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Diversity and distribution pattern of scuttle flies (Diptera: Phoridae) in India

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Abstract
A total of 67 species of the family Phoridae under 04 subfamilies belonging to the order Diptera are reported from India which is only 1.59% of total global Phorid fauna. Among 67 species, 32 species have restricted their distribution within the country. But there is no sufficient information about the specific distributional localities of 28.35% of Indian Phorids. Considering the bio-geographic zones of India, the highest number (37.31%) of scuttle flies were found in the Ghats and Peninsular regions and the least number from both the Arid- Semi Arid and Hot desert region and the Islands region (1.49%). This communication serves the consolidated report on the current status of Indian phorid fauna.

Keywords: Biodiversity, Bio-geographical Patterns, Endemism, Phoridae

1 Introduction
The family Phoridae is one of the most biologically diverse groups among brachyceran Diptera, which constitute nearly 2% of the total global animal species [1]. Phorid flies are commonly known as Coffin flies, Scuttle flies and sometimes also Hump backed flies. They are usually blackish or brownish in colour. Sometimes they appear as yellowish, orange, pale grey and pale white coloured also. Phorid flies can easily be differentiated from their closest families with their quick running behaviour, dorsal hump and long middle legs. Their ecological importance is immense for parasitic habits of immature stages and also represented as a useful tool in forensic science. Altogether, 4,202 species under 302 genera distributed throughout the world [2] and Indian phorid fauna are rich with 67 species under 18 genera of 4 sub families [3].
This present compilation of work documents the current status of phorids in India including their habit and habitats, economic importance, distributional pattern in different biogeographical and zoogeographical regions and overall the gaps in knowledge of this family which certainly help to the future researchers of Indian Phoridae.

2. History of Taxonomic Research
Probably, *Dohrniphora orientalis* Schiner, 1868 is the first Indian species, reported from the Nicobar Island. After a long period, in the early 20th century Brues [4], Schmitz [5], Brunetti [6], Senior-White [7-8], Brown [9] etc. provided their valuable contributions on this group. In 1977, Marcedes & Hardy catalogued few phorid flies from Oriental Region [10]. The contribution of Disney [11-13], Papp [14] etc. are also enriched the Indian phorid fauna by exploring several new species. Beside taxonomic work, Disney (2006), Disney & Manlove (2005), Manlove & Disney (2008), Boehme *et al.* (2010), Disney *et al.* (2014) worked on different phorid species in forensic entomology as experimental tools [15-19].
Afterwards, Mitra & Bhattacharya (2010) and Dutta Saha *et al.,* (2012) reported phorid flies from the State of Uttarakhand and Maharashtra [20-21]. Recently, Chakraborti *et al.* published a consolidated list of Indian scuttle fly [3], which enumerates 67 species belonging to 04 subfamilies (Table- 1).

Table 1: Taxonomic diversity of the family Phoridae in India

Sub Family	No. of Genera	No. of Species
Metopininae	9	43
Phorinae	5	15
Termitoxeniinae	3	8
Aenigmatiinae	1	1
	18	67

3. Distinguishing Characters
The Phoridae is generally considered as a distinctive family of the Infraorder Aschiza of the Suborder Brachycera, being placed in the superfamily Phoroidea along with the family Lonchopteridae, Opetiidae, Ironomyiidae and Platypezidae [2]. The flies are minute or small - 0.5–6 mm in length, resemble with fruit flies (Diptera: Tephritidae) in appearance, but they lack the red eye that is the classic feature of the fruit fly. When viewed from the side, there is a pronounced hump to the thorax of this phorid flies. The head is usually rounded and in some species it is narrowed towards the flat vertex. In some species the ocellar callus is engorged and raised above the surface of the vertex. The eyes are dichoptic in both the males and females (eyes of males' close-set and of females' wide-set). The wing is clear or tinge. Sometimes wings are marked. They have a distinctive reduced wing venation [12, 15].

4. Habit and Habitats
Adults show quick, jerky movement when running**.** The larvae is characterised by the presence of tapered processes on each body segment, they are either scavengers or parasitic on other insects. Usually, they found on dead animals and heavily decaying vegetation. In urban area, they are found to breed in drains, rubbish containers, dumpsters, garbage disposals, crawlspaces, and the place where moist organic matter can accumulate for few days. Few phorids are reported to feed on pollen, nectar etc. [22]. The oviposition rate of phorids is

significant, because it reflects the fitness of phorids and the behavioral effect which they exert on their host [23].

5. Economic Importance

Phoridae has been accepted as an important mediator of ant community structure. Indeed, over the past decades, there have been many studies on the impacts of phorids on ants reported [24]. Phorids are the parasites of the leaf-cutting ants, which affects foraging activity of their hosts by altering their behavioral patterns [25-26]. Parasitism is the most common behaviour of these flies and ants are reported as host of them in maximum cases. The genus *Pseudacteron* is very usual parasites on *Solenopsis* fire ants (Hymenoptera: Formicidae) [23]. Usually, they are connected with dead animals and heavily decaying vegetation, that signifies its forensic importance. Forensic Entomology uses these insects to help law enforcement to determine the cause, location and time of death of a human being also. Disney & Kurahasi [27], Singh & Rana [28], Greenberg & Well [29], Disney [30], reported these flies as forensic tools. Few species are closely associated with buried dead matters *viz. Conicera* sp. The most common species reported from buried human body is the closely related to *C. tibialis* Schmitz [13].

6. Discussion

India shares only 1.59% of global phorid fauna and among them, the states Maharashtra (20.89%) and West Bengal (19.40%) share maximum reported species followed by Karnataka (8.95%), Assam (7.46%), Meghalaya (5.97%,), Bihar (4.47%) and Kerala (2.98%). The other states and Union territories (Tamil Nadu, Himachal Pradesh, Uttarakhand, Chhattisgarh, Chandigarh, and Andaman & Nicobar Islands) share very minimum number of species (1.49%). There are also 1.49% of species which are cosmopolitan in distribution (fig. 1).

Considering the diversity of phorid fauna among six bio-geographic zones in India [31], the maximum flies have been reported from the Ghats and Peninsular regions (37.31%). In addition to, Indo-Gangetic Plains shares 16.41% followed by North-East Region (10.44%) and Himalayan region (7.46%). Both the Arid, Semi-Arid & Hot Desert and Island bio-geographic region shares 1.49% species of the total reported species in India (fig. 2).

Due to paucity of literature, this communication could not put 28.35% species under any specific states or Union territories of India. Those species are treated here as NSL (No specific locality). But a single species, *Metopina ciceri* Disney, 1988, have been reported from distinct biogeographical zones (Peninsular regions) of India. Therefore, considering the bio-geographic distribution 26.86% of total Indian phorid fauna have no specific locality. *Megaselia rupifes* (Meigen, 1804) is the only species distributed in all bio-geographic zones in India (fig. 1 and 2).

Less than 50% of the total species are restricted/Endemic to India. Moreover, considering the taxonomic and forensic importance of this dipteran family more emphasis to be given on faunal exploration throughout India and non-reported states and Union territories (Andhra Pradesh, Arunachal Pradesh, Dadra & Nagar Haveli, Daman & Diu, Delhi, Goa, Gujarat, Haryana, Jammu & Kashmir, Jharkhand, Lakshadweep, Madhya Pradesh, Manipur, Mizoram, Nagaland, Odisha, Puducherry, Punjab, Rajasthan, Sikkim, Telengana, Tripura, Uttar Pradesh) in particular.

7. Abbreviations Used

TL: Type Locality; HR: The Himalayan Region; IGP: Indo Gangetic Plains; GPR: The ghats & peninsular regions; ASHD: Arid, Semi-Arid & Hot desert region; NER: North Eastern region; NSL: No specific Locality; IS: Islands; RI: Restricted in India.

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Table 2: Distribution of species in different states and biogeographic zones of India (Biogeographical zones are classified as Alfred *et al*. [31] and binomial nomenclature are followed after Systema Dipterorum) [32]

Sl. No.	Name of the species	Distribution in India	Biogeographic Zones of India	Distribution other than India
	Subfamily: Aenigmatiinae **Genus: *Assmutherium*** Schmitz, 1924			
1.	*Assmutherium rostratum* Schimtz,1924 TL: Western Ghats, Kanara, India	Karnataka	GPR	RI
	Subfamily: Metopininae **Tribe: Metopinini** **Genus: *Apocephalus*** Coquillett, 1901 **Subgenus: *Apocephalus*** Coquillett, 1901			
2.	*Apocephalus (Apocephalus) caudatarius* Schmitz,1915 TL: Bombay (Mumbai) or nearby Khandala, India	Maharashtra	GPR	RI
	Genus: *Bolsiusia* Schmitz, 1913			
3.	*Bolsiusia termitiphila* Schmitz,1913 TL: Bombay, India	Maharashtra	GPR	RI
	Genus: *Chonocephalus* Wandolleck, 1898			
4.	*Chonocephalus collini* Disney,2002 TL: Seychelles	NSL	NSL	Thailand
5.	*Chonocephalus fletcheri* Schmitz,1912 TL: Chaumashani	Bihar, West Bengal	IGP	Thailand
6.	*Chonocephalus similis* Brues,1905 TL: Bombay: Matheran	Maharashtra	GPR	Thailand

Genus: *Megaselia* Rondani, 1856				
7.	*Megaselia apposita* Brues,1936 TL: Calian, Davao, Mindanao, Philippines	NSL	NSL	Japan, Philippines
8.	*Megaselia chlumetiae* Disney,1992 TL: Maharashtra, India	Maharashtra	GPR	RI
9.	*Megaselia curtineura* (Brues,1909) TL: Manila, Luzon,Philippines	West Bengal	IGP	Philippines, Africa, Hawai, Israel, Takao, Formosa Malaysia, Pelang, Australia, Taiwan, New Zealand
10.	*Megaselia malaisei* Beyer,1958 TL: Kambaiti, Burma	NSL	NSL	Myanmar
11.	*Megaselia (Aphiochaeta) pallicornis* (Brunetti,1912) TL: Kurseong, Darjeeling, West Bengal, India	West Bengal	HR	RI
12.	*Megaselia palpella* (Bayer,1967) TL: Palau Island (Tausnm)	NSL	NSL	Micronesia
13.	*Megaselia pleurota* Disney,1994 TL: Chandigarh, India	Chandigarh	ASHD	Indonesia
14.	*Megaselia (Megaselia)ruficornis*(Meign,1830) TL: Europe	NSL	NSL	Russia: Kuril Islands, Estonia, Western Europe, Madeira, Canary, North America.
15.	*Megaselia rupifes* (Meign,1804) TL: Europe	Cosmopolitan	Cosmopolitan	Europe, Michigan Arab, Atlantic Islands, Canary Islands.
16.	*Megaselia rutilipes* Beyer,1958 TL: Kambaiti, Burma	NSL	NSL	Myanmar
17.	*Megaselia sandhui* Disney,1981 TL: India	NSL	NSL	RI
18.	*Megaselia (Megaselia) scalaris* (Loew,1866)TL: Manila, Luzon, Philippines	Assam, West Bengal	NER, IGP	Sri Lanka, Philippines, Java, Subtropics & Tropic region of World, Saudi Arabia
19.	*Megaselia tamilnaduensis* Disney,1995 TL: Tamil Nadu, India	Tamil Nadu	GPR	South Africa
20.	*Megaselia (Megaselia) tetricifrons* Beyer,1967 TL: Bonin Island (T F USNM)	NSL	NSL	Micronesia, Japan: Bonin Island
21.	*Megaselia (Aphiochaeta) apicalis* (Brues,1905) TL: Bombay, India.	Maharashtra	GPR	RI
22.	*Megaselia approximate* (Brunetti,1912) TL: Calcutta (Kolkata), West Bengal	West Bengal	IGP	RI
23.	*Megaselia flavifacies* (Brunetti,1912) TL: Calcutta (Kolkata), West Bengal	West Bengal	IGP	RI
24.	*Megaselia (Aphiochaeta) flavifacioides* (Senior-white,1922) TL: Charrapunji, Khasi Hills, Assam	Assam, Meghalaya	NER	RI
25.	*Megaselia (Aphiochaeta) inaequalis* (Brunetti,1912) TL: Thamaspur, Nepal	NSL	NSL	Nepal (Thamaspur)
26	*Megaselia (Aphiochaeta) latifasciata* (Brunetti,1912) TL: Sylhet, East Pakistan and Madhupur, West Bengal, India	Bihar, West Bengal	IGP	East Pakistan, Sylhet
27.	*Megaselia (Aphiochaeta) pseudoscalaris* (Senior-White,1922) TL: Banhar, North Bihar, India	Bihar, Chhattisgarh	IGP,GPR	Sri Lanka
28.	*Megaselia (Aphiochaeta) tibialis* (Brues,1905) TL: Madheran, India	Maharashtra	GPR	RI
29.	*Megaselia (Aphiochaeta) trilineata* (Brunetti,1912) TL: Calcutta (Kolkata), West Bengal, India	West Bengal	IGP	RI
Genus: *Metopina* Macquart, 1835				
30.	*Metopina ciceri* Disney,1988 TL: India	(Peninsular region) NSL	GPR	Nearctic region
Genus: *Phalacrotophora* Enderlein, 1912 **Subgenus: *Omapanta*** Schmitz,1932				
31.	*Phaacrotophora (Omapanta) indiana* Colyer,1961 TL: India	NSL	NSL	RI
32.	*Phalacrotophora (Omapanta) marginata* (Brunetti,1912) TL: Tenmalai, Travencore, India	Kerala	GPR	RI
Genus: *Puliciphora* Dahl, 1897				
33.	*Puliciphora anceps* Scmitz,1915 TL: Navoor, Western Ghats, East Mangalore (Bangalore), India	Karnataka	GPR	RI
34.	*Puliciphora borinquenensis* Wheeler,1906 TL: Puerto Rico. Utuado, Utudas	NSL	NSL	(NT:NT:AF:AF:AU:OR) South Africa
35.	*Puliciphora matheranensis* Brues,1907 TL: Matheran, India	Maharashtra	GPR	RI
36.	*Puliciphora termitum* Schmitz,1926 TL: Haldwani, Kumaon, India	Uttarakhand	HR	RI

37.	*Puliciphora velocipes* (Schmitz,1913) TL: Khandala, Bombay (Mumbai), India	Maharashtra	GPR	RI
Genus: *Rhynchomicropteron* Annandale, 1912				
38.	*Rhynchomicropteron brevipes* Papp,1982 TL: India	Meghalaya	NER	RI
39.	*Rhynchomicropteron caucutiens* Schmitz,1914 TL: Bombay (Mumbai), India	Maharashtra	GPR	RI
40.	*Rhynchomicropteron dudichi* Papp,1982 TL: India	West Bengal	IGP	RI
41.	*Rhynchomicropteron nudicosta* (Brues,1907) TL: Bombay (Mumbai), Matheran, India	Maharashtra	GPR	RI
42.	*Rhynchomicropteron nudiventer* Papp,1982 TL: India	Meghalaya	NER	Hungary, Thailand.
43.	*Rhynchomicropteron puliciforme* Annandale,1912 TL: Perandeniya, Kandy district, Ceylon	NSL	NSL	Sri Lanka (Perandeniya, Kandy District)
Genus: *Woodiphora* Schmitz, 1925 **Sub genus: *Triemisticha*** Schmitz, 1925				
44.	*Woodiphora (Triemisticha) limbata* (Brues,1905) TL: Madheran, India	Maharashtra	GPR	Seychelles
Subfamily: Phorinae **Genus: *Conicera*** Meigen, 1830				
45.	*Conicera kempi* Brunetti,1924 TL: Siju Cave, Garo Hills, Assam, India	Meghalaya, Assam	NER	RI
Genus: *Diplonevra* Lioy, 1864				
46.	*Diplonevra assmunthi* Schmitz,1915 TL: Namunikuli, Ceylon	Maharashtra	GPR	Cosmopolitan
47.	*Diplonevra basalis* Brunetti,1912 TL: India	Assam	NER	Cosmopolitan
48.	*Diplonevra rufithorax* Brunetti,1912 TL: India	NSL	NSL	Cosmopolitan
Subgenus: *Tristoechia* Schmitz, 1927				
49.	*Diplonevra (Tristoechia)bifasciata* (Walker,1860) TL: Makasar, Celebes	Assam	NER	East Asia, Japan, Taiwan
Genus: *Dohrniphora* Dahl, 1898				
50.	*Dohrniphora aequididtans* Brunetti,1912 TL: Kurseong, Darjeeling, West Bengal, India	West Bengal	HR	RI
51.	*Dohrniphora cornuta* (Bignot1857) TL: Cuba	West Bengal	IGP	Formosa, Philippines (Samar), Cuba, Cosmopolitan, Michigan.
52.	*Dohrniphora geetae* (Disney,2001) TL: Bangalore, Mysore road, India	Karnataka	GPR	RI
53	*Dohrniphora indiae* Disney,2001 TL: Calcutta (Kolkata), West Bengal, India	West Bengal	IGP	RI
54	*Dohrniphora orientalis* Schiner,1868 TL: Condue, Nicobars, India	Andaman & Nicobar Island	IS	RI
55	*Dohrniphora transformata* Schimtz,1915 TL: Malwadi, Mysore, Western Ghats, India	Karnataka	GPR	Sumatra
56	*Dohrniphora vorax* Schimtz,1915 TL: Navoor, Western Ghats, India	Karnataka	GPR	PNG, Sulawesi, Sumatra
Genus: *Hypocera* Lioy, 1864				
57	*Hypocera marginata* Brunetti,1912 TL: Travancore, Tenmalai, India	Kerala	GPR	RI
Genus: *Phora* Latreille, 1796				
58	*Phora bullata* Schmitz,1927 TL: Finland	NSL	NSL	England
59	*Phora himachalensis* Mostovski,2002 TL: Himachal Pradesh, India	Himachal Pradesh	HR	RI
Subfamily: Termitoxeniinae **Genus: *Ceylonoxenia*** Schmitz, 1936				
60	*Ceylonoxenia bugnioni* (Wasmann,1913) TL: Ambalangoda, Ceylon	NSL	NSL	Sri Lanka
61	*Ceylonoxenia butteli* (Wasmann,1913) TL: Ceylon	NSL	NSL	Sri Lanka
62	*Ceylonoxenia flavescenes* Schmitz,1938 TL: India	NSL	NSL	Java
63	*Ceylonoxenia heimi* (Wasmann,1902) TL: Ahmednagar, East India	Maharashtra	GPR	RI

64	*Ceylonoxenia wasmanni* Schmitz,1938 TL: India	NSL	NSL	RI
Genus: *Clitelloxenia* Kemner, 1932				
65	*Cllitelloxenia assmuthi* (Wasmann,1902) TL: Khandala, India	Maharashtra	GPR	Sri Lanka, Malaysia, Java
66	*Clitelloxenia marshali* Schmitz,1938 TL: India	Karnataka	GPR	RI
Genus: *Termitosphaera* Wasmann, 1913				
67	*Termitosphaera fletcheri* (Wasmann,1913) TL: Bankura, West Bengal, India	West Bengal	IGP	Myanmar

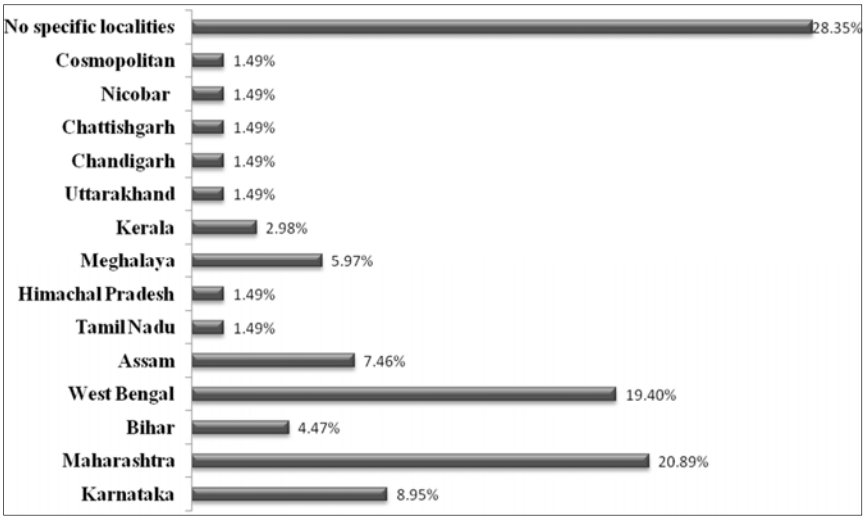

Fig 1: State wise percentage of reported species of Phoridae from India

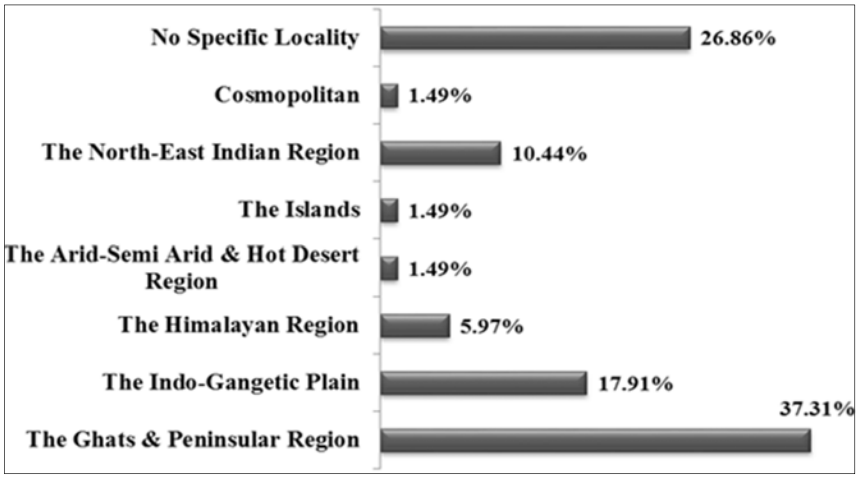

Fig 2: Percentage in different Bio-geographic zones of India

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