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Cover: Orange Oakleaf *Kallima inachus* with colour pencils and watercolor wash by Elakshi Mahika Molur adapted from a workshop by Lenin Raj.

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REVIEW

Diversity of Calliphoridae and Polleniidae (Diptera) in the Himalaya, India

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Abstract: The family Calliphoridae (Diptera: Calyptratae: Oestroidea) is primarily known for its synanthropic, necrophagous, and myiasis–causing species. This study presents an updated checklist of blow fly species recorded in the Himalayan regions of India, Nepal, and Pakistan. The dataset includes 23 genera and 69 Species from Indian Himalayas, 18 genera and 52 species from the Pakistani Himalayas, and 22 genera and 74 species from Nepalese Himalaya. The data is categorised into three elevation zones: the Shivalik range (350–1,200 m), Lesser Himalaya (1200-2,200 m), and Upper Himalaya (2,200 m and above) taking into consideration factors such as vegetation, temperature, and other environmental variables. The Sorensen Similarity Index was utilized to quantify the degree of species overlap and similarity among blow fly communities within these elevation ranges.

Keywords: Calliphoridae, Himalaya, Ameniinae, Bengallinae, Calliphorinae, Chrysomyinae, Luciliinae, Phumosiinae, Rhiniinae, Polleniidae, Sorensen index.

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and is also actively involved in such studies from other countries. Her other significant contributions are in the field of ant ecology and molecular phylogeny of blow flies.

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INTRODUCTION

The upsurge of the youngest, largest, and highest chains of mountains, the Himalaya, from the Mediterranean seabeds of Tethys involved three distinct and widely separated phases of the uplift (Pandit et al. 2014). The upliftment of marine sediments during the post-Eocene epoch gave rise to the present-day "Greater ranges of Himalaya". The second upheaval at the end of the Miocene epoch formed the present-day "Middle or Lesser Himalayan ranges" and the last movement at the end of the Tertiary period led to the formation of the "Shivalik range" of Himalaya (Wadia 1963). Afghanistan, Pakistan, India, Nepal, Bhutan, China, and Myanmar have sovereignty over the Himalayan landscape (Xu et al. 2009; Pandit et al. 2014). The Shivalik ranges and the Lesser Himalayan ranges fall in the Oriental region and witness a subtropical to sub-temperate type of climate. On the other hand, the Greater Himalayan ranges, which lie in the Palaearctic zone, experience a temperate type of climatic conditions. Thus, the complex ecosystem and topography of the Himalaya, coupled with factors such as adaptive divergence, speciation, following immigration, or allopatric speciation, have made it a hotspot of biodiversity (Xu et al. 2009). While extensive research has explored the biodiversity and evolutionary dynamics of plants and vertebrates in the Himalayan region, there is a significant knowledge gap. This gap pertains to our understanding of the biodiversity and distribution of invertebrates, especially insects, which constitute the largest percentage of organisms worldwide.

The origin and diversification of dipteran lineages (true flies) encompass the four largest Mesozoic insect radiations within its sub-order Brachycera, i.e., the "higher Diptera" (Wiegmann et al. 2011). Most hypotheses suggest that the four major Brachyceran lineages (Xylophagomorpha, Tabanomorpha, Stratiomyomorpha (SXT clade), and Muscomorpha) originated in the Jurassic (200 MYA) and radiated rapidly into the diverse extant forms present today. The family Calliphoridae belongs to the clade Schizophora and the group Calyptratae of the infra-order Muscomorpha. According to Wiegmann (2011), the clade Schizophora originated within the Upper Cretaceous (74–98 MYA) and diversified in the Tertiary (65–20 MYA), exploding into numerous families of acalyptrate Diptera between 65–40 MYA, radiation that has occurred within a short period. The calyptrate, on the other hand, comprises the youngest lineage of Diptera, e.g., blow flies, house flies, etc., and first appeared in the fossil record about 40 million years ago (Wiegmann et al. 2011). Schizophoran radiation, which accounts for more than a third of extant fly diversity and 3% of all animal diversity, is the largest insect radiation in the Tertiary (Wiegmann et al. 2011). This period coincides with the formation of the Himalaya. The blow fly species of seven subfamilies have adapted well to the environmental stress of the region and have undergone adaptive radiation. It is also believed that the flies appear to become diverse because of higher rates of speciation and lower rates of extinction (Wiegmann et al. 2011). Compared to other dipteran lineages, the young calyptrate taxa have evolved a variety of life strategies, namely, the development of ptilinum sacs, the capacity to feed in almost any nutrient-rich medium, and have diversified to occupy a broad range of trophic niches (Cerretti et al. 2017).

The family Calliphoridae (Diptera: Calyptratae: Oestroidea) is largely known for its synanthropic, necrophagous, and myiasis-causing species (Courtney et al. 2017). Historically, the group was an assemblage of paraphyletic taxa (Rognes 1997; Kutty et al. 2010) and comprised up to 14 sub-families, viz., Ameniinae, Aphyssurinae, Bengaliinae, Calliphorinae, Melanomyinae, Chrysomyinae, Helicoboscinae, Luciliinae, Mesembrinellinae, Phumosiinae, Polleniinae, Prosthetosominae, Rhiniinae, and Toxotarsinae (Yan et al. 2021). The study of Calliphoridae phylogeny has accelerated in the last decade thanks to the application of molecular methods. Multiple hypotheses and taxonomic actions have been put forth in the study of certain fly families, such as raising polleniids, rhiniids, and mesembrinellids to full family status (Kutty et al. 2010; Marinho et al. 2011, 2017; Singh & Wells 2013; Cerretti et al. 2017, 2019). These hypotheses have faced challenges in terms of robust support, particularly in critical nodes, when relying on traditional multi-locus Sanger sequencing.

A pivotal shift occurred with the adoption of next-generation sequencing (NGS) methods, leading to the emergence of three highly supported phylogenetic hypotheses (Kutty et al. 2019; Buenaventura et al. 2021; Yan et al. 2021). Notably, Yan et al. (2021) proposed a formal reclassification of the family, revisiting the concept of a broad Calliphoridae family that includes various subfamilies: Ameniinae (incorporating the former Helicoboscinae), Bengaliinae, Calliphorinae (encompassing the former Aphyssurinae, Melanomyinae, and Toxotarsinae), Chrysomyinae, Luciliinae, Phumosiinae, Rhiniinae, and Rhinophorinae.

This study focuses on exploring the taxonomic and ecological diversity of the Calliphoridae and Polleniidae groups in the Himalayan region, with a specific emphasis

on their elevation ranges. In the Oriental region, these groups are expansive, encompassing approximately 47 genera and 390 species (Kurahashi & Kirk-Spriggs 2006). Within India, there are 128 species belonging to these groups, distributed across 30 genera and eight subfamilies (Bharti & Kurahashi 2009, 2010; Bharti 2011, 2012, 2014a,b, 2015a,b,c, 2018, 2019; Bharti & Bharti 2016; Bharti & Bunchu 2016; Bharti & Verves 2016; Bharti & Singh 2017; Bharti & Rognes 2018). In contrast, the Indian Himalayan region is represented by 23 genera and 69 species. Similarly, Pakistan exhibits a diversity of 18 genera and 57 species (Hassan et al. 2018), with 52 species located on the Pakistani side of the Himalaya. The Nepalese Himalaya house 22 genera and 74 species of blow flies (Kurahashi & Thapa 2002) (Table 1). This comprehensive checklist provides an updated record of blow fly species found across various Himalayan regions in India, Nepal, and Pakistan.

MATERIALS AND METHODS

The Himalayan blow flies (including families Calliphoridae and Polleniidae) checklist is based on original papers (Senior-White et al. 1940; Kurahashi 1989, 1994; Rognes 1993; Wells & Kurahashi 1995; Cerretti 2017, 2019; Hassan et al. 2018), lead author's collection data from northwestern and northeastern Himalaya (Bharti & Kurahashi 2009, 2010; Bharti 2011, 2012, 2014a,b, 2015a,b,c, 2018, 2019; Bharti & Bharti 2016; Bharti & Bunchu 2016; Bharti & Verves 2016; Bharti & Singh 2017; Bharti & Rognes 2018) and Pakistan (Kurahashi & Afzal 2002; Hassan et al. 2018). It includes the currently valid genera and species of the two families reported from India, Pakistan, and the Nepalese Himalaya. The data is divided into three altitude zones: the Shivalik range (350–1,200 m), the Lesser Himalaya (1,200–2,200 m), and the Upper Himalaya (2,200 m and above) with respect to vegetation, temperature, and other environmental factors (Mani 1968). The Sorensen similarity index was calculated to measure the extent of species overlap or similarity among blow fly communities in the three ranges.

RESULTS

Representatives of seven subfamilies, namely Ameniinae (including Helicoboscinae), Bengaliinae, Calliphorinae, Chrysomyinae, Luciliinae, Phomosiinae, and Rhiniinae, are present in the Himalaya. Subfamily Ameniinae is represented by two species of the genus *Catapicephala* (*C. pattoni* from Pakistan and the Nepalese Himalaya and *C. splendens* and *C. pattoni*) and

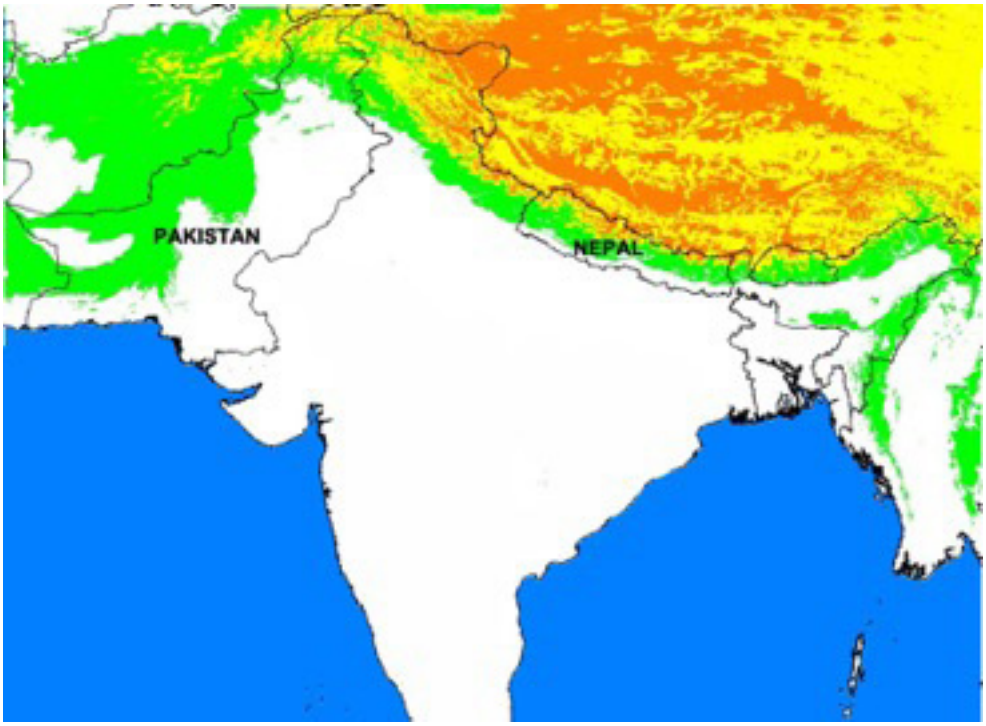

Figure 1. Map showing Himalayan regions spanning across India, Pakistan, and Nepal.

Figure 1. Map showing Himalayan regions spanning across India, Pakistan, and Nepal.

Family	Sub-family	Species	Indian Himalaya	Pakistan Himalaya	Nepalese Himalaya
Calliphoridae	**Ameniinae**	*Catapicephala splendens*	√		
		Catapicephala pattoni	√	√	√
		Gulmargia angustisquama	√		
	Bengaliinae	*Bengalia varicolor*	√	√	√
		Bengalia martinleakei	√	√	√
		Bengalia surcoufi	√	√	√
		Bengalia torosa	√	√	√
		Bengalia unicolor		√	
		Bengalia emarginata			√
		Bengalia escheri	√	√	√
		Bengalia subnitida			√
		Bengalia hastativentris	√		
		Termitoloemus marshalli	√		
		Aldrichina grahami		√	
		Calliphora chinghaiensis		√	√
		Calliphora himalayana		√	√
		Calliphora uralensis	√		
		Calliphora vicina	√	√	√
		Calliphora vomitoria	√	√	√
		Calliphora loewi		√	√
		Calliphora pattoni	√		√
		Cynomya mortuorum	√	√	
		Melinda sugiyamai		√	√
		Melinda scutellata	√	√	√
		Melinda abdominalis	√		
		Melinda bengalensis	√		
		Melinda pusilla indica	√		√
		Melinda nuortevae			√
		Melinda nepalica			√
		Nepalonesia pulchokii			√
		Nepalonesia shinonagai			√
		Onesia sp.		√	
		Onesia kiyoshii		√	
		Onesia menechmiodes		√	
		Onesia flavisquama			√
		Onesia atripalpis	√		
		Onesia khasiensis	√		
		Onesia girii			√
		Polleniopsis sp.		√	
		Polleniopsis himalayana			√
		Polleniopsis nepalica			√
		Polleniopsis pilosa	√		
		Polleniopsis kasmirensis	√		

Family	Sub-family	Species	Indian Himalaya	Pakistan Himalaya	Nepalese Himalaya
		Polleniopsis pulchokii			√
	Chrysomyinae	*Chrysomya megacephala*	√	√	√
		Chrysomya albiceps	√	√	
		Chrysomya nigripes	√	√	√
		Chrysomya phaonis	√	√	√
		Chrysomya pinguis	√	√	√
		Chrysomya putoria	√		
		Chrysomya regalis		√	
		Chrysomya rufifacies	√	√	√
		Chrysomya bezziana	√		
		Chrysomya defixa	√		
		Chrysomya villeneuvi	√		√
		Chrysomya chani	√		√
		Chrysomya thanomthini	√		√
		Protocalliphora azurea		√	
		Protocalliphora maruyamensis		√	
		Protocalliphora terraenovae		√	
		Trypocalliphora braueri			√
	Luciliinae	*Hemipyrellia ligurriens*	√	√	√
		Hemipyrellia pulchra	√	√	√
		Lucilia cuprina	√	√	√
		Lucilia papuensis	√	√	√
		lucilia porphyrina	√	√	√
		Lucilia sericata	√	√	
		Lucilia ampullacea	√		
		Lucilia bazini	√		
		Lucilia calviceps	√	√	
		Lucilia illustris	√		
		Lucilia bismarkensis			√
		Lucilia shenyangensis			√
		Lucilia sinensis			√
	Phumosiinae	*Phumosia testacea*			√
	Rhiniinae	*Borborhinia bivitatta*	√		
		Cosmina prasina	√	√	√
		Cosmina nepalica			√
		Cosmina limbipennis	√		
		Isomyia aurifacies		√	
		Isomyia fulvicornis	√	√	
		Isomyia pseudoviridana	√	√	√
		Isomyia coei			√
		Isomyia electa		√	√
		Isomyia facialis			√
		Isomyia gomezmenori			√
		Isomyia hetauda			√
		Isomyia nepalana			√

Family	Sub-family	Species	Indian Himalaya	Pakistan Himalaya	Nepalese Himalaya
		Isomyia oestracea	√		√
		Isomyia pichoni			√
		Isomyia pictifacies			√
		Isomyia shelpa			√
		Isomyia singhi			√
		Isomyia sivah	√		√
		Isomyia versicolor	√		√
		Isomyia delectans	√		
		Isomyia viridaurea	√		
		Isomyia nebulosa	√		
		Metallea flavibasis	√		
		Metallea setosa	√		√
		Metallea setiventris			√
		Rhyncomya townsendi		√	
		Rhyncomya setipyga			√
		Strongyloneura prolata			√
		Chlororhina exempta	√		
		Idiella divisa	√		√
		Rhinia apicalis	√	√	
		Stomorhina cribrata		√	
		Stomorhina discolor	√	√	√
		Stomorhina procula	√	√	√
		Stomorhina lunata	√	√	
		Stomorhina melastoma	√		√
		Stomorhina xanthogaster	√	√	√
		Stomorhina luteigaster			√
Polliniidae		*Dexopollenia nigriscens*			√
		Dexopollenia testacea	√		√
		Morinia argenticincta	√		√
		Pollenia dasypoda		√	
		Pollenia pediculata		√	
		Pollenia rudis	√	√	√

one species of the genus *Gulmargia* from the Indian Himalaya.

Thirteen taxa of Bengaliinae are known from the world (Rognes 2011), out of which only two, namely, *Bengalia* and *Termitoloeus,* are known from Nepal, Pakistan, and the Indian Himalaya. The adults of *Bengalia* are predaceous on the immature stages of ants (Rognes 2009), and their larvae feed in termite nests (Rognes 2011). There is also an observation of an adult *Bengalia* sucking the abdomen of a termite (Rognes 2011). *Termitoloeus marshalli* Baranov is the sole species known from the Indian Himalaya that attacks and captures termite mounds and feeds on termite broods. The fly in question is so voracious that it can finish a termite colony in a few months, and this aspect could potentially be used to control the termite menace in India.

Sub-family Calliphorinae (including Aphyssurinae, Melanomyinae, and Toxotarsinae) is represented by the genera *Aldrichina*, *Calliphora*, *Cynomya*, *Melinda*, *Nepalonesia, Onesia,* and *Polleniopsis* from Nepal, Pakistan, and the Indian Himalaya (Kurahashi & Afzal 2002; Bharti 2015a,b, 2018; Bharti & Rognes 2018; Hassan et al. 2018). Representatives of the genus

Cynomya have been reported from Pakistan and the Indian Himalaya (Bharti & Rognes 2018). *Nepalonesia* only comes from the Nepalese Himalaya. The genus *Aldrichina* is represented by single species, *Calliphora, Polleniopsis,* and *Melinda* by seven species, and *Onesia* by six each from the region under study (Table 1). The flies belonging to this group are oviparous or viviparous. Larvae are saprophagous, parasites of snails, or predators of earthworms.

The subfamily Chrysomyinae encompasses 12 genera, including *Phormia* Robineau-Desvoidy, *Protophormia* Townsend, *Protocalliphora* Hough, *Trypocalliphora* Peus, *Phormiata* Grunin, and *Chrysomya* Robineau-Desvoidy, all generally characterized as Holarctic/Paleotropical or belonging to the Old World Chrysomyines. Additionally, it includes *Chrysopyrellia* Seguy, *Cochliomyia* Townsend, *Compsomyiops* Townsend, *Hemilucilia* Brauer, *Paralucilia* Brauer & Bergenstamm, and *Chloroprocta* Wulp, classified as Neotropical. The previous practice of employing arbitrary tribal classifications, as proposed by Rognes in 1991 and later reaffirmed by Singh & Wells in 2013, has been abandoned. In the Himalayan region, this subfamily is represented by the genera *Chrysomya*, *Protocalliphora*, and *Trypocalliphora*. For instance, *Chrysomya* comprises thirteen species distributed across different Himalayan ranges, each playing distinct ecological roles such as scavenging, parasitism, and predation (Bharti & Kurahashi 2009; Bharti 2019).

Subfamily Luciliinae includes two species of the genus *Hemipyrellia* and 11 species of the genus *Lucilia* from the studied area. All species are oviparous, with larvae primarily exhibiting saprophagous behaviour in decaying animal matter. The adults visit flowers, faeces, and dead animals, and many species are involved in human or animal myiasis, inflicting wounds. The genus *Lucilia* is of great medical, hygienic, and forensic importance, with some species suspected of transmitting the poliomyelitis virus to humans (Rognes 1991).

Phumosia testacea is the sole representative of the Phumosiinae subfamily identified in the Nepalese Himalayan region. Records also confirm its presence in southern India, where observations have been made regarding the breeding of these flies within frog egg masses. An interesting aspect of their behaviour is the targeted attack on frog egg nests, with the larvae actively preying upon and consuming the developing embryos. This phenomenon was documented by Senior-White et al. (1940), shedding light on the unique ecological interactions of these flies within their habitat.

Subfamily Rhiniinae is broadly divided into two subfamilies, Cosminiinae and Rhiniinae. It is one of

Table 2. Sorensen similarity index shows similarity between different assemblages.

	Shivalik Range	Lower Himalaya	Upper Himalaya
Shivalik Range	_	0.43	0.21
Lower Himalaya		_	0.37
Upper Himalaya			_

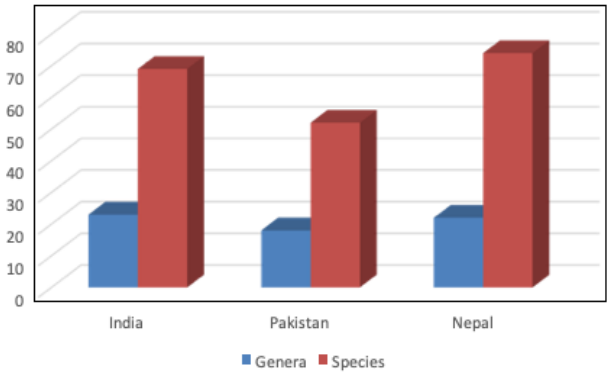

Figure 2. Total species of Calliphoridae and Polleniidae from the Himalaya.

the most diverse and widely distributed families in the Oriental region, with approximately 14 genera. The subfamily includes the genera *Borbororhinia*, *Cosmina*, *Strongyloneura, Isomyia, Metallia, Rhyncomya, Chlororhinia, Idiella, Rhinia*, and *Stomorhina* from the Nepalese, Pakistani, and Indian Himalaya. These flies are closely associated with Hymenoptera, Isoptera, and Orthoptera. Some species are predators of locust egg capsules, while others are associated with termites and ant nests (Senior-White 1940; Arce et al. 2019). The subfamily remains relatively unexplored biologically (Dear 1977).

Family Polleniidae, previously considered a part of the Calliphoridae family, has undergone a reclassification based on molecular studies and their breeding habits as parasitoids of soil-dwelling invertebrates. Molecular research conducted by Singh and Wells (2013), Winkler et al. (2015), Cerretti et al. (2017), Blaschke et al. (2018), Kutty et al. (2019), Stireman et al. (2019), and Johnston et al. (2022) has indicated their sister group relationship with Tachinidae, suggesting a phylogenetic distance from Calliphoridae. Furthermore, Cerretti et al. (2014) and Stireman et al. (2019) proposed that a non-molecular synapomorphy could be established based on their breeding habit as parasitoids of soil-dwelling invertebrates, aligning them with sister group tachinids, which also parasitize soil-dwelling insect larvae.

Table 3. List of blowfly species from Pakistan, Nepal, and Indian Himalaya.

Family	Sub-family	Species	Shivalik Range	Lower Himalaya	Upper Himalaya
Calliphoridae	Ameniinae	*Catapicephala splendens*	P	P	A
		Catapicephala pattoni	P	P	A
		Gulmargia angustisquama	A	P	P
	Bengaliinae	*Bengalia varicolor*	P	P	A
		Bengalia martinleakei	A	P	A
		Bengalia surcoufi	P	A	A
		Bengalia torosa	P	P	A
		Bengalia unicolor	A	A	P
		Bengalia emarginata	A	A	P
		Bengalia escheri	P	P	A
		Bengalia subnitida	P	P	A
		Bengalia hastativentris	P	A	A
		Termitoloemus marshalli	P	A	A
		Aldrichina grahami	A	P	A
		Calliphora chinghaiensis	A	A	P
		Calliphora himalayana	A	A	P
		Calliphora uralensis	A	A	P
		Calliphora vicina	P	P	P
		Calliphora vomitoria	P	P	P
		Calliphora loewi	A	P	P
		Calliphora pattoni	A	P	P
		Cynomyamortuorum	A	A	P
		Melinda sugiyamai	P	P	A
		Melinda scutellata	A	P	P
		Melinda abdominalis	A	P	A
		Melinda bengalensis	A	A	P
		Melinda pusilla indica	A	P	P
		Melinda nuortevae	A	A	P
		Melinda nepalica	A	A	P
		Nepalonesia pulchokii	A	P	P
		Nepalonesia shinonagai	A	P	P
		Onesia sp.	A	P	A
		Onesia kiyoshii	A	A	P
		Onesia menechmiodes	P	P	A
		Onesia flavisquama	A	P	P
		Onesia atripalpis	A	A	P
		Onesia khasiensis	A	P	A
		Onesia girii	A	P	A
		Polleniopsis sp.	A	P	A
		Polleniopsis himalayana	A	A	P
		Polleniopsis nepalica	A	P	P
		Polleniopsis pilosa	A	P	A
		Polleniopsis kasmirensis	A	A	P
		Polleniopsis pulchokii	A	A	P
	Chrysomyinae	*Chrysomya megacephala*	P	P	P
		Chrysomya albiceps	P	P	A

Family	Sub-family	Species	Shivalik Range	Lower Himalaya	Upper Himalaya
		Chrysomya nigripes	P	P	P
		Chrysomya phaonis	P	P	P
		Chrysomya pinguis	P	P	P
		Chrysomya putoria	A	P	A
		Chrysomya regalis	A	P	A
		Chrysomya rufifacies	P	P	A
		Chrysomya bezziana	P	P	A
		Chrysomya defixa	P	A	A
		Chrysomya villeneuvi	P	P	P
		Chrysomya chani	P	A	A
		Chrysomya thanomthini	A	P	P
		Protocalliphora azurea	A	P	P
		Protocalliphora maruyamensis	A	A	P
		Protocalliphora terraenovae	A	A	P
		Trypocalliphora braueri	A	A	P
	Luciliinae	*Hemipyrellia ligurriens*	P	P	A
		Hemipyrellia pulchra	P	P	P
		Lucilia cuprina	P	P	P
		Lucilia papuensis	P	P	P
		Lucilia porphyrina	P	P	P
		Lucilia sericata	P	P	P
		Lucilia ampullacea	P	P	A
		Lucilia bazini	P	A	A
		Lucilia calviceps	P	A	A
		Lucilia illustris	P	P	A
		Lucilia bismarkensis	P	P	P
		Lucilia shenyangensis	A	P	P
		Lucilia sinensis	A	P	P
	Phumosiinae	*Phumosia testacea*	A	P	A
	Rhiniinae	*Borborhinia bivitatta*	P	A	A
		Cosmina prasina	P	P	P
		Cosmina nepalica	A	P	A
		Cosmina limbipennis	P	A	A
		Isomyia aurifacies	P	A	A
		Isomyia fulvicornis	P	P	A
		Isomyia pseudoviridana	P	P	P
		Isomyia coei	P	A	A
		Isomyia electa	P	A	A
		Isomyia facialis	P	A	A
		Isomyia gomezmenori	P	P	P
		Isomyia hetauda	A	P	A
		Isomyia nepalana	P	A	A
		Isomyia oestracea	P	P	A
		Isomyia pichoni	A	P	A
		Isomyia pictifacies	P	P	A
		Isomyia shelpa	P	A	A
		Isomyia singhi	P	P	P

Family	Sub-family	Species	Shivalik Range	Lower Himalaya	Upper Himalaya
		Isomyia sivah	P	P	P
		Isomyia versicolor	P	P	A
		Isomyia delectans	P	A	A
		Isomyia viridaurea	P	A	A
		Isomyia nebulosa	P	A	A
		Metallea flavibasis	P	A	A
		Metallea setosa	P	P	P
		Metallea setiventris	A	P	A
		Rhyncomya townsendi	A	P	A
		Rhyncomya setipyga	P	P	A
		Strongyloneura prolata	P	P	A
		Chlororhina exempta	A	P	A
		Idiella divisa	P	A	A
		Rhinia apicalis	P	P	A
		Stomorhina cribrata	A	P	A
		Stomorhina discolor	P	P	P
		Stomorhina procula	P	P	P
		Stomorhina lunata	A	P	P
		Stomorhina melastoma	P	A	A
		Stomorhina xanthogaster	P	P	A
		Stomorhina luteigaster	A	A	P
Polliniidae		*Dexopollenia nigriscens*	A	A	P
		Dexopollenia testacea	A	A	P
		Moriniaargenticincta	A	P	A
		Pollenia dasypoda	A	P	P
		Pollenia pediculata	A	P	A
		Pollenia rudis	A	P	A

Presently, 147 species of Polleniidae are classified under eight genera worldwide (Cerretti et al. 2019). The genus *Pollenia* stands out as the most species-rich, with 95 representatives from Oriental, Australasian, and Palaearctic regions. *Dexopollenia* comprises 21 species, *Morinia* 13, *Melanodexia* 8, and *Xanthotryxus* 7, with *Anthracomyza* Malloch, *Alvamaja* Rognes, and *Nesodexia* Villeneuve each represented by a single species. In the Himalaya, these flies are represented by the genera *Dexopollenia, Morinia*, and *Pollenia* (Table 1). *Morinia* species primarily feed on dead decaying matter, whereas lumbricids serve as hosts and substrates for larval development in *Pollenia* species. Cluster fly larvae exclusively develop on earthworms and do not accept other food sources, although there are occasional reports of alternative hosts such as insect larvae (Yahnke & George 1972; Jewiss-Gaines et al. 2012).

Ecological diversity

Blow flies being ubiquitous seem to occur in almost all the available ecosystems on Earth. Having said so, it is also true that there is a disparity in the distribution of species regarding climate, latitude, and altitude. Like many other groups of plants and animals, blow flies show a strong latitudinal gradient in their diversity, with the highest at the equator and declining towards the poles. Similarly, altitude also has a profound effect on the richness and abundance of Calliphoridae. Generally, species diversity decreases with an increase in altitude. But, in the case of Himalayan blow flies, diversity was maximum at the mid-elevation (MDE), i.e., lower Himalaya (79 species) compared to Shivalik (64) and upper Himalayan ranges (56).

CONCLUSIONS

A comprehensive survey in the regions of Pakistan, Nepal, and the Indian Himalayas has resulted in the recording of a total of 30 genera and 120 species of blow flies. Among these regions, Pakistan exhibits 60% of the generic diversity, while the Nepalese and Indian Himalaya each contribute 70% (Figure 1).

To assess the spatial variability of environmental conditions and describe species composition along environmental gradients, the Himalayan blow fly fauna was categorised into three distinct elevation ranges: 350–1,200 m (Shivalik range, sub-tropical), 1,200–2,200 m (Lower Himalayan ranges, sub-temperate), and 2,200 m onwards (Upper Himalayan ranges, temperate) (Table 3). It's important to note that the first two elevation ranges are situated in the Oriental region, while the Upper Himalayan ranges belong to the Palaearctic region.

The evaluation of faunal similarity between these three assemblages used the incidence-based Sorensen Similarity Index (Sorensen 1948): 2a/(2a+b+c), where 'a' represents the number of shared species, 'b' the number of unique species in the first assemblage, and 'c' the number of unique species in the second assemblage. Findings indicate that the Shivalik range shares approximately 43% faunal similarity with the Lower Himalayan ranges but only about 21.42% with the Upper Himalayan ranges. Conversely, the lower and upper ranges exhibit a 37.11% similarity in their species assemblages (Table 2). Additionally, 11 genera were identified that are common to all three elevational ranges, differing only in the composition of species along different gradients in the Himalaya. The highest generic similarity was observed between the lower and upper ranges of the Himalaya, accounting for 56.6% similarity. Specifically, the genera *Morinia* and *Phumosia* were unique to the lower ranges, while *Dexopollenia, Trypocalliphora*, and *Cynomya* were unique to the upper Himalayan ranges.

These findings contribute valuable insights into the distribution and diversity of blow flies across the Himalayan region, shedding light on the unique characteristics of each elevation range.

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