REVIEW ARTICLE

A Current Status on Diversity and Distribution of Black Flies (Insecta: Diptera: Simuliidae) in India

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Introduction:

Simuliidae, or black flies, under the infra-order Culicomorpha of the suborder Nematocera are a group of dipteran flies (Pape *et al.*, 2011) which are well known for being an annoyance to the man and animals of different regions. This group of insects are belonged to the aquatic insect communities and also play a role as detritivores in lotic ecosystems (Cummins, 1987). These flies are ideal organisms to understand species richness of aquatic insects. A total of 2219 species under 26 genera of Simuliidae have been reported from the World (Adler & Crosskey, 2016). Mitra & Sharma (2010) published a checklist of Indian simuliid where they mentioned a list of 67 species, among which 11 species were mentioned up to genus level. Till date, there is no consolidated list of Simuliidae reported from India. Present communication is a compilation of work based on recent classification and valid nomenclature followed after Systema Dipteriorum (Pape and Thomson, 2013) and World Catalogue of Simuliidae (Adler & Crosskey, 2016) and others available literature along with its distribution in states and union territories of India. Altogether, 69 species belonging to eight subgenera and a single genus reported so far, which includes only valid species reported from India (Table - 1).

History of taxonomic research:

Probably, Latreille is the first man who described the type genus *Simulium* in the year 1802. Later, Meigen (1818) made it a well-defined group and finally the family named Simuliidae was designated with a single genus by Newman (1834). As far knowledge goes, Becher (1885) was the first person who described a species of Simuliidae from India. Afterward, several workers like Brunetti (1911), Senior-

Abstract

Till date a total of 69 species of eight sub-genera under one genus belonging to the family Simuliidae of the order Diptera are reported from India, which is 3.11% of the total world extant simuliid fauna. Among these, 30.43% species are restricted to India. Out of 36 states and union territories of India, simuliids are reported only from 20 states and UTs. Highest numbers of species are reported from the Himalayan biogeographic zone (68.11%) and lowest in Indo-Gangetic plains (5.79%). So far, nothing has been known from Islands biogeographic zone.

White (1922a,b); Edwards (1927); Puri (1932 a,b,c,d,e); Puri (1933 a,b,c) contributed new species in the Indian simuliid fauna. Datta (1973; 1974; 1975; 1985), Datta & Pal (1975) also studied the Indian simuliid fauna and described several species from this country. In addition to, Datta (1983) reviewed the family Simuliidae of Oriental Region. Recently, Takaoka & Somboon (2008); Takaoka *et al.*, (2010; 2011); Anbalagan (2014; 2015 a,b) described several species of Simuliidae from India. Several new distributional records of Indian simuliids have been reported by Datta (1978; 1985; 1992; 1997), Henry *et al.* (2011), Shrestha & Takaoka (2009); Mitra *et al.* (2006); Dutta Saha *et al.* (2012).

Distinguishing characters:

Adults are usually small, dark coloured flies with a short horn-like antenna (generally 11-segmented) and short mouthparts. Mandibles and maxilla are usually armed with teeth and adapted for blood sucking. Thorax is remarkably arched. Wings are broad, three anterior veins are more prominent than the posterior vein. The mature larva is more or less 6 mm long, cylindrical and swollen posteriorly. There is a pair of dark spots laterally and a proleg ventrally in the thoracic region. (Datta, 1980)

Habit and habitats:

The members of this family were found most abundantly in hilly terrain with watercourses like water channels, streams, nearby areas of the river etc. Actually, these areas are most common for their breeding (Datta, 1980). Females usually lay eggs in the vegetation (whatever it may live or dead), rocks or other suitable submerged substrate (Datta *et al.*, 1975). After emerging from the pupae they

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usually used to fly near the water bodies. Most of the species of the simuliid flies appear to mate in the mid-air and sheltered near the bushes and tree tops. (Datta, 1980). These flies are with sucking type of mouthparts as these are adapted to blood sucking of several animals and human.

Biology and economic importance:

Black flies are one of the most common and important groups of insects with medical and economic importance. Black flies have the symbiotic relations with the fungi of the class Trichomycetes, and common in the larvae as the larvae also shows symbiotic relations. Even in Africa, many larvae show phoratic relations with small crabs. These worms (which) can be seen in the fly's body appearing like a loop (Upton, 2005; Adler, 2003; Azevedo, 2006). The simuliids are economically important as the females of most of the species are haematophagous and their habit of blood-feeding is closely related to the transmission of certain diseases like human and non-human onchocerciasis, leucocytozoonosis, avian trypanosomiasis, rabbit myxomatosis in different parts of the world (Fallis, 1964). Though in India, several records of biting of black flies were reported (Lewis, 1974; Datta & Dasgupta, 1975) but there was no direct evidence of disease transmission (Datta, 1980). Itching and localized swelling and inflammation are very common responses that occur at the site of a bite.

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

Table-1: Distribution of species in different states and biogeographic zones of India

[Biogeographical zones are classified as Alfred *et al.*, 2001]

Sl.	Name of the species	Distribution in India B.Z.India*	Distribution outside India
1.	<i>Simulium (Eusimulium) aureum</i> Fries, 1824 TL: Sweden. Scania: Esperod & Bjornstorp	Jammu & Kashmir, Himachal Pradesh HR	Eurasia, Iceland, China, Sweden, Austria, Latvia, Belarus, Belgium, Italy, Britain, Czech Republic, Denmark, Estonia, Japan, Finland, France, Pakistan, Germany, Iceland, Ireland, Lithuania, Russia, Norway, Romania Netherlands, Poland, Siberia, Slovakia, Spain, Sweden, Switzerland, Ukraine, Bulgaria, Uzbekistan, Kazakhstan, Guizhou, China
2.	<i>Simulium (Eusimulium) weiningense</i> Chen & Zhang, 1997; TL: China. Guizhou: Weining	W. Bengal HR	
3.	<i>Simulium (Gomphostilbia) bucolicum</i> Datta, 1975; TL: Sonai Rupai Forest	Assam NER	Nepal
4.	<i>Simulium (Gomphostilbia) fidum</i> Datta, 1975; TL: Assam: Sonai Rupai Forest	Assam NER	Restricted within India
5.	<i>Simulium (Gomphostilbia) litoreum</i> Datta, 1975; TL: Assam: Sonai Rupai Forest	Assam NER	Restricted within India
6.	<i>Simulium (Gomphostilbia) pattoni</i> Senior-white, 1922 TL: Madras: Coonoor (HT A BMNH)	Tamil Nadu GPR	China, Sri Lanka
7.	<i>Simulium (Gomphostilbia) unum</i> Datta, 1975; TL: Assam: Sonai Rupai Forest	Assam NER	Restricted within India
8.	<i>Simulium (Gomphostilbia) darjeelingense</i> Datta, 1973; TL: W. Bengal, Lebong	W. Bengal, Arunachal P., Assam. HR, NER	Nepal
9.	<i>Simulium (Gomphostilbia) metatarsale</i> Brunetti, 1911 TL: Kurseong, E.Himalaya	W. Bengal, Sikkim HR	China, Taiwan [West Malaysia, Indonesia (Java)]
10.	<i>Simulium (Gomphostilbia) tenuistylum</i> Datta, 1973; TL: W.Bengal, Lebong	W. Bengal, Sikkim, Assam, Arunachal P. HR, NER	Restricted within India
11.	<i>Simulium (Montisimulium) dasguptai</i> Datta, 1974; TL: W. Bengal, Darjeeling	W. Bengal HR	China (Sichuan)
12.	<i>Simulium (Montisimulium) dattai</i> Takaoka & Somboon, 2008; TL: W. Bengal	West Bengal HR	Bhutan, Nepal
13.	<i>Simulium (Montisimulium) ghoomense</i> Dutta, 1973; TL: India, W.Bengal, Darjeeling	West Bengal HR	China (Tibet)
14.	<i>Simulium (Montisimulium) nemorivagum</i> Datta, 1973 TL: W.Bengal, Darjeeling	West Bengal, Arunachal P. HR, NER	Bhutan, China (Tibet), Nepal, Pakistan
15.	<i>Simulium (Montisimulium) yuntaiense</i> Chen, Wen & Wei, 2006; TL: China	West Bengal HR	China (Henan)

16. *Simulium (Nevermannia) praelargum* Datta, 1973; TL: W.Bengal, Darjeeling West Bengal China (Tibet), Nepal **HR**
17. *Simulium (Nevermannia) rufithorax* Brunetti, 1911; TL: W.Bengal, Darjeeling, Kurseong Karnataka, Restricted within India Maharashtra, W. Bengal **HR, GPR**
18. *Simulium (Nevermannia) senile* Brunetti, 1911; TL: Simla: Phagu Himachal Pradesh Restricted within India **HR**
19. *Simulium (Nevermannia) aureohirtum* Brunetti, 1911 TL: Umling, Meghalaya Assam, Nepal, Pakistan, Arunachal P. Philippines(Bohol, Luzon, Himachal P. Mindanao, Negros, Karnataka, Palawan,Panay),Sri Lanka Maharashtra Taiwan, Thailand, Guam, Meghalaya, Vietnam, Bhutan, Borneo Manipur, China (Fu,Gd,Gu,Hainan, Mizoram, Macao, HK, Si, Tibet, Yu), Tamil Nadu, Indonesia (Flores, Java, West Bengal, Kalimantan, Sulawesi, Haryana **NE, GPR, HR, ASHD** Maluku,Sumatra), Japan (Hon,Ky, NI,Sh), Malaysia (Malaya, Sabah,Sarawak)
20. *Simulium (Nevermannia) gracilis* Datta, 1973; TL: W.Bengal, Darjeeling West Bengal China (Tibet), Nepal **HR**
21. *Simulium (Nevermannia) puri* Datta, 1973; TL: W.Bengal, Darjeeling West Bengal China (Tibet), Nepal **HR**
22. *Simulium (Tetisimulium) stevensoni* Edwards, 1927 TL: Jammu & Kashmir: Chillas, Gilgit(LTA BMNH) Jammu and Pakistan Kashmir **HR**
23. *Simulium (Simulium) ephemerophilum* Rubstov, 1947; TL: Tajikistan. Hissar Himachal P. Pakistan, Central Asia, Tajikistan, Uzbekistan, Kyrgyzsthan, Pakistan **HR**
24. *Simulium (Simulium) rashidi* Lewis, 1973; TL: Pakistan. Bahrain (HT A BMNH) Himachal P. Pakistan **HR**
25. *Simulium (Simulium) graveli* Puri, 1933; TL: India. Madras: Kodaikanal, Palmi Hills, Law's Ghat, Silver Cascades (4ABMNH) Tamil Nadu China (Tibet) **GPR**
26. *Simulium (Simulium) griseifrons* Brunetti, 1911; TL: Uttar P.: Kumaon, Kalighat (Uttarakhand) Himachal P., Malaya, Thailand, Jammu & China (Tibet), Pakistan Kashmir , Uttarakhand **HR**
27. *Simulium (Himalayum) indicum* Becher 1885; TL: Assam Assam, Afghanistan, Myanmar, Arunachal P., Bangladesh, Bhutan, Himachal P., China (Tibet), Myanmar, Jammu & Nepal, Pakistan (Jammu Kashmir, & Kashmir), Siam, Karnataka, Thailand Maharashtra, Manipur, Meghalaya, Nagaland, Sikkim, Uttar P., W. Bengal. **NER, HR, GPR, IGP**
28. *Simulium (Simulium) tenuitarsus* Puri, 1933 TL: West Bengal: Bengal, Terai, Marianbarie West Bengal Restricted within India **HR**
29. *Simulium (Simulium) hirtipannus* Puri, 1932 TL: Assam: Manipur , Imphal Manipur, China (Fu, Gu, Tibet) Assam, W. Bengal **NER, HR**
30. *Simulium (Simulium) barraudi* Puri, 1932; TL: India. Jammu & Kashmir: Prang & Nara-Nag (ST A BMNH) Himachal P., China (Tibet), Pakistan Jammu & Kashmir **HR**
31. *Simulium (Simulium) dentatum* Puri, 1932; TL: W.Bengal: Darjeeling, Kurseong & Tarai, Marianbarie (2A BMNH) Assam, Bhutan, China (Tibet) Meghalaya, Sikkim, W. Bengal **NER, HR**
32. *Simulium (Simulium) digitatum* Puri, 1932; TL: Himachal Pradesh: Chhota Simla & Chadwick Falls; Punjab: Kasauli & Dagshai Himachal P., China (Gd, Tibet) Punjab **HR, ASHD**
33. *Simulium (Simulium) lineothorax* Puri, 1932; TL: Assam: Cachar, Haflong (2 A BMNH) Assam, Restricted within India Tamil Nadu **NER, GPR**
34. *Simulium (Simulium) novolineatum* Puri, 1933; TL: W. Bengal: Terai Bengal, Marianbarie Arunachal P., Burma Assam, Uttar Karnataka, W. Bengal, Uttarakhand **NER, IGP, GPR, HR**
35. *Simulium (Simulium) asishi* Datta, 1985; TL: Jalpaiguri, Terai W. Bengal Restricted within India **HR**
36. *Simulium (Simulium) nodosum* Puri, 1933; TL: Mysore: Coorg, Cauvery River, Frazerpet Karnataka, China (Fu, Hainan, HK, Assam, W. Tibet, Yu), Thailand, Bengal,**NER**, Vietnam **GPR,HR**
37. *Simulium (Simulium) adventicium* Datta, 1985; TL: Shalimar, Srinagar, Jammu & Kashmir Himachal P., Restricted within India Jammu & Kashmir **HR**
38. *Simulium (Simulium) consimile* Puri, 1932 TL: Punjab: Ambala, Chandigarh (2A BMNH) Himachal P., Pakistan, Sri Lanka Punjab **HR, ASHD**
39. *Simulium (Simulium) grisescens* Brunetti, 1911; TL: W.Bengal: Darjeeling, Kurseong W. Bengal, Bhutan, Pakistan, Arunachal P., Taiwan Assam, Kerala, Himachal P., Karnataka, Maharashtra, Meghalaya, Manipur, Nagaland, Punjab, Tamil Nadu. **NER, HR, GPR,ASHD**
40. *Simulium (Simulium) kapuri* Datta, 1975; TL: Assam:Sonai Rupai Forest Assam, Restricted within India W. Bengal **NER, HR**
41. *Simulium (Simulium) pallidum* Puri, 1932; TL: Punjab: Kasauli (5A BMNH) Punjab, Pakistan Himachal P., **ASHD, HR**
42. *Simulium (Simulium) palmatum* Puri, 1932; Maharashtra, Restricted within India Karnataka,

- TL: Maharashtra: Bombay, Savantvadi (4 A BMNH)
43. *Simulium (Simulium) striatum* Brunetti, 1912; TL: Sri Lanka:Peradeniya
44. *Simulium (Simulium) biforminiferum* Datta, 1974; TL: W. Bengal, Darjeeling
45. *Simulium (Simulium) nigrifacies* Datta, 1974; TL: W.Bengal, Darjeeling
46. *Simulium (Simulium) nitidithorax* Puri, 1932; TL: India, W. Bengal: Terai, Marianbarie (3 A BMNH)
47. *Simulium (Simulium) ramosum* Puri, 1932; TL: Simla (2A BMNH)
48. *Simulium (Simulium) rufibasis* Brunetti, 1911; TL: Kurseong, Darjeeling
49. *Simulium (Simulium) gurneyae* Senior-White, 1922; TL: Madras: Coonoor (HT A BMNH)
50. *Simulium (Simulium) himalayense* Puri, 1932; TL: Simla (8 A BMNH)
51. *Simulium (Simulium) nilgircum* Puri, 1932; TL: Madras: Coonoor, (1 A BMNH)
52. *Simulium (Simulium) christophersi* Puri, 1932; TL: Jammu & Kashmir: Nara-Nag (4 A BMNH)
53. *Simulium (Simulium) howletti* Puri, 1932; TL: Bihar: Pusa
54. *Simulium (Simulium) palniense* Puri, 1932; TL: Madras:Kodaikanal, (5A BMNH)
55. *Simulium (Simulium) singtamense* Datta & Pal, 1975; TL: W.Bengal: Darjeeling,
56. *Simulium (Wilhelmia) pseudequinum* Seguy, 1921; TL: Canary Is. Punjab
- Kerala **GRP**
- Karnataka, Sri Lanka, Bhutan
- Kerala,Assam
- Maharashtra, Tamil nadu, **GPR, NER**
- W. Bengal **HR**
- Bhutan
- Karnataka, China (Tibet)
- Kerala, Andhra P., Tamil nadu, W. Bengal **GPR, HR**
- Arunachal P., China (Fu, Hainan, W. Bengal **NER, HR**
- Tibet), Malaysia
- Himachal P., Nepal, Pakistan, Bhutan, W. Bengal **HR**
- Thailand
- Arunachal P., China, Japan, Korea
- Himachal P., (South), Ryukyu islands, Meghalaya, Nepal, Pakistan, Taiwan, Manipur, Thailand, Vietnam
- Sikkim, W. Bengal, Assam **NER, HR**
- Karnataka, Restricted within India
- Maharashtra, Tamil Nadu **GPR**
- Arunachal P., China (Tibet), Nepal, Assam, Bihar **NER, HR, IGP**
- Himachal P., Manipur, Sikkim, W. Bengal. **NER, HR, IGP**
- Tamil Nadu Sri Lanka **GPR**
- Himachal P., China (Tibet)
- Jammu & Kashmir, Assam, Arunachal P. **HR, NER**
- Bihar **IGP**
- China (Tibet)
- Tamil Nadu **GPR**
- NSL
- W.Bengal **HR**
- Nepal
- Jammu & Kashmir, **HR, ASHD**
- Canary Islands (Gran Canaria, Gomera, Tenerife),Algeria, Austria, Armenia, Iran,
- Cyprus, France, Greece,
- Iraq, Azerbaijan, Bosnia, Britain,China (Sx, Xi),
- Georgia,Israel,Italy (incl. Sardinia, Sicily),Jordan, Kazakhstan, Kyrgyzstan, Lebanon, Libya, Serbia, Macedonia, Morocco, Pakistan, Spain, Portugal, Romania, Turkey, Russia (Caucasus),Slovakia, Slovenia,Tajikistan, Tunisia, Turkmenistan, Ukraine (incl. Crimea), Uzbekistan,Czech Repub.
- Arunachal P., Malaysia, Thailand
- NER**
- Assam **NER**
- Indonesia (Java,Sumatra), Malaysia (Malaya, Sabah, Sarawak), Thailand
- Kerala **GPR**
- Restricted within India
- Kerala **GPR**
- Restricted within India
- W. Bengal **HR**
- Nepal
- W. Bengal **HR**
- Restricted within India
- Arunachal P., Thailand **NER**
- Karnataka **GPR**
- Restricted within India
- W. Bengal **HR**
- Restricted within India
- Kerala **GPR**
- Restricted within India
- Tamil Nadu **GPR**
- Restricted within India
- Jammu & Kashmir **HR**
- Tajikistan, Kyrgyzstan
- Arunachal P., China, Japan, Korea, Myanmar,Nepal,Pakistan Taiwan, Thailand
- NER**

Abbreviation used: TL: Type Locality, **HR**: Himalayan Region; **IGP**: Indo Gangetic Plains; **GPR**: Ghats & peninsular regions; **ASHD**: Arid, Semi-Arid & Hot desert region; **NER**: North Eastern region; **NSL**: No specific Locality, IS: Islands, P.: Pradesh

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Discussion:

The present communication provides a list of 69 species (3.11% of total world simuliid fauna) belonging to eight sub-genera and a single genus in comparison to the total number of species of Simuliidae (2219 species) found worldwide. As per the present data the simuliids are recorded from 20 out of 36 states of India. Of them, West Bengal represents maximum number of Simuliidae about (47.82%), followed by Assam (28.98%), Himachal Pradesh (24.63%), Arunachal Pradesh (20.28%), Karnataka (15.94%) and Tamil Nadu (15.94%), Jammu & Kashmir (13.04%), Kerala and Maharashtra (each with 10.14%), Manipur and Sikkim (each with 8.69%), Punjab and Meghalaya (each with 7.24%). Bihar, Uttar Pradesh, Uttarakhand, Nagaland and Andhra Pradesh (each with 2.89%). Besides this, Haryana and Mizoram each shared 1.44% of the Simuliidae of India (Table 1, Fig. 1). Out of these 69 simuliid species, 20 species have restricted their distribution within India. Among the six major biogeographic zones of India (Alfred *et al.*, 2001), the maximum number of species (68.11%) are reported from the Himalayan regions, followed by North-eastern Regions (36.23% species), Ghats & Peninsular regions (28.98% species), Arid-Semiarid & hot desert regions (8.69% species), Indo-gangetic plains (5.79% species). Nothing has been known from Islands biogeographical zone (Fig.-2). Present document aims to generate up to date distribution data of Indian simuliids. The number of simuliid species in West Bengal is maximum due to extensive survey in this state that has been made by the scientists of ZSI, Kolkata. On the other hand, under explored states are having less number of species. Similarly, more species of this family were reported from the Himalayan region due to more survey and explorations have been made in Himalayan region by both the British taxonomists and Indians as well. Therefore, it is an urgent need to explore every corners of India which may lead discoveries of several new species/new records.

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