 101: Effect of altitude on hoverfly species richness.

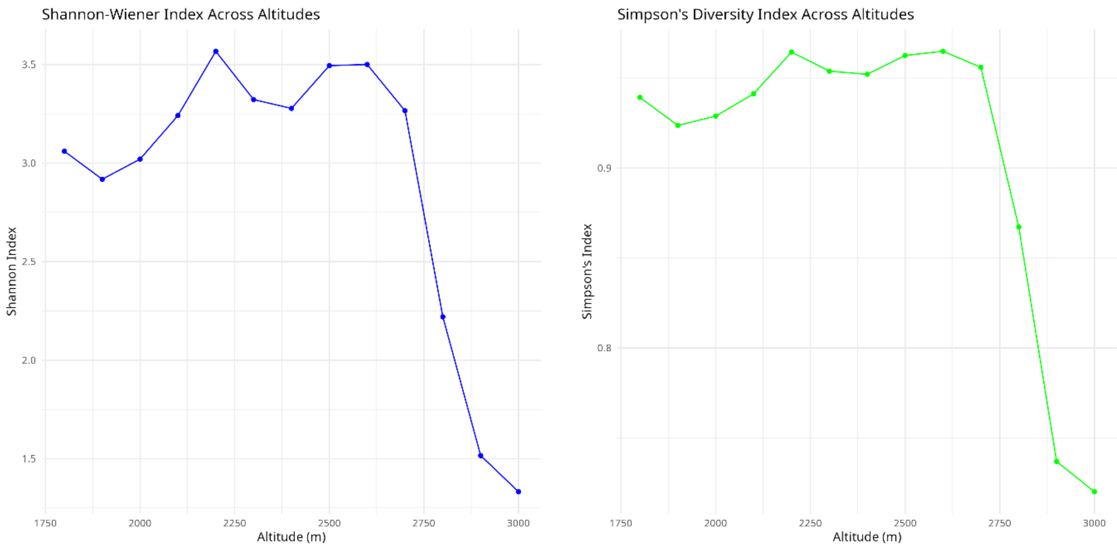

Figure 102: Effect of altitude on hoverfly species diversity

4.3 Hoverflies across anthropogenic gradients

Hoverfly species diversity showed a negative correlation with increasing urbanization gradient. was negatively related to increasing human population density. Both, abundance and species richness showed a decreasing trend with the increasing urbanization gradient. Hoverflies exhibited consistently decreased species richness in all urban and suburban regions relative to rural areas.

Table 3: Hoverfly species distribution across urbanization gradient

S.No	Species	Anantnag (Moderate Urbanization)	Baramulla (Low Urbanization)	Srinagar (High Urbanization)
1	***Allobaccha apicalis*** (Loew, 1858)	-	+	-
2	***Asarkina porcina*** (Coquillett, 1898)	-	+	-
3	***Baccha maculate*** (Walker, 1852)	-	+	-
4	***Betasyrphus isaaci*** (Bhatia, 1933**)**	-	+	-
5	***Brachyopa kashmiricum* n. sp**	-	+	-
6	***Ceriana dimidiatipennis*** (Brunetti, 1923)	+	+	-
7	***Chrysogaster himalaynana* n. sp**	+	+	+
8	***Chrysotoxum antiquum*** Walker, 1852	-	+	-
9	***Chrysotoxum baphyrum*** Walker, 1849	-	+	-
10	***Chrysotoxum corbetti*** Ghorpade, 1994	-	+	-

11	***Criorhina imitator*** Brunetti, 1915	-	+	-
12	***Criorhina pallipilosa*** Hull, 1944	-	+	-
13	***Criorhina rubropilosa*** Hull, 1950	-	+	-
14	***Criorhina vivida*** Brunetti, 1923	-	+	-
15	***Dasysyrphus orsua*** (Walker, 1852)	-	+	-
16	***Didea vockerothi*** Ghorpade, 1994	-	+	-
17	***Episyrphus balteatus*** (de Geer, 1776)	+	+	+
18	***Eriozona bombylans*** **n. sp**	-	+	-
19	***Eristalinus aeneus*** (Scopoli, 1763)	+	+	+
20	***Eristalinus arvorum*** (Fabricius, 1787)	-	+	-
21	***Eristalinus megacephalus*** (Rossi, 1758)	+	+	+
22	***Eristalinus sepulchralis*** (Linnaeus, 1758)	+	+	+
23	***Eristalinus taeniops*** (Wiedemann, 1818)	+	+	+
24	***Eristalinus tarsalis*** (Macquart, 1855)	+	+	+
25	***Eristalis arbustorum*** (Linnaeus, 1758)	+	+	+
26	***Eristalis brevifacies*** Coe, 1964	-	+	-

27	***Eristalis cerealis*** Fabricius, 1805	+	+	+
28	***Eristalis himalayensis*** Brunetti, 1908	-	+	-
29	***Eristalis tenax*** (Linnaeus, 1758)	+	+	+
30	***Eupeodes corollae*** (Fabricius, 1794)	+	+	+
31	***Eupeodes latifasciatus*** (Macquart, 1829)	+	+	+
32	***Ferdinandea isabella*** Hull, 1942	-	+	-
33	***Ferdinandea montana*** Hull, 1942	-	+	-
34	***Graptomyza flavonotata*** Brunetti, 1917	+	+	+
35	***Helophilus trivittatus*** (Fabricius, 1805)	+	-	+
36	***Ischiodon scutellaris*** (Fabricius, 1805)	-	-	+
37	***Lejogaster tarsata*** (Meigen, 1822)	+	+	+
38	***Megasyrphus kashmirensis*** **n. sp**	-	+	-
39	***Melanostoma orientale*** (Wiedemann, 1824)	+	+	+
40	***Meliscaeva cinctelloides*** Ghorpade, 1994	-	+	-
41	***Meliscaeva strigifrons*** (Meijere, 1914)	-	+	-

42	***Myathropa semenovi*** (Smirnov, 1925)		+	-
43	***Neocnemodon indiana*** **n. sp**	-	+	-
44	***Paragus bicolor*** (Fabricius, 1794)	+	-	+
45	***Paragus karnaliensis,*** Claussen & Weipert (2004)	+	+	+
46	***Paragus quadrifasciatus*** Meigen, 1822	+	-	+
47	***Parasyrphus kashmiricus*** Ghorpade, 1994	-	+	-
48	***Parasyrphus thompsoni*** Ghorpade, 1994	-	+	-
49	***Platycheirus pseudoalbimanus*** **n. sp**	+	+	+
50	***Rhingia laticincta*** Brunetti, 1907	-	+	-
51	***Rhingia sexmaculata*** Brunetti, 1913	-	+	-
52	***Scaeva pyrastri*** (Linnaeus, 1758)	+	-	+
53	***Sphaerophoria scripta*** (Linnaeus, 1758)	+	+	+
54	***Sphegina baccha*** **n.sp**	-	+	-
55	***Sphegina bispinosa*** Brunetti, 1915	-	+	-
56	***Sphegina conifera*** **n.sp**	-	+	-
57	***Sphegina parbati*** **n.sp**	-	+	-

58	***Sphegina robusta* n.sp**	-	+	-
59	***Sphegina tricoloripes*** Brunetti, 1915	-	+	-
60	***Spilomyia recta* van Steenis,** Maqbool & Wachkoo, 2024	-	+	-
61	***Syritta pipiens*** (Linnaeus, 1758)	+	+	+
62	***Syrphus dalhousiae*** Ghorpade, 1994	+	+	+
63	***Syrphus ribesii*** (Linnaeus, 1758)	+	+	+
64	***Volucella linearis*** Walker, 1852	-	+	-
65	***Volucella peleterii*** Macquart, 1834	-	+	-
66	***Volucella pellucens*** (Linnaeus, 1758)	-	+	-
67	***Volucella ruficauda*** Brunetti, 1907	-	+	-
68	***Xylota nursei*** Brunetti, 1923	+	+	+
	Total species	**28**	**54**	**28**

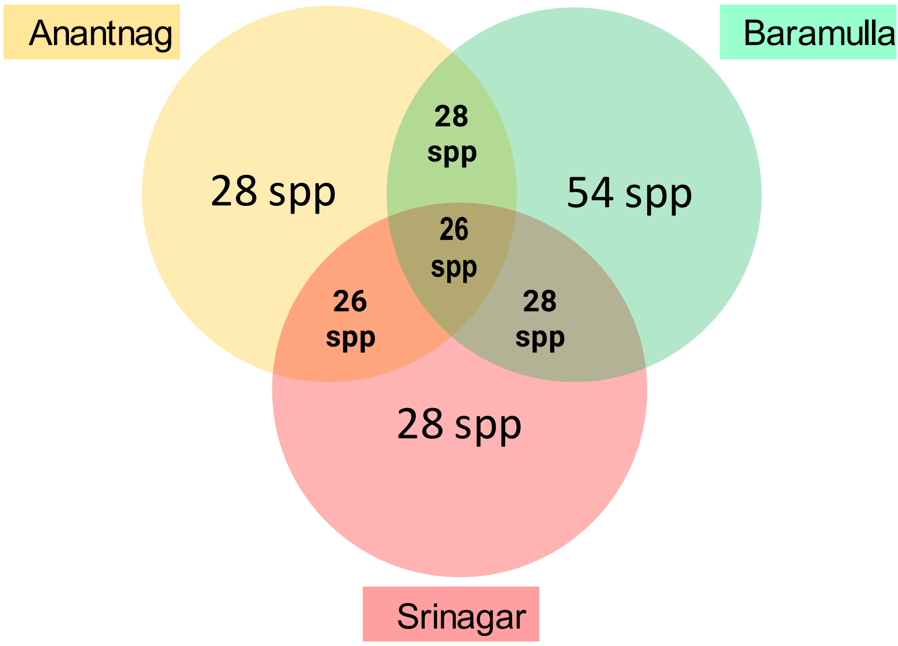

Fig 103: Venn diagram showing Syrphid Fly Diversity Overlap Across Urbanization Gradients in Jammu &Kashmir UT.

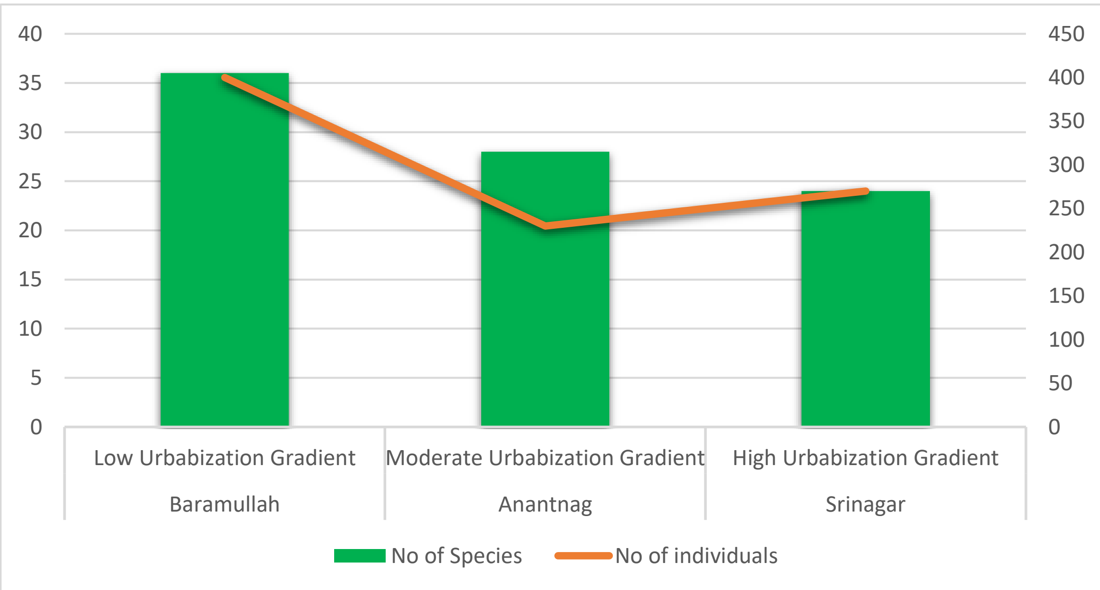

Figure: 104 Species Abundance and Richness across urbanization gradients

Table 4: Hoverfly species diversity across an urbanization gradient.

Sampling Site	Urbanization Gradient	No of Species	No of individuals	SE (Mean±SD)*	BPE (Mean±SD)*
Baramulla	Low	54	324	0.94±0.03[a]	6.21±0.6[a]
Anantnag	Moderate	28	168	0.91±0.06[b]	3.98±0.8[b]
Srinagar	High	28	162	0.87±0.08[b]	3.91±1.1[b]

SE=Simpson's evenness index

BPE=Berger-Parker's evenness index

*Means with same superscript are not significantly different (Dunn's test)

Discussion

Taxonomy and diversity of hoverflies of Jammu and Kashmir

The present study explores hoverflies (Syrphidae) in Jammu and Kashmir's different agro-climatic zones. From India's total of 355 hoverfly species across 69 genera (Sengupta et al. 2016), the research documented 72 species within 38 genera spanning 3 subfamilies. Notably, 11 new to science species were discovered and described, 4 genera were recorded for the first time from India; 5 new country records and 15 new state records are made; some misidentifications and doubtful presence issues are also resolved.

The research meticulously developed comprehensive identification tools for hoverflies in Jammu and Kashmir, creating detailed keys that systematically classify these insects from subfamily to species levels. High-definition photographs of hoverfly species could be utilized as pictorial guides for future identification. By providing annotated visual guides and generating the first systematic documentation of 70 hoverfly species across all regional zones, the study fills a significant knowledge gap in the local entomological research, offering researchers and scientists an unprecedented taxonomic resource for identifying and understanding hoverfly diversity in the region.

While the earlier works of Brunetti (1923), Nayar (1967, 1968) and Ghorpade (1992-1994) laid the foundation of Syrphidae research in western Himalayan region including Jammu and Kashmir and are still being referred to as the primary source of reference in this region, nevertheless they have some common limitations that the present study has taken into consideration and accounted for:

S. No	Previous studies	Present study
1.	Descriptions not supplemented with photographs or good quality diagrammatic sketches	Descriptions supplemented with high-definition photographs.
2.	More focused on the morphological aspect without any importance being laid to general characterization	Male genitalia of almost all species photographed and studied.
3.	No stress on molecular taxonomy	Molecular characters also provided in case of morphologically very similar species.
4.	No or very little information about floral host	All species provided with floral host range
5.	Distributional patters not discussed	Distributional patterns and factors affecting distribution studied.

Good quality photographs are essential for accurate insect species identification, enhancing both scientific research and public engagement. High-resolution images allow for detailed observation of morphological features, which are crucial for distinguishing between closely related species. This capability is particularly beneficial in entomology, where visual characteristics can be subtle. Macro photography reveals intricate details such as colours, patterns, and body shapes, which are often imperceptible to the naked eye (Gamba & Rincón 2020). Studies show that expert identification accuracy from photographs can reach 92.4%, demonstrating the effectiveness of high-quality images (Colgan et al. 2024). Digital photography has revolutionized entomological research by providing a non-destructive method of specimen documentation. Photographic identification methods reduce stress on insects compared to traditional marking techniques, leading to more reliable demographic data

(Díaz-Calafat et al. 2018). These visual records not only support current taxonomic research but also create permanent archival references for future scientific investigations.

The previous studies lack good images or graphical descriptions which makes it difficult to compare and identify a species without having expert guidance. In the present study we have presented all the species with high quality images including field, live and 'postmortem' studio images. One of the most striking features is supplementation of live images of specimens taken with modern equipment and techniques that could be used as pictorial keys for identification.

The male genitalia of insects play a crucial role in species identification due to their complex structures that often exhibit significant interspecific variation. This morphological diversity allows taxonomists to distinguish closely related species, making genitalia a key character in systematic entomology (Schilthuizen 2003). Male genitalia are often the most variable and rapidly evolving traits among species, making them essential for distinguishing closely related species. In hoverflies, specific structures such as the aedeagus and parameres are critical for accurate identification, as they exhibit significant morphological diversity across species (Vujic et al. 1998; Metcalf 1921; Kim and Han 2022). Most of the previous studies involving Syrphidae of Jammu and Kashmir have neglected this important anatomical character but here we have tried to study and present the male genitalia structures with best possible descriptions by utilizing modern high-end equipment and techniques.

Molecular markers have revolutionized hoverfly species identification by providing unprecedented taxonomic resolution and by promoting a better understanding of insect ecological relationships and diversity (Avise 2004). Mitochondrial DNA (mtDNA) has become a valuable tool in evolutionary biology and ecological studies due to its ease of use in the lab, maternal inheritance, lack of recombination, almost neutral, no recombination, and higher evolution rate compared to nuclear DNA (Harrison 1989; Ballard & Rand 2005; Galtier et al. 2009). In the last decade, many hoverfly phylogenetic questions have been answered by using the molecular markers, which provide unique insights into species variability beyond morphological characters. Genetic markers, particularly COI and LWRh, provide reliable species identification, especially when morphological traits are insufficient

(Derocles et al. 2012). While molecular markers significantly enhance species identification, reliance solely on these methods may overlook the value of traditional morphological assessments, suggesting a need for integrative approaches in hoverfly taxonomy.

The previous workers have shown no interest in molecular characters and solely relied on the morphological characters. In the present study we have complimented morphological characters with anatomical characters (male genitalia structure) and in some cryptic and morphologically very similar species adopted an integrated approach including molecular markers too for the species level identification.

Floral host range

Hoverflies require nectar and pollen for sustenance, which directly influences their reproductive rates and effectiveness as natural pest controllers (Rijn & Wäckers 2010; Bloemhard & Messelink 2016). Hoverflies, particularly those with aphidophagous larvae, rely on flowering plants for nectar and pollen, which are essential for their growth, development, survival, and reproductive success (Leman et al. 2023). Hoverflies exhibit specific foraging preferences influenced by the availability and quality of floral resources, with a tendency to favour native and near-native plants over non-native species (Lowe et al. 2022). The availability of floral resources affects hoverfly community composition and foraging behavior, which in turn influences their effectiveness in pollination and pest control (Evans 2018). Therefore, documenting floral hosts for hoverflies is crucial for enhancing their populations and improving biological pest control in agricultural systems. Understanding the relationship between hoverflies and their floral hosts can lead to better management practices that support these beneficial insects. Research indicates that only certain flower species with accessible nectar are suitable for hoverfly survival, emphasizing the need for careful selection in habitat management (Rijn & Wäckers 2010).

In the present study floral host range of hoverflies of Jammu and Kashmir was also studied. 60 flowering plant species across 21 families were documented as floral hosts for syrphid fly species. The floral host species were dominated by two families: Asteraceae (22%) and Apiaceae (17%). At high altitudes, Himalayan horsemint (*Mentha longifolia*) was the most favoured flowering plant with 39 species observed visiting, followed by white Himalayan hogweed (*Heracleum candicans*) with 34 species visitations and Japanese spirea (*Spiraea bella*) with 27 species visitations. At lower altitudes tall hedge mustard (*Sisymbrium loeselii*) was the most favoured flowering plant with 24 syrphid species visiting the flowers followed by Poison hemlock (*Conium maculatum*) with 22 species visiting the flowers.

Floral host records are very important when we take the conservation perspective into consideration. In the previous studies no or very scanty knowledge about the floral host range of hoverflies of J&K is available. In this study we tried to observe the floral host range for each species, and this would be very helpful for future conservationist studies

Non-crop plants play a crucial role in maintaining and conserving hoverfly populations through multiple ecological mechanisms. These plants provide essential ecosystem services that support hoverfly biodiversity, survival, and reproductive success. (Martínez-Uña et al. 2013). Non-crop plants, including wildflowers, hedgerow vegetation, and native flowering species, serve as crucial nectar sources for adult hoverflies. These plants offer diverse and continuous flowering patterns that supplement agricultural landscapes, ensuring consistent food availability for hoverfly populations. Many hoverfly species depend on these alternative flowering plants during periods when crop plants are not in bloom. The attractiveness of specific flowering plants to hoverflies can be influenced by their blooming periods and the availability of floral resources throughout the growing season (Mueller & Dauber, 2016).

By maintaining a diverse non-crop plant community, ecosystems can support a wide range of hoverfly species, contributing to overall insect biodiversity and ecological stability. (Martínez-Uña et al. 2013). This diversity is essential for maintaining robust pollination networks and pest control mechanisms across agricultural and natural landscapes. The information about floral host range generated in the present study gives insights into habitat and nectar resources of hoverflies of J&K and would be an important tool in hoverfly conservation as well as implementation of IPM programmes.

Hoverfly diversity and distribution: effect of environmental gradients

The study of diversity and distribution of hoverflies is crucial for understanding their ecological roles, particularly in pollination and pest control. These insects exhibit varied distribution patterns influenced by environmental factors such as climate, habitat type and altitude. This knowledge is essential for conservation efforts, especially in the face of climate change and habitat degradation. Geographic analyses show declines in pollinator diversity in certain regions, emphasizing the need for targeted conservation efforts (Souther et al. 2024).

In the present study the effect of two environmental factors i,e, urbanization and altitude were studied. The present study reveals two significant patterns in syrphid fly species diversity: a unimodal distribution along an altitudinal gradient in the Kashmir Himalayas and a negative correlation with urbanization intensity. these research findings provide valuable insights into the ecological dynamics of syrphid flies and their responses to both natural and anthropogenic environmental gradients, contributing to our broader understanding of insect diversity patterns in mountainous regions and urban landscapes.

Effect of altitudinal gradient

The altitudinal gradient presents an ecological framework that highlights how both abiotic and biotic factors interact to shape patterns of species distribution, richness, and abundance.

Researchers have long investigated the relationship between altitude and species distribution. Two predominant patterns have emerged from extensive ecological studies:

1. <u>A Consistent decline in species richness:</u>

   As altitude increases, a monotonic reduction in species diversity has been consistently observed. This pattern suggests that environmental constraints at higher elevations progressively limit species survival and diversity (Joshi et al. 2008; Leingärtner et al. 2014; Hamerlík et al. 2017; Nunes et al. 2017; Kunene et al. 2022; Neves et al. 2024).

2. <u>Unimodal distribution peak</u>

   An alternative pattern reveals species richness reaching its maximum at intermediate elevations, with a distinctive peak that reflects optimal ecological conditions at middle altitudinal ranges. (Keil & Konvicka 2005; Beck et al. 2010; Peters et al. 2016; Sommaggio et al. 2022)

Despite these established observations across various taxonomic groups, scientific research has notably neglected the Diptera order. This gap in knowledge represents a significant opportunity for further ecological investigation, particularly in understanding how altitude influences the distribution and diversity of fly species (Sommaggio et al. 2022).

In the present study altitude was observed to affect significantly the hoverfly species abundance and species richness. Both species abundance and richness showed a unimodal distribution along the altitudinal gradient with peak richness being observed at mid altitude range (2300-2500m (amsl)). Similar results have been reported by other workers (Keil & Konvička, 2005; Peters et al. 2016; Sommaggio et al. 2022).

Numerous studies demonstrate a hump-shaped richness or abundance pattern for hoverflies along altitudinal gradients, with peaks occurring typically at mid-elevations. For example, Sommaggio et al. (2022) recorded such patterns in the Dolomites, where hoverfly species richness was highest between 1200 and 1600 m, before declining significantly at lower and higher elevations. Keil and Konvička (2005) provided similar findings across 163 Central European syrphid assemblages, identifying thermal constraints at higher altitudes and resource competition at lower altitudes as primary drivers.

This unimodal distribution has been linked strongly to gradients in temperature, which directly impact hoverfly physiological processes and indirectly influence associated floral resources. Mid-elevations provide moderate thermal conditions that are conducive to hoverfly activity, metabolism, and reproduction (Keil & Konvička, 2005; Sommaggio et al. 2022). High altitudes, by contrast, are characterized by temperature thresholds that exceed the tolerances of many hoverfly species, thereby reducing both abundance and richness (McCabe et al. 2019). Additionally, lowland competition with other pollinators, such as bees, and reduced habitat heterogeneity further constrain hoverflies in these areas (Baumann et al. 2021; Sommaggio et al. 2022). Similar type of observations have been made in the Himalayas with optimal environmental conditions occurring at intermediate altitudes. Sinha et al. (2022) observed that hoverfly diversity in Neora Valley National Park predominantly peaked at altitudes above 2500 m, with certain species, such as *Eristalis tenax*, dominating pollination networks at higher elevations. Similarly, Sengupta et al. (2018) documented 34 species distributed across altitudinal gradients in Himachal Pradesh, further underscoring the prevalence of richness peaks at mid-elevations. This aligns with the "mid-domain effect," where richness reaches a zenith in areas where biotic and abiotic conditions converge optimally to support diverse taxa.

Temperature and altitudinal gradients emerge as the principal abiotic determinants governing elevational diversity patterns in syrphid assemblages (Sengupta et al. 2018; Sinha et al. 2023). Thermal regimes exert multifaceted influences on adult metabolic activity while simultaneously functioning as critical developmental constraints for immature life stages. Abbreviated growing seasons characteristic of high-elevation environments impose physiological limitations on thermophilic taxa, restricting developmental success and population recruitment. Conversely, mid-elevation zones provide optimal thermal balances, facilitating favorable temperature conditions concurrent with enhanced resource availability for specialized larval microhabitats, including decomposing organic substrates and aphid-colonized vegetation (Ferreira et al. 2012; Hussain et al. 2018). These thermal gradients remain fundamental in delineating altitudinal richness patterns, reinforcing the complex interplay between abiotic environmental conditions and syrphid ecological physiology.

Floral resource availability represents the primary biotic determinant of syrphid richness and abundance, with mid-elevation zones maximizing floral diversity and nectar density. Babaei et al. (2018) established positive correlations between flower abundance and syrphid populations, while plant species richness exerted indirect community effects. Hussain et al. (2018) similarly documented enhanced hoverfly abundance with increased floral richness across Austrian Alpine meadows. Mid-elevation habitats optimize resource heterogeneity through diverse nectar and pollen-producing taxa, creating optimal foraging conditions (Meyer et al. 2009; Sommaggio et al. 2022). Vegetation architecture critically structures assemblages, with intermediate altitudes supporting dense cover and complex microhabitat mosaics that enhance species richness (Sinha et al. 2023). Conversely, high-altitude environments exhibit sparse vegetation and reduced larval habitat suitability, constraining diversity. Specialized taxa experience cascading effects from altitudinal plant community shifts (Sinha et al. 2023). Functional studies suggest high-elevation community turnover results from vegetation-mediated environmental filtering, where generalists replace specialists under extreme conditions (de Groot & Vrezec 2019). However, these patterns remain underexplored in temperate Himalayan ecosystems.

Functional traits such as larval microhabitat specialization, inundation tolerance, flight capacity, and floral preferences play critical roles in determining species distributions along altitudinal gradients. The distribution of these microhabitats along elevation gradients impacts larval survival and recruitment into adult populations. Regions with greater structural and habitat heterogeneity, particularly in mid-elevation forests, support higher larval resource availability, further driving the unimodal diversity pattern (Babaei et al. 2018; Hussain et al. 2018). However, studies addressing these traits in the context of Himalayan hoverfly diversity remain sparse. Existing literature suggests that generalist traits, including adaptability in larval microhabitats and broader floral preferences, allow hoverfly species to persist across altitudinal ranges (Miličić et al. 2021). Species adapted to specific larval microhabitats, such as detrivory or aquatic niches, may find fewer suitable resources at higher altitudes, contributing to species turnover (Sinha et al. 2023). Flight capacity may similarly influence altitudinal distributions. Hoverflies with stronger flight musculature (*Volucella* spp, *Spilomyia* spp. etc) are presumably better suited for dispersal in windy or steep environments typical of higher altitudes (Miličić et al. 2021). However, studies specifically quantifying flight capacity or other dispersal-related traits in temperate Himalayan hoverflies are lacking. Another critical yet neglected trait is inundation tolerance, which may determine hoverfly survival in wetter, low-altitude environments (de Groot & Vrezec 2019). Conversely, arid, or harsh conditions higher in the altitudinal gradient may support only a limited subset of species adapted to such environments.

Competition between syrphids and other pollinators, particularly bees, can strongly influence hoverfly altitudinal patterns. Bees are often dominant at lower elevations, where warmer temperatures and higher resource densities favour bee populations (Baumann et al. 2021; Sommaggio et al. 2022). As elevation increases, however, cooler temperatures and shorter floral seasons limit bee abundance and richness, while favouring hoverflies, which are generally less thermally constrained (McCabe et al. 2019). This bee-to-fly dominance shift has been observed globally, with transitions occurring at mid-elevation temperature ranges of 4.9–5.7°C (McCabe et al. 2021).

Although a strong foundation exists for understanding hoverfly diversity along altitudinal gradients, several knowledge gaps remain. Few studies explicitly address the role of larval microhabitats across elevation zones, limiting insights into juvenile life stages (Larrieu et al. 2016; Hussain et al. 2018). Additionally, data on interspecific interactions in plant-pollinator networks remain sparse, hindering a full understanding of how hoverflies coexist and compete with other taxa (Baumann et al. 2021). Moreover, studies in temperate regions have been geographically biased toward Europe, with limited research from Asia, leaving open questions regarding the generalizability of observed patterns (Ferreira et al. 2012; Sengupta et al. 2018). In the context of Himalayan hoverfly diversity, current research rarely incorporates trait-based approaches to evaluate how hoverfly traits mediate responses to altitudinal gradients. While Miličić et al. (2021) outlined functional groups in a European context, no similar studies exist for the Himalayas. This omission is significant because factors such as larval microhabitats, flight capacity, and inundation tolerance play intrinsic roles in determining how species are distributed (de Groot & Vrezec 2019). Introducing more comprehensive trait-based methodologies could elucidate mechanisms behind altitudinal shifts in richness, abundance, and evenness.

Understanding altitudinal responses in hoverflies is critical as global warming shifts species ranges upward, exacerbating mismatches between hoverflies and their floral resources. For instance, rising temperatures may shorten flowering periods at high altitudes, disproportionately impacting specialist hoverflies (Sinha et al. 2023). Coupled with habitat loss, these changes threaten pollination networks and ecosystem services, especially in biodiversity hotspots like the Himalayas. Conservation strategies must prioritize mid- to high-altitude vegetation through habitat restoration, focusing specifically on maximizing floral resources suitable for hoverflies.

Additionally, targeted research investigating hoverfly functional traits is imperative to predict species' resilience to climatic changes. Failing to address these gaps limits the scope of biodiversity monitoring and functional studies critical for conservation planning.

Effect of Urbanization:

The negative correlation between syrphid fly species diversity and urbanization intensity reveals the vulnerability of these insects to anthropogenic habitat modification. Urbanization significantly alters ecosystems, transforming natural habitats into a mosaic of built environments, green spaces, and fragmented remnants of native vegetation. Hoverflies (Diptera: Syrphidae), as important pollinators and biological control agents, exhibit distinct responses to these changes, shaped by their functional traits, resource use, and landscape requirements. Urbanization reshapes hoverfly communities by selectively filtering species based on their traits and ecological functions. Numerous studies have established that hoverfly richness and abundance decline with increasing urbanization, with suburban zones often acting as biodiversity hotspots (Schweiger et al. 2007; Bates et al. 2011; Biella et al. 2022). Urbanized areas typically favour generalist hoverfly species like *Episyrphus balteatus* and *Syrphus ribesii*, which tolerate higher levels of habitat disturbance and can exploit floral resources from non-native or ornamental plant species (Schweiger et al. 2007; McCune et al. 2023). In contrast, specialist species with narrow habitat or resource requirements, such as saproxylic hoverflies, struggle to survive in urban contexts, where larval habitats and floral resources are often limited (Biella et al. 2022).

Suburban areas consistently emerge as intermediate habitats suitable for hoverfly assemblages. These zones, characterized by lower impervious surface cover and heterogeneous land use, often contain a mix of native and ornamental plant species, maintaining sufficient habitat quality to support diverse pollinator communities (Bates et al. 2011; Schirmel et al. 2018). For example, in a study in Northern Italy, species richness peaked in suburban areas before declining sharply in urban cores (Biella et al. 2022). However, there remains variability in how suburban habitats perform depending on factors such as connectivity, patch size, and floral diversity. While suburban areas can act as refuges, they may still fail to prevent beta diversity loss and ecological homogenization as species repeatedly dominate urban landscapes (Schweiger et al. 2007; McCune et al. 2023).

This homogenization of species composition along urban gradients is a critical issue, as it is indicative of reduced ecological redundancy. Redundancy, defined as the presence of multiple species performing similar roles in ecosystems, enhances ecological resilience to environmental disturbances (Moquet et al. 2018; McCune et al. 2023). The dominance of generalists in urban areas leads to functional simplification and compromises the ability of communities to buffer against further human impacts (Schweiger et al. 2007).

In the present study species abundance and richness of hoverflies showed a negative relation to increasing human population density. Both, abundance, and species richness showed a decreasing trend with the increasing urbanization gradient. Hoverflies showed a consistently lower species richness in all urban areas compared to rural areas. The areas with lowest urbanization gradient had the highest species richness and diversity with areas having moderate and high urbanization gradient supporting similar anthrophillic species showing resilience to anthropogenic pressure. These include *E. arbustorum*, *E. cerealis, E. tenax, S. pipiens, E. balteatus, P. karnaliensis* and *S. scripta.* Although all these species were abundantly collected in both urban as well as suburban areas, nevertheless main urban centres had saprophagous species dominating (*E. arbustorum, E. cerealis, E. tenax, S. pipiens*) and suburban areas showed a slightly greater dominance of predatory species (*E. balteatus, P. karnaliensis, S. scripta*).

Predatory hoverfly larvae, primarily aphidophagous species, play a critical ecological role in urban pest control by feeding on aphid prey. These larvae exhibit high adaptability to urban prey dynamics, driven by urban vegetation diversity and prey population density. Studies consistently report that aphid richness and abundance in urban greenspaces (e.g., gardens, hedgerows) are strongly associated with hoverfly abundance and diversity (Trzciński et al. 2016; Rocha et al. 2017). For example, *Episyrphus balteatus*, a widely studied aphidiphagous species, has been found to dominate hoverfly assemblages in urban environments, thriving due to its ability to exploit common ornamental plants hosting aphid populations (Trzciński et al. 2016). This indicates that predatory hoverflies can align their reproductive cycles and feeding behaviours with urban aphid dynamics, showcasing their ecological plasticity.

Urban environments also present challenges for predatory larval development, particularly due to habitat fragmentation and seasonal prey fluctuations. Habitat connectivity has been shown to influence prey accessibility and larval survival, especially in urban and suburban landscapes where green spaces are discontinuous (Moquet et al. 2018). For instance, well-connected gardens and hedgerows allow for higher aphid densities and serve as critical resources for larval development (Hänke et al. 2014; Rocha 2017). Conversely, fragmented, or isolated urban green spaces may reduce habitat functionality. Moreover, extreme urban microclimate conditions, such as heat island effects, may induce seasonal aphid population crashes, limiting prey availability for developing hoverfly larvae (Diaz Lucas et al. 2020). As a result, urban predatory hoverflies might exhibit selection for traits like rapid development or multivoltinism to ensure reproductive success in unpredictable prey environments (Rocha 2017).

In contrast to the prey reliance of predatory larvae, saprophagous hoverfly species exhibit unique adaptations to urban environments by exploiting anthropogenic resources such as organic waste, artificial water bodies, and other decaying matter. Urbanized areas, characterized by high concentrations of organic detritus and stagnant water, provide nutrient-rich microhabitats attractive to saprophagous larvae, such as those of *Eristalis* spp. (Moquet et al. 2018; de Groot et al. 2022). These species contribute to key ecosystem services such as nutrient cycling and waste breakdown, underscoring their ecological importance in urban systems.

Urban habitat fragmentation poses a significant challenge to hoverfly populations by disrupting larval resource connectivity. The availability of prey and organic substrates, essential for predatory and saprophagous larvae respectively, is often patchy and inconsistent across urban landscapes (Hänke et al. 2014; Moquet et al. 2018). Landscape-scale studies reveal that hoverfly diversity and abundance are closely tied to complementary resource availability for both larval and adult stages (Hänke et al. 2014; Moquet et al. 2018). For instance, predatory larval abundance correlates with proximity to vegetation patches hosting aphid prey, while saprophagous hoverflies depend on organic detritus distribution across the urban area.

Furthermore, urban habitat fragmentation may exacerbate the mismatch between larval and adult resource needs. Urban floral plantings and green spaces are often designed to support adult pollinators but may fail to align with larval habitat requirements, particularly for saprophagous species (Mueller & Dauber 2016). Similarly, while predatory larvae rely on aphid-rich host vegetation, frequent pesticide use in urban and suburban gardens can diminish prey availability, indirectly affecting hoverfly population dynamics (Diaz Lucas et al. 2020). Effective hoverfly conservation in urban spaces requires integrated habitat design that accounts for resource needs across multiple life stages.

To bolster hoverfly conservation in urban and suburban settings, targeted habitat enhancements are crucial. For predatory hoverflies, planting "aphid banks" with aphid host plants or hedgerows can provide spatially consistent prey availability, while minimizing pesticide use could protect larval prey populations (Hänke et al. 2014; Rocha et al. 2017). Meanwhile, saprophagous hoverflies would benefit from the strategic placement of artificial water bodies or organic detritus to sustain their populations, provided these habitats are managed to mitigate pollutant risks (Moquet et al. 2018). Landscape planning should also incorporate diverse floral resources to cater to hoverfly needs across life stages, encouraging balanced larval guild representation (Mueller & Dauber 2016).

CHAPTER-5

Summary & Conclusion

Summary and Conclusions

Building the foundational contributions of Brunetti (1923) and Ghorpade (1992-1994), this work addresses a critical gap in our understanding of the syrphid fauna of Jammu and Kashmir through comprehensive taxonomic treatment. While previous studies remain valuable foundational resources for J&K's syrphid diversity, they share a common limitation: inadequate visual documentation and morphological illustrations. This study presents all species with high-resolution images that serve as effective pictorial identification keys. Additionally, we have incorporated detailed analysis of male genitalia—essential diagnostic characters for species-level identification that were largely overlooked in earlier works—using modern high-resolution equipment and advanced imaging techniques. A distinctive feature of this research is the integration of molecular data to resolve taxonomic uncertainties in cryptic species and morphologically similar taxa.

Sampling over different agro-climatic zones of Jammu and Kashmir revealed 72 hoverfly species across 38 genera, dominated by genus *Eristalinus*, *Eristalis* and *Sphegina*. The overall abundance showed, *Eristalis arbustorum* to be the most abundant species (12%), followed by *Episyrphus balteatus* (7%), *Eristalis tenax* (5.6%), and *Eristalis cerealis* (5.3%).

A total of 60 flowering plant species were observed for syrphid flies with Asteraceae and Apiaceae species dominating. *Mentha longifolia* was the most favoured flowering plant at higher altitudes with 39 species observed visiting and *Sisymbrium loeselii* was the most favoured flowering plant at lower altitudes with 24 syrphid species visiting the flowers.

Floral resources such as pollen and nectar are important for growth, development, survival, and reproduction of hoverflies (Leman et al. 2023). and their availability affects hoverfly community composition and foraging behavior. The availability of these resources directly influences hoverfly community composition and foraging behavior, which consequently affects their efficacy as pollinators and biological control agents (Evans 2018). Floral host records are very important when we take the conservation perspective into consideration. In the previous studies no or very scanty knowledge about the hoverflies of J&K is available. In this study we tried to observe the floral host range for each species, and this would be very helpful for future conservationist studies as well as implementation of IPM programmes.

The altitudinal distribution of hoverflies exhibited a unimodal pattern, with peak species richness and abundance occurring at mid-elevations (2300-2500m (amsl)). Lower elevations were predominantly characterized by species with saprophagous and predatory larval feeding strategies, while larger saproxylic species dominated higher elevations. Notably, several specialist species were confined to high-altitude zones with extremely narrow altitudinal ranges.

Climate change induces varied evolutionary responses in insect populations. When faced with shifting environmental conditions, species may adapt in situ, migrate to more suitable habitats, or face local extinction (Parmesan and Yohe 2003; Parmesan 2007). Under current global warming scenarios, lower-altitude species may exhibit upward range shifts toward higher elevations. However, high-altitude specialists with restricted distributions face heightened extinction risk due to limited migration options and habitat constraints. These findings underscore the urgent need for targeted conservation strategies that prioritize mid- to high-altitude ecosystems. Conservation efforts should focus on habitat restoration and enhancement of floral resources specifically tailored to support hoverfly communities, particularly given their critical ecological roles as pollinators and biological control agents.

Urbanization had a negative imapact on the hoverfly species diversity with many species lost to urban landscape and now confined to rural and high-altitude ecosystems. However, there are some anthrophillic resilient species like *E. arbustorum* and *E. balteatus* demonstrate remarkable adaptability to urban and suburban environments, primarily through their predatory and saprophagous larval roles. While predatory hoverflies rely on prey-rich landscapes for pest control, saprophagous species exploit urban detritus-rich habitats for nutrient recycling. However, urbanization-driven habitat fragmentation, prey fluctuations, and pollution stressors constrain their population dynamics, requiring targeted management interventions. By addressing these challenges and aligning habitat resources across hoverfly life stages, urban planners can enhance hoverfly resilience and safeguard their ecological functions. Future research should focus on bridging gaps in our understanding of larval niche interactions and stress responses to optimize urban hoverfly conservation efforts.

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List of Publications

1. Maqbool A, Yatoo SF, Akbar SA, Banu AN, Wachkoo AA. 2024. Confirmed record of *Criorhina vivida* Brunetti, 1923 (Diptera, Syrphidae) in India with description of the male, and notes on the distribution and checklist of the genus in the country. J Insect Biodivers. 56(2):50-59.
2. Maqbool A, Wachkoo AA, Yatoo SF, Skevington JH, van Steenis J. 2024. A new species of the genus *Spilomyia* Meigen, 1803 (Diptera: Syrphidae) from South Asia. J Asia-Pac Entomol. 27(2):102254.
3. Maqbool A, Wachkoo AA, Banu AN. 2024. New record of Hemilea hyalina Wang, 1998 (Diptera: Tephritidae) from India with description of the previously unknown female: New record of *Hemilea hyalina* Wang, 1996 from India. J Insect Biodivers. 47(1):26-32.
4. Maqbool I, Varga O, Maqbool A, Wachkoo AA, Banu AN, Rather SU. 2022. *Xorides xylotrechi* sp. n. (Hymenoptera: Ichneumonidae: Xoridinae) parasitizing *Xylotrechus stebbingi* (Gahan, 1906)(Coleoptera: Cerambycidae) in India. Zootaxa. 5150(1):121-128.
5. Maqbool A, Maqbool I, Rather SU, Wachkoo AA. 2022. First record of *Amobia quatei* (Diptera: Sarcophagidae: Miltogramminae) from the Indian subcontinent as kleptoparasite of *Anterhynchium flavomarginatum* (Hymenoptera: Vespidae: Eumeninae). Rev Soc Entomol Argent. 81(3).

List of Conferences

1. Maqbool A., Banu, A. N., & Wachkoo, A. A. (2024). Distributional Patterns of Hoverflies Along an Elevational Gradient in North-Western Himalayas, India. In ***International Conference on Multidisciplinary Research and Innovation (ICMRI 2024***, organised by GCW M. A. Road Cluster University Srinagar J&K, India.
2. Maqbool A., Banu, A. N., & Wachkoo, A. A. (2023). Distributional Patterns of Hoverflies Along an Elevational Gradient in North-Western Himalayas, India. In **4th** ***International Siirt Conference on Scientific Research***, organised by Siirt University & IKSAD Institute, Turkey.
3. Maqbool A., Banu, A. N., & Wachkoo, A. A. (2023). Distributional Patterns of Hoverflies Along an Elevational Gradient in North-Western Himalayas, India. In **III** ***International Architectural Sciences And Applications Symposium***, organised by IARCSAS in collaboration with University of Naples, Italy.