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Faunal richness and checklist of sandflies (Diptera: Pyschodidae) in India

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ABSTRACT

This review aims to fill the voids and to update the checklist of sandfly fauna along with its spatial distribution in India. Resource databases *i.e.* either online or offline were searched to deduce the information to systematize the Indian sandfly fauna. Articles/data retrieved were screened and analysed to further update the available latest checklist. The species name and authorship were given in accord with the International Code for Zoological Nomenclature. We compiled an updated checklist of reported Indian sandfly species along with their state-wise distribution till 2022 as per published literature. Kerala has maximum number of species reports when compared to other endemic states and states with pockets of transmission. *Phlebotomus argentipes* is the most widely distributed, recorded so far, followed by other *Sergentomyia* and *Phlebotomus* species in India. In this review, we have also described the vector and non-vector species of sandfly prevalent in different parts of the country. *Phlebotoiella eoindianensis*, an amber fossil sandfly species recorded from Gujarat might be older than other records of Indian sandfly fauna. So far 69 species (4 genera and 15 subgenera/groups) of Phlebotomine sandflies have been recorded in India. Proper knowledge of species diversity and its distribution is a prerequisite for planning a systematic vector control strategy and disease management.

KEYWORDS: Indian sandfly fauna; Checklist; Phlebotomine sandflies

1. Introduction

Sandflies (Diptera: Psychodidae) are the exclusive vectors of protozoan parasites, and *Leishmania* (Kinetoplastida: Trypanosomatidae) causes different types of leishmaniasis

throughout the globe[1]. They are also involved in the transmission of some bacterial and arboviral infections such as the chandipura virus[2]. Globally, over 800 sandfly species have been recorded so far from different climatic regions ranging from tropical and temperate to arid habitats[3]. As per the widely accepted classification, these species are grouped under four genera in the old world namely, *Phlebotomus* (P.), *Sergentomyia* (S.), *Grassomyia* (G.), and *Chinius*, and three genera in the New world *viz*; *Lutzomyia*, *Bumptomya*, and *Warileya*[1,4,5].

Taxonomic description of the Indian sandfly fauna was initiated in the early 20th century with the identification of *P. argentipes* by Annandale and Brunetti[6]. For the next 7 decades, many new species were morphologically identified and added to Indian faunal richness. Subsequently, a checklist and the spatial distribution status of the recorded sandfly species prevalent in the Oriental region was documented by Lewis in 1978[7]. Further, additional species like *S. cherukara*, *S. kottamala*, and *S. varghesei* were added to the list in mid-1990s from the southern Western Ghats region by Kaul[8]. An in-depth survey of sandflies in the epidemiologically active zones and leishmaniasis non-endemic regions of the country revealed new species like *S. monticola*[9]. This investigation brought in some crucial findings on the biodiversity and spatiotemporal distribution of sandflies from the Western Ghats, India[10].

In India, visceral leishmaniasis or ‘Kala-azar’ is known to be

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endemic for centuries and its current annual contribution to the global burden of visceral leishmaniasis is nearly 90%, along with other endemic countries like Brazil, Sudan, Bangladesh, Ethiopia, Nepal, and South Sudan[11]. The first records of indigenous visceral leishmaniasis symptomatic patients with enlarged liver and spleen with intermittent fever was reported from Bengal[12]. The abundance of vector species and the presence of reservoir hosts are an important factor for the potential transmission of parasite in the country[13,14]. *P. papatasi* and *P. argentipes* are the 2 proven vectors of *Leishmania* parasites in the Indian subcontinent[15–17]. The natural infections of *P. argentipes* populations with *L. donovani* in the epidemiologically active zones of Kerala incriminated this species as the vector of both visceral leishmaniasis and atypical cutaneous leishmaniasis[19–21].

Among the four genera recorded in India, *Sergentomyia* have more species richness and abundance[22,23]. Considering the expanding zone of leishmaniasis and their transmission potential for *Phleboviruses* and *Bartonella* species, many studies have been performed to report the sandfly diversity in the country and the catalogue is still expanding[9,24–30]. However, a proper understanding of the current diversity and distribution of these medically important insects is lacking. Here, we attempted to fill this lacuna, by compiling the current checklist of sandflies, with their spatial distribution status in India.

2. Materials and methods

Information was collected from online and offline resource databases (PubMed, Semantic Scholar, ResearchGate, Google Scholar, J-Gate etc.) i.e. published materials, standard morphological identification key books, and collated data from ICMR- Vector Control Research Centre's work on sand fly taxonomy until 2022. Online articles were searched using the phrase "sandflies (AND) india", "sandflies (AND) indian state name" e.g. Kerala or Bihar, etc. in the PubMed NCBI platform. Whereas, web-based search was done using the phrases "sandflies in India" and "sandflies in Indian state name" e.g. Kerala or Bihar, etc. cross or back references from the published material were also searched for any new information. All the articles retrieved were screened for sandfly species report or diversity in India first via abstract and then full article. Articles with relevant information were used further for detailed analysis and updating the checklist. The authorship of generic and species names is provided in the checklist in accordance with the International Code for Zoological Nomenclature. The sandfly species data collected via this review is a continuation and update of the list published by Ilango in 2009.

Table 1. Sandfly species of Psychodidae family recorded in India.

Genus	Subgenus	Species
<i>Grassomyia</i>	<i>Grassomyia</i>	1. <i>indica</i> Theodor, 1931
<i>Phlebotoiella</i>	–	2. <i>eoindianensis</i> Solarzano Kraemer & Wagner, 2009
<i>Phlebotomus</i>	<i>Adlerius</i>	3. <i>hindustanicus</i> Theodor, 1958
		4. <i>longiductus</i> Parrot, 1928
	<i>Anaphlebotomus</i>	5. <i>chiyankiensis</i> N.S. Singh, Doris Phillips Singh and IPE M. IPE, 2009
		6. <i>colabaensis</i> Young and Chalam, 1927
		7. <i>hoepflii</i> Tang and Maa, 1945
		8. <i>palamaensis</i> N.S. Singh, Doris Phillips Singh and IPE M. IPE, 2007
		9. <i>stantoni</i> Newstead, 1914
	<i>Euphlebotomus</i>	10. <i>argentipes</i> Annandale and Brunetti, 1908
	<i>Idiophlebotomus</i>	11. <i>tubifer</i> Lewis and Lane, 1976
	<i>Kasaulius</i>	12. <i>newsteadii</i> Sinton, 1926
	<i>Larrousius</i>	13. <i>kandelakii burneyi</i> Lewis, 1967
		14. <i>major</i> Annandale, 1910
	<i>Paraphlebotomus</i>	15. <i>alexandri</i> Sinton, 1928
		16. <i>sergenti</i> Parrot, 1917
	<i>Phlebotomus</i>	17. <i>papatasi</i> Scopoli, 1786
		18. <i>salehi</i> Mesghali, 1965
		19. <i>sundarai</i> Basab Basak and Neelam Tandon, 1997
	<i>Synphlebotomus</i>	20. <i>eleanorae</i> Sinton, 1931
		21. <i>sikandraensis</i> N.S. Singh and IPE M. IPE, 2005
<i>Sergentomyia</i>	<i>Neophlebotomus</i>	22. <i>arboris</i> Sinton, 1931
		23. <i>chakravarti</i> Mitra & Roy, 1953
		24. <i>dhandai</i> Lewis, 1978
		25. <i>gemmea</i> Lewis, 1979
		26. <i>hodgsoni</i> Sinton, 1933
		27. <i>hodgsoni hodgsoni</i> Artemiev, 1976
		28. <i>iyengari</i> Sinton, 1932
		29. <i>kottamala</i> Kaul, 1993
		30. <i>kurandamallai</i> Kaul, 1993
		31. <i>linearis</i> Lewis, 1978
		32. <i>malabarica</i> Annandale, 1910
		33. <i>monticola</i> Srinivasan, Jambulingam, Pradeep Kumar, 2014
		34. <i>nilamburensis</i> Kaul & Prabha, 1993
		35. <i>perturbans</i> de Meijere, 1967
		36. <i>purii</i> Sinton, 1931
		37. <i>quatei</i> Lewis, 1978
		38. <i>verghesei</i> Kaul, 1993
		39. <i>zeylanica</i> Annandale, 1910
	<i>nicnic</i> group	40. <i>bailyi</i> Sinton, 1931
		41. <i>cherukara</i> Kaul, 1993
		42. <i>shettyi</i> Ilango, 1994
	<i>Parrotomyia</i>	43. <i>babu</i> Annandale, 1910
		44. <i>baghdadis</i> Adler & Theodor, 1910
		45. <i>barraudi</i> Sinton, 1929
		46. <i>grekovi</i> Khodukin, 1929
		47. <i>himalayensis</i> Annandale, 1910
		48. <i>insularis</i> Theodor, 1938
		49. <i>jerighatiansis</i> Srinivasan & Jambulingam, 2013
		50. <i>kauli</i> Lewis, 1978
		51. <i>modii</i> Lewis, 1978
		52. <i>rectangulata</i> Srinivasan & Jambulingam, 2010
		53. <i>santokhi</i> N.S. Singh and IPE M. IPE, 2005
		54. <i>shorttii</i> Adler & Theodor, 1927
		55. sp. A Kaul, Dhanda & Modi, 1973
		56. sp. B Kaul, Dhanda & Modi, 1973
		57. <i>vadhanurensis</i> R. Srinivasan, P. Jambulingam, 2011
		58. <i>yercaudensis</i> Ilango, 2004
	<i>Sergentomyia</i>	59. <i>dentata</i> N.S. Singh and Doris Philips Singh, 1958
		60. <i>pondicherriensis</i> R. Srinivasan, P. Jambulingam, 2010
		61. <i>punjabensis</i> Sinton, 1933
	<i>Sintonius</i>	62. <i>christophersi</i> Sinton, 1927
		63. <i>clydei</i> Sinton, 1928
		64. <i>eadithae</i> Sinton, 1932
		65. <i>hospitii</i> Sinton, 1924
		66. <i>orissa</i> Kaul & Lewis, 1977
		67. <i>shirohi</i> Kaul, Dhanda & Modi, 1973
	<i>Ungrouped</i>	68. <i>montana</i> Sinton, 1924
		69. <i>koraputa</i> Lewis & Kaul, 1987

Table 2. State-wise distribution of sandfly species in India.

No.	State	Species	No.	State	Species
1.	Andaman & Nicobar Islands	1. <i>Sergentomyia</i> (<i>Neophlebotomus</i>) <i>gemmea</i> 2. <i>Sergentomyia</i> (<i>Neophlebotomus</i>) <i>quatei</i>	12.	Jammu and Kashmir	1. <i>Grassomyia</i> (<i>Grassomyia</i>) <i>indica</i> 2. <i>Phlebotomus</i> (<i>Adlerius</i>) <i>longiductus</i> 3. <i>Phlebotomus</i> (<i>Larroussius</i>) <i>major</i> 4. <i>Phlebotomus</i> (<i>Paraphlebotomus</i>) <i>sergenti</i> 5. <i>Phlebotomus</i> (<i>Phlebotomus</i>) <i>papatasi</i> 6. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>babu</i> 7. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>baghdadis</i> 8. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>grekovi</i> 9. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>kauli</i> 10. <i>Sergentomyia</i> (<i>Sergentomyia</i>) <i>punjabensis</i> 11. <i>Sergentomyia</i> <i>montana</i>
2.	Andhra Pradesh	1. <i>Grassomyia</i> (<i>Grassomyia</i>) <i>indica</i> 2. <i>Phlebotomus</i> (<i>Euphlebotomus</i>) <i>argentipes</i> 3. <i>Phlebotomus</i> (<i>Phlebotomus</i>) <i>papatasi</i> 4. <i>Sergentomyia</i> (<i>Sintonius</i>) <i>clydei</i>	13.	Jharkhand	1. <i>Phlebotomus</i> (<i>Anaphlebotomus</i>) <i>chiyankiensis</i> 2. <i>Phlebotomus</i> (<i>Anaphlebotomus</i>) <i>palamauensis</i> 3. <i>Phlebotomus</i> (<i>Euphlebotomus</i>) <i>argentipes</i> 4. <i>Phlebotomus</i> (<i>Larroussius</i>) <i>major</i> 5. <i>Sergentomyia</i> <i>nicnic group bailyi</i> 6. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>babu</i> 7. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>insularis</i>
3.	Assam	1. <i>Grassomyia</i> (<i>Grassomyia</i>) <i>indica</i> 2. <i>Phlebotomus</i> (<i>Anaphlebotomus</i>) <i>stantoni</i> 3. <i>Phlebotomus</i> (<i>Euphlebotomus</i>) <i>argentipes</i> 4. <i>Sergentomyia</i> (<i>Neophlebotomus</i>) <i>zeylanica</i> 5. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>barraudi</i> 6. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>modii</i> 7. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>shorttii</i>	14.	Karnataka	1. <i>Phlebotomus</i> (<i>Euphlebotomus</i>) <i>argentipes</i> 2. <i>Sergentomyia</i> (<i>Neophlebotomus</i>) <i>arboris</i> 3. <i>Sergentomyia</i> <i>nicnic group bailyi</i> 4. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>babu</i> 5. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>insularis</i> 6. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>shorttii</i>
4.	Bihar	1. <i>Grassomyia</i> (<i>Grassomyia</i>) <i>indica</i> 2. <i>Phlebotomus</i> (<i>Anaphlebotomus</i>) <i>colabaensis</i> 3. <i>Phlebotomus</i> (<i>Euphlebotomus</i>) <i>argentipes</i> 4. <i>Phlebotomus</i> (<i>Paraphlebotomus</i>) <i>sergenti</i> 5. <i>Phlebotomus</i> (<i>Phlebotomus</i>) <i>papatasi</i> 6. <i>Sergentomyia</i> (<i>Neophlebotomus</i>) <i>iyengari</i> 7. <i>Sergentomyia</i> <i>nicnic group bailyi</i> 8. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>babu</i> 9. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>insularis</i> 10. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>shorttii</i> 11. <i>Sergentomyia</i> (<i>Sergentomyia</i>) <i>punjabensis</i> 12. <i>Sergentomyia</i> (<i>Sintonius</i>) <i>clydei</i>	15.	Kerala	1. <i>Grassomyia</i> (<i>Grassomyia</i>) <i>indica</i> 2. <i>Phlebotomus</i> (<i>Anaphlebotomus</i>) <i>colabaensis</i> 3. <i>Phlebotomus</i> (<i>Anaphlebotomus</i>) <i>stantoni</i> 4. <i>Phlebotomus</i> (<i>Euphlebotomus</i>) <i>argentipes</i> 5. <i>Sergentomyia</i> (<i>Neophlebotomus</i>) <i>arboris</i> 6. <i>Sergentomyia</i> (<i>Neophlebotomus</i>) <i>dhandai</i> 7. <i>Sergentomyia</i> (<i>Neophlebotomus</i>) <i>iyengari</i> 8. <i>Sergentomyia</i> (<i>Neophlebotomus</i>) <i>kottamala</i> 9. <i>Sergentomyia</i> (<i>Neophlebotomus</i>) <i>linearis</i> 10. <i>Sergentomyia</i> (<i>Neophlebotomus</i>) <i>malabarica</i> 11. <i>Sergentomyia</i> (<i>Neophlebotomus</i>) <i>monticola</i> 12. <i>Sergentomyia</i> (<i>Neophlebotomus</i>) <i>nilamburensis</i> 13. <i>Sergentomyia</i> (<i>Neophlebotomus</i>) <i>verghesei</i> 14. <i>Sergentomyia</i> (<i>Neophlebotomus</i>) <i>zeylanica</i> 15. <i>Sergentomyia</i> <i>nicnic group bailyi</i> 16. <i>Sergentomyia</i> <i>nicnic group cherukara</i> 17. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>babu</i> 18. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>baghdadis</i> 19. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>barraudi</i> 20. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>himalayensis</i> 21. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>insularis</i> 22. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>jerighatiansis</i> 23. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>kauli</i> 24. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>modii</i> 25. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>rectangulata</i> 26. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>shorttii</i> 27. <i>Sergentomyia</i> (<i>Sergentomyia</i>) <i>punjabensis</i> 28. <i>Sergentomyia</i> (<i>Sintonius</i>) <i>christophersi</i> 29. <i>Sergentomyia</i> (<i>Sintonius</i>) <i>eadithae</i> 30. <i>Sergentomyia</i> (<i>Sintonius</i>) <i>hospitii</i>
5.	Chandigarh	1. <i>Sergentomyia</i> <i>nicnic group bailyi</i> 2. <i>Sergentomyia</i> (<i>Sergentomyia</i>) <i>punjabensis</i>	16.	Ladakh	1. <i>Phlebotomus</i> (<i>Adlerius</i>) <i>longiductus</i> 2. <i>Phlebotomus</i> (<i>Paraphlebotomus</i>) <i>sergenti</i>
6.	Chhattisgarh	1. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>shorttii</i>	17.	Madhya Pradesh	1. <i>Grassomyia</i> (<i>Grassomyia</i>) <i>indica</i> 2. <i>Phlebotomus</i> (<i>Anaphlebotomus</i>) <i>colabaensis</i> 3. <i>Phlebotomus</i> (<i>Anaphlebotomus</i>) <i>stantoni</i> 4. <i>Phlebotomus</i> (<i>Euphlebotomus</i>) <i>argentipes</i> 5. <i>Phlebotomus</i> (<i>Phlebotomus</i>) <i>papatasi</i> 6. <i>Sergentomyia</i> <i>nicnic group bailyi</i> 7. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>babu</i> 8. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>insularis</i> 9. <i>Sergentomyia</i> (<i>Sergentomyia</i>) <i>punjabensis</i> 10. <i>Sergentomyia</i> (<i>Sintonius</i>) <i>clydei</i> 11. <i>Sergentomyia</i> (<i>Sintonius</i>) <i>christophersi</i>
7.	Delhi	1. <i>Phlebotomus</i> (<i>Paraphlebotomus</i>) <i>sergenti</i> 2. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>babu</i> 3. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>insularis</i> 4. <i>Sergentomyia</i> (<i>Sergentomyia</i>) <i>punjabensis</i> 5. <i>Sergentomyia</i> (<i>Sintonius</i>) <i>christophersi</i> 6. <i>Sergentomyia</i> (<i>Sintonius</i>) <i>clydei</i>	11.	Himalayan region	1. <i>Phlebotomus</i> (<i>Adlerius</i>) <i>hindustanicus</i> 2. <i>Phlebotomus</i> (<i>Anaphlebotomus</i>) <i>hoepflii</i> 3. <i>Phlebotomus</i> (<i>Paraphlebotomus</i>) <i>alexandri</i>
8.	Gujarat	1. <i>Grassomyia</i> (<i>Grassomyia</i>) <i>indica</i> 2. <i>Phlebotomiella</i> <i>eoindianensis</i> 3. <i>Phlebotomus</i> (<i>Paraphlebotomus</i>) <i>sergenti</i> 4. <i>Sergentomyia</i> (<i>Neophlebotomus</i>) <i>malabarica</i> 5. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>babu</i> 6. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>baghdadis</i> 7. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>insularis</i> 8. <i>Sergentomyia</i> (<i>Sergentomyia</i>) <i>punjabensis</i> 9. <i>Sergentomyia</i> (<i>Sintonius</i>) <i>clydei</i>			
9.	Haryana	1. <i>Grassomyia</i> (<i>Grassomyia</i>) <i>indica</i> 2. <i>Phlebotomus</i> (<i>Euphlebotomus</i>) <i>argentipes</i> 3. <i>Phlebotomus</i> (<i>Paraphlebotomus</i>) <i>sergenti</i> 4. <i>Phlebotomus</i> (<i>Phlebotomus</i>) <i>papatasi</i> 5. <i>Phlebotomus</i> (<i>Synphlebotomus</i>) <i>eleanorae</i> 6. <i>Sergentomyia</i> <i>nicnic group bailyi</i> 7. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>babu</i> 8. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>baghdadis</i> 9. <i>Sergentomyia</i> (<i>Parrotomyia</i>) <i>insularis</i> 10. <i>Sergentomyia</i> (<i>Sintonius</i>) <i>christophersi</i> 11. <i>Sergentomyia</i> (<i>Sintonius</i>) <i>clydei</i>			
10.	Himachal Pradesh	1. <i>Grassomyia</i> (<i>Grassomyia</i>) <i>indica</i> 2. <i>Phlebotomus</i> (<i>Adlerius</i>) <i>longiductus</i> 3. <i>Phlebotomus</i> (<i>Euphlebotomus</i>) <i>argentipes</i> 4. <i>Phlebotomus</i> (<i>Kasaulius</i>) <i>newsteadi</i> 5. <i>Phlebotomus</i> (<i>Larroussius</i>) <i>kandelakii burneyi</i> 6. <i>Phlebotomus</i> (<i>Larroussius</i>) <i>major</i> 7. <i>Phlebotomus</i> (<i>Paraphlebotomus</i>) <i>sergenti</i> 8. <i>Sergentomyia</i> <i>nicnic group bailyi</i> 9. <i>Sergentomyia</i> (<i>Sintonius</i>) <i>hospitii</i> 10. <i>Sergentomyia</i> <i>Montana</i>			

Table 2. Continued.

No.	State	Species	No.	State	Species		
18.	Maharashtra	1. <i>Grassomyia (Grassomyia) indica</i>			6. <i>Sergentomyia (Neophlebotomus) kurandamallai</i>		
		2. <i>Phlebotomus (Anaphlebotomus) colabaensis</i>			7. <i>Sergentomyia (Neophlebotomus) malabarica</i>		
		3. <i>Phlebotomus (Euphlebotomus) argentipes</i>			8. <i>Sergentomyia nicnic group bailyi</i>		
		4. <i>Phlebotomus (Idiophlebotomus) tubifer</i>			9. <i>Sergentomyia nicnic group shettyi</i>		
		5. <i>Phlebotomus (Paraphlebotomus) sergenti</i>			10. <i>Sergentomyia (Parrotomyia) babu</i>		
		6. <i>Phlebotomus (Phlebotomus) papatasi</i>			11. <i>Sergentomyia (Parrotomyia) baghdadis</i>		
		7. <i>Sergentomyia (Neophlebotomus) dhandai</i>			12. <i>Sergentomyia (Parrotomyia) barraudi</i>		
		8. <i>Sergentomyia (Neophlebotomus) zeylanica</i>			13. <i>Sergentomyia (Parrotomyia) insularis</i>		
		9. <i>Sergentomyia nicnic group bailyi</i>			14. <i>Sergentomyia (Parrotomyia) yercaudensis</i>		
		10. <i>Sergentomyia (Parrotomyia) babu</i>			15. <i>Sergentomyia (Sergentomyia) punjabensis</i>		
		11. <i>Sergentomyia (Parrotomyia) baghdadis</i>			16. <i>Sergentomyia (Sintonius) clydei</i>		
		12. <i>Sergentomyia (Parrotomyia) insularis</i>					
		13. <i>Sergentomyia (Sergentomyia) punjabensis</i>					
		14. <i>Sergentomyia (Sintonius) clydei</i>					
19.	Odisha	1. <i>Phlebotomus (Anaphlebotomus) colabaensis</i>	24.	Telangana	1. <i>Phlebotomus (Anaphlebotomus) colabaensis</i>		
		2. <i>Phlebotomus (Euphlebotomus) argentipes</i>			2. <i>Phlebotomus (Euphlebotomus) argentipes</i>		
		3. <i>Sergentomyia nicnic group bailyi</i>			3. <i>Phlebotomus (Phlebotomus) papatasi</i>		
		4. <i>Sergentomyia (Parrotomyia) babu</i>			4. <i>Sergentomyia nicnic group bailyi</i>		
		5. <i>Sergentomyia (Parrotomyia) baghdadis</i>			5. <i>Sergentomyia (Parrotomyia) shortii</i>		
		6. <i>Sergentomyia (Parrotomyia) insularis</i>			6. <i>Sergentomyia (Sergentomyia) punjabensis</i>		
		7. <i>Sergentomyia (Parrotomyia) jerighatiansis</i>			7. <i>Sergentomyia (Sintonius) clydei</i>		
		8. <i>Sergentomyia (Parrotomyia) kauli</i>			8. <i>Sergentomyia (Sintonius) eadithae</i>		
		9. <i>Sergentomyia (Sergentomyia) punjabensis</i>					
		10. <i>Sergentomyia (Sintonius) christophersi</i>			25.	Uttar Pradesh	1. <i>Grassomyia (Grassomyia) indica</i>
		11. <i>Sergentomyia (Sintonius) clydei</i>					2. <i>Phlebotomus (Euphlebotomus) argentipes</i>
		12. <i>Sergentomyia (Sintonius) orissa</i>					3. <i>Phlebotomus (Paraphlebotomus) sergenti</i>
		13. <i>Sergentomyia koraputa</i>					4. <i>Phlebotomus (Phlebotomus) papatasi</i>
	5. <i>Phlebotomus (Synphlebotomus) sikandraensis</i>						
	6. <i>Sergentomyia nicnic group bailyi</i>						
	7. <i>Sergentomyia (Parrotomyia) santokhi</i>						
	8. <i>Sergentomyia (Sergentomyia) dentata</i>						
	9. <i>Sergentomyia (Sergentomyia) punjabensis</i>						
	10. <i>Sergentomyia (Sintonius) clydei</i>						
20.	Pondicherry	1. <i>Sergentomyia (Parrotomyia) babu</i>	26.	Uttarakhand	1. <i>Grassomyia (Grassomyia) indica</i>		
		2. <i>Sergentomyia (Parrotomyia) baghdadis</i>			2. <i>Phlebotomus (Adlerius) longiductus</i>		
		3. <i>Sergentomyia (Parrotomyia) barraudi</i>			3. <i>Phlebotomus (Euphlebotomus) argentipes</i>		
		4. <i>Sergentomyia (Parrotomyia) insularis</i>			4. <i>Phlebotomus (Larrousius) major</i>		
		5. <i>Sergentomyia (Parrotomyia) rectangulata</i>			5. <i>Phlebotomus (Paraphlebotomus) sergenti</i>		
		6. <i>Sergentomyia (Parrotomyia) vadhanurensis</i>			6. <i>Sergentomyia (Neophlebotomus) hodgsoni hodgsoni</i>		
		7. <i>Sergentomyia (Sergentomyia) pondicherriensis</i>			7. <i>Sergentomyia (Neophlebotomus) zeylanica</i>		
		8. <i>Sergentomyia (Sergentomyia) punjabensis</i>			8. <i>Sergentomyia nicnic group bailyi</i>		
21.	Punjab	1. <i>Phlebotomus (Kasaulius) newsteadi</i>			9. <i>Sergentomyia (Parrotomyia) babu</i>		
		2. <i>Phlebotomus (Paraphlebotomus) sergenti</i>			10. <i>Sergentomyia (Parrotomyia) himalayensis</i>		
		3. <i>Phlebotomus (Phlebotomus) papatasi</i>			11. <i>Sergentomyia (Parrotomyia) insularis</i>		
		4. <i>Sergentomyia nicnic group bailyi</i>			12. <i>Sergentomyia (Parrotomyia) kauli</i>		
		5. <i>Sergentomyia (Parrotomyia) baghdadis</i>			13. <i>Sergentomyia (Parrotomyia) shortii</i>		
		6. <i>Sergentomyia (Sergentomyia) punjabensis</i>			14. <i>Sergentomyia (Sergentomyia) punjabensis</i>		
22.	Rajasthan	1. <i>Grassomyia (Grassomyia) indica</i>			15. <i>Sergentomyia (Sintonius) hospitii</i>		
		2. <i>Phlebotomus (Anaphlebotomus) colabaensis</i>			16. <i>Sergentomyia montana</i>		
		3. <i>Phlebotomus (Euphlebotomus) argentipes</i>					
		4. <i>Phlebotomus (Paraphlebotomus) sergenti</i>			27.	West Bengal	1. <i>Grassomyia (Grassomyia) indica</i>
		5. <i>Phlebotomus (Phlebotomus) papatasi</i>					2. <i>Phlebotomus (Adlerius) longiductus</i>
		6. <i>Phlebotomus (Phlebotomus) salehi</i>					3. <i>Phlebotomus (Euphlebotomus) argentipes</i>
		7. <i>Sergentomyia nicnic group bailyi</i>					4. <i>Phlebotomus ((Kasaulius) newsteadi</i>
		8. <i>Sergentomyia (Parrotomyia) babu</i>					5. <i>Phlebotomus (Larrousius) major</i>
		9. <i>Sergentomyia (Parrotomyia) baghdadis</i>					6. <i>Phlebotomus (Phlebotomus) papatasi</i>
		10. <i>Sergentomyia (Parrotomyia) insularis</i>					7. <i>Phlebotomus (Phlebotomus) sundarai</i>
		11. <i>Sergentomyia (Parrotomyia) shortii</i>					8. <i>Sergentomyia (Neophlebotomus) arboris</i>
		12. <i>Sergentomyia (Sergentomyia) punjabensis</i>					9. <i>Sergentomyia (Neophlebotomus) perturbans</i>
		13. <i>Sergentomyia (Sintonius) christophersi</i>					10. <i>Sergentomyia (Neophlebotomus) purii</i>
		14. <i>Sergentomyia (Sintonius) clydei</i>					11. <i>Sergentomyia (Neophlebotomus) zeylanica</i>
		15. <i>Sergentomyia (Sintonius) eadithae</i>					12. <i>Sergentomyia (Parrotomyia) babu</i>
16. <i>Sergentomyia (Sintonius) shirohi</i>	13. <i>Sergentomyia (Parrotomyia) himalayensis</i>						
23.	Tamil Nadu	1. <i>Grassomyia (Grassomyia) indica</i>					14. <i>Sergentomyia (Parrotomyia) insularis</i>
		2. <i>Phlebotomus (Anaphlebotomus) colabaensis</i>					15. <i>Sergentomyia (Parrotomyia) shortii</i>
		3. <i>Phlebotomus (Euphlebotomus) argentipes</i>			16. <i>Sergentomyia (Sergentomyia) punjabensis</i>		
		4. <i>Phlebotomus (Phlebotomus) papatasi</i>					
		5. <i>Sergentomyia (Neophlebotomus) arboris</i>					
28.	Data not available	1. <i>Sergentomyia (Neophlebotomus) hodgsoni</i>					

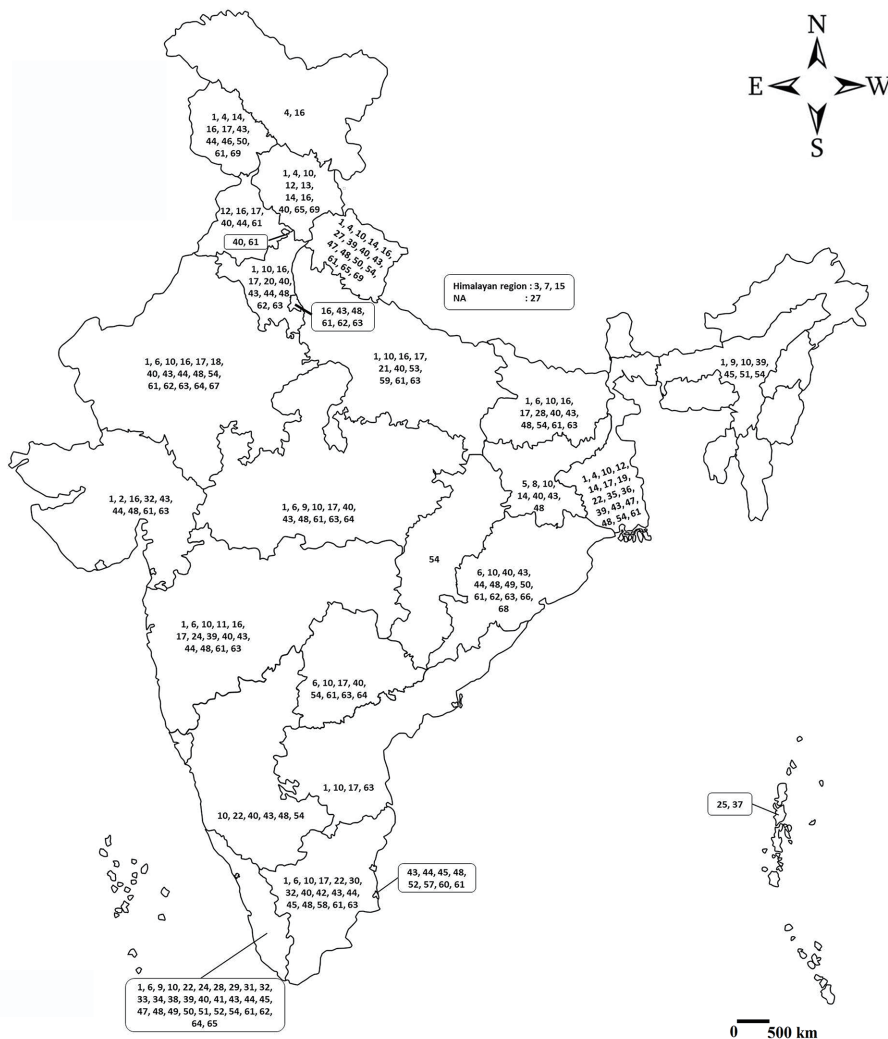


Figure 1. The map representing spatial distribution of sandfly species recorded from different states of India. The serial numbers shown in the figure are enlisted in Table 1, which includes details of the species.

3. Results

Records indicate that the Indian sandfly fauna includes 69 species divided among 4 genera, 15 subgenera/groups and many species remain ungrouped. The authorship along with the year of discovery of the species is provided in Table 1. Their spatial distribution in different states of India has been shown in Table 2 and Figure 1. *Phlebotiella* genus has recorded only one species i.e., *Phlebotiella eoindianensis* which was recorded in an amber fossil. Genus *Phlebotomus* included 9 subgenera/groups which contain 19 species of sandflies among which *Phlebotiella (Euphlebotomus) argentipes* is the known vector of visceral leishmaniasis in India. *Grassomyia* which was previously designated as one of the subgenera under the genus *Sergentomyia* has been upgraded to genus status recently, which contains single species i.e., *G. (Grassomyia) indica*. Forty-eight species under the genus *Sergentomyia* are categorised under 6 subgenera including a few ungrouped species.

The oldest of any Indian sandfly species recorded was *P. papatasi* Scopoli, 1786[7], whereas a fossil sandfly specimen was found preserved in amber in 2009[31] might have been much older. Most

of the sandfly species reported in India by various investigators have been reported since 1700's. In the Indian subcontinent during the 18th century, no records of sandfly species were documented. Moreover, from the early 17th to the late 19th century also, no attempt was made in order to consolidate the fauna of Indian sandflies. The extant taxonomic keys for the identification of sandfly fauna in India was put forward based on the records by D. J. Lewis in 1978[7] and Kalra and Bang in 1988[32]. In the late 1900s and 2000s, 20 more species have been reported and described by different investigators in India. Species like *P. hindustanicus*, *P. hoepflii*, *P. kandelakii burneyi*, *P. alexandri* and *S. dentata* which are usually found in the neighbouring countries of India like Pakistan, China, etc., have also been recorded in India and were included in the checklist by Ilango during 2009[33]. In the Indian subcontinent, the major vector of visceral leishmaniasis and cutaneous leishmaniasis belongs to the genus *Phlebotomus*[13]. However, a few suspected vectors belonging to the genus *Sergentomyia* have also been reported globally involved in zoonotic and anthroponotic transmission[34–39].

According to the state-wise distribution of sandfly in India (Table

Table 3. Sandfly distribution in different states of India and their known vector status in transmission of leishmaniasis.

No.	Species	State	Role in disease transmission	References
1.	<i>Grassomyia (Grassomyia) indica</i>	Gujarat, Andhra Pradesh, West Bengal, Tamil Nadu, Bihar, Himachal Pradesh, Maharashtra, Jammu and Kashmir, Rajasthan, Haryana, Uttar Pradesh, Kerala, Madhya Pradesh, Assam, Uttarakhand,	NV	[7,40]
2.	<i>Phlebotiella eoindianensis</i>	Gujarat	-	[31]
3.	<i>Phlebotomus (Adlerius) hindustanicus</i>	Himalayan region	V	[33,41,42]
4.	<i>Phlebotomus (Adlerius) longiductus</i>	Uttarakhand, Himachal Pradesh, Jammu and Kashmir, West Bengal, Ladakh	V	[7,43,44]
5.	<i>Phlebotomus (Anaphlebotomus) chiyankiensis</i>	Jharkhand	NV	[27]
6.	<i>Phlebotomus (Anaphlebotomus) colabaensis</i>	Kerala, Rajasthan, Telangana, Maharashtra, Odisha, Tamil Nadu, Bihar, Madhya Pradesh	NV	[7,40,45]
7.	<i>Phlebotomus (Anaphlebotomus) hoeppli</i>	Himalayan region	NV	[33]
8.	<i>Phlebotomus (Anaphlebotomus) palamaensis</i>	Jharkhand	NV	[26]
9.	<i>Phlebotomus (Anaphlebotomus) stantoni</i>	Uttar Pradesh, Assam, Madhya Pradesh, Kerala	NV	[7]
10.	<i>Phlebotomus (Euphlebotomus) argentipes</i>	West Bengal, Bihar, Andhra Pradesh, Kerala, Rajasthan, Maharashtra, Assam, Jharkhand, Himachal Pradesh, Uttarakhand, Madhya Pradesh, Telangana, Tamil Nadu, Uttar Pradesh, Odisha, Haryana, Karnataka	V	[7,46]
11.	<i>Phlebotomus (Idiophlebotomus) tubifer</i>	Maharashtra	NV	[7]
12.	<i>Phlebotomus (Kasaulius) newsteadi</i>	Himachal Pradesh, Punjab, West Bengal	NV	[7]
13.	<i>Phlebotomus (Larrousius) kandelakii burneyi</i>	Himachal Pradesh	NV	[47]
14.	<i>Phlebotomus (Larrousius) major</i>	Jharkhand, Uttarakhand, Himachal Pradesh, Jammu and Kashmir, West Bengal	NV	[7]
15.	<i>Phlebotomus (Paraphlebotomus) alexandri</i>	Himalayan region	NV	[33]
16.	<i>Phlebotomus (Paraphlebotomus) sergenti</i>	Delhi, Haryana, Punjab, Maharashtra, Jammu and Kashmir, Rajasthan, Bihar, Himachal Pradesh, Uttar Pradesh, Gujarat, Uttarakhand, Ladakh	V	[7,48]
17.	<i>Phlebotomus (Phlebotomus) papatasi</i>	Bihar, West Bengal, Maharashtra, Jammu and Kashmir, Rajasthan, Madhya Pradesh, Telangana, Andhra Pradesh, Haryana, Tamil Nadu, Uttarakhand, Uttar Pradesh, Punjab	V	[7,49]
18.	<i>Phlebotomus (Phlebotomus) salehi</i>	Rajasthan	PV	[7,50,51]
19.	<i>Phlebotomus (Phlebotomus) sundarai</i>	West Bengal	NV	[52]
20.	<i>Phlebotomus (Synphlebotomus) eleanorae</i>	Haryana	NV	[7]
21.	<i>Phlebotomus (Synphlebotomus) sikandraensis</i>	Uttar Pradesh	NV	[25]
22.	<i>Sergentomyia (Neophlebotomus) arboris</i>	West Bengal, Karnataka, Tamil Nadu, Kerala	NV	[7,10]
23.	<i>Sergentomyia (Neophlebotomus) chakravarti</i>	Jammu and Kashmir	NV	[7]
24.	<i>Sergentomyia (Neophlebotomus) dhandai</i>	Maharashtra, Kerala	NV	[7,53]
25.	<i>Sergentomyia (Neophlebotomus) gemmea</i>	Andaman & Nicobar Islands	V	[54]
26.	<i>Sergentomyia (Neophlebotomus) hodgsoni</i>	Western India	NV	[7]
27.	<i>Sergentomyia (Neophlebotomus) hodgsoni</i>	Uttarakhand	NV	[7]
28.	<i>Sergentomyia (Neophlebotomus) iyengari</i>	Kerala, Bihar	NV	[7,40]
29.	<i>Sergentomyia (Neophlebotomus) kottamala</i>	Kerala	NV	[8]
30.	<i>Sergentomyia (Neophlebotomus) kurandamallai</i>	Tamil Nadu	NV	[8]
31.	<i>Sergentomyia (Neophlebotomus) linearis</i>	Kerala	NV	[7]
32.	<i>Sergentomyia (Neophlebotomus) malabarica</i>	Gujarat, Kerala, Tamil Nadu	NV	[7]
33.	<i>Sergentomyia (Neophlebotomus) monticola</i>	Kerala	NV	[9]
34.	<i>Sergentomyia (Neophlebotomus) nilamburensis</i>	Kerala	NV	[33,55]
35.	<i>Sergentomyia (Neophlebotomus) perturbans</i>	West Bengal	NV	[7]
36.	<i>Sergentomyia (Neophlebotomus) purii</i>	West Bengal	NV	[7]
37.	<i>Sergentomyia (Neophlebotomus) quatei</i>	Andaman & Nicobar Islands	NV	[7,54]
38.	<i>Sergentomyia (Neophlebotomus) verghesei</i>	Kerala	NV	[8]
39.	<i>Sergentomyia (Neophlebotomus) zeylanica</i>	Kerala, West Bengal, Maharashtra, Uttarakhand, Assam	PV	[7,35]
40.	<i>Sergentomyia nicnic group bailyi</i>	Rajasthan, Odisha, Uttar Pradesh, Bihar, Tamil Nadu, Maharashtra, Telangana, Jharkhand, Punjab, Chandigarh, Madhya Pradesh, Uttarakhand, Haryana, Himachal Pradesh, Karnataka, Kerala, Jammu and Kashmir	PV	[7,40,34]
41.	<i>Sergentomyia nicnic group cherukara</i>	Kerala	NV	[8]
42.	<i>Sergentomyia nicnic group shettyi</i>	Tamil Nadu	NV	[22]
43.	<i>Sergentomyia (Parrotomyia) babu</i>	Rajasthan, Delhi, West Bengal, Maharashtra, Haryana, Uttar Pradesh, Bihar, Gujarat, Madhya Pradesh, Jharkhand, Odisha, Kerala, Karnataka, Uttarakhand, Tamil Nadu, Pondicherry, Jammu and Kashmir	NV	[7,40]
44.	<i>Sergentomyia (Parrotomyia) baghdadis</i>	Pondicherry, Tamil Nadu, Kerala, Maharashtra, Jammu and Kashmir, Rajasthan, Punjab, Haryana, Gujarat	SV	[7,39]

V: Vector; NV: Non vector; PV: Potential vector; SV: Suspected vector.

Table 3. Continued.

No.	Species	State	Role in disease transmission	References
45.	<i>Sergentomyia (Parrotomyia) barraudi</i>	Assam, Pondicherry, Tamil Nadu, Kerala	SV	[7,37,36]
46.	<i>Sergentomyia (Parrotomyia) grekovi</i>	Jammu and Kashmir	NV	[56]
47.	<i>Sergentomyia (Parrotomyia) himalayensis</i>	Uttarakhand, West Bengal, Kerala	NV	[7]
48.	<i>Sergentomyia (Parrotomyia) insularis</i>	Rajasthan, Delhi, West Bengal, Maharashtra, Haryana, Uttar Pradesh, Bihar, Gujarat, Madhya Pradesh, Jharkhand, Odisha, Kerala, Karnataka, Uttarakhand, Tamil Nadu, Pondicherry	NV	[33]
49.	<i>Sergentomyia (Parrotomyia) jerighatiansis</i>	Odisha, Kerala	NV	[30]
50.	<i>Sergentomyia (Parrotomyia) kauli</i>	Odisha, Uttarakhand, Uttar Pradesh, Jammu and Kashmir, Kerala	NV	[7,53]
51.	<i>Sergentomyia (Parrotomyia) modii</i>	Assam, Kerala	NV	[7]
52.	<i>Sergentomyia (Parrotomyia) rectangulata</i>	Pondicherry, Kerala	NV	[57,53]
53.	<i>Sergentomyia (Parrotomyia) santokhi</i>	Uttar Pradesh	NV	[25]
54.	<i>Sergentomyia (Parrotomyia) shortii</i>	Assam, West Bengal, Rajasthan, Chhattisgarh, Telangana, Uttarakhand, Karnataka, Bihar, Kerala	NV	[7,40]
55.	<i>Sergentomyia (Parrotomyia) sp. A</i>	Data Not Available	-	[33]
56.	<i>Sergentomyia (Parrotomyia) sp. B</i>	Data Not Available	-	[33]
57.	<i>Sergentomyia (Parrotomyia) vadhanurensis</i>	Pondicherry	NV	[29]
58.	<i>Sergentomyia (Parrotomyia) yercaudensis</i>	Tamil Nadu	NV	[58]
59.	<i>Sergentomyia (Sergentomyia) dentate</i>	Uttar Pradesh	V	[59,60,38]
60.	<i>Sergentomyia (Sergentomyia) pondicherriensis</i>	Pondicherry	NV	[28]
61.	<i>Sergentomyia (Sergentomyia) punjabensis</i>	Uttarakhand, Madhya Pradesh, Maharashtra, Punjab, Chandigarh, Rajasthan, Jammu and Kashmir, Telangana, Tamil Nadu, Gujarat, Odisha, West Bengal, Kerala, Delhi, Uttar Pradesh, Pondicherry, Bihar	PV	[7,40,15]
62.	<i>Sergentomyia (Sintonius) christophersi</i>	Rajasthan, Delhi, Haryana, Odisha, Uttar Pradesh, Kerala	NV	[7]
63.	<i>Sergentomyia (Sintonius) clydei</i>	Maharashtra, Rajasthan, Telangana, Gujarat, Delhi, Andhra Pradesh, Haryana, Tamil Nadu, Odisha, Uttar Pradesh, Bihar, Madhya Pradesh	NV	[7,40]
64.	<i>Sergentomyia (Sintonius) eadithae</i>	Rajasthan, Telangana, Kerala, Madhya Pradesh	NV	[7]
65.	<i>Sergentomyia (Sintonius) hospitii</i>	Uttarakhand, Himachal Pradesh, Kerala	NV	[7,53]
66.	<i>Sergentomyia (Sintonius) orissa</i>	Odisha	NV	[7]
67.	<i>Sergentomyia (Sintonius) shirohi</i>	Rajasthan	NV	[7]
68.	<i>Sergentomyia koraputa</i>	Odisha	NV	[33]
69.	<i>Sergentomyia montana</i>	Uttarakhand, Himachal Pradesh, Jammu and Kashmir	NV	[7]

V: Vector; NV: Non vector; PV: Potential vector; SV: Suspected vector.

2), the Western Ghats region of Kerala has reported a maximum number of species. As it is a biodiversity hotspot and also one of the recently emerging epidemiological active zones, a greater number of entomological studies have been carried out in this southern state in the recent past. Unlike this, in other endemic states, vector-oriented studies are given prime importance over the faunistic surveys of the sandflies. Data compiled here on state-wise species diversity of sandfly for endemic (Bihar, Jharkhand, Uttar Pradesh, and West Bengal) of leishmaniasis and the states which have some pockets of transmission (Rajasthan, Himachal Pradesh, Sikkim, Assam, and Kerala), would help in the vector management and control, to achieve the national leishmaniasis elimination goal.

Altogether in India, four species *i.e.*, *P. argentipes*, *S. bailyi*, *S. babu* and *S. punjabensis* are the most widely distributed species with records from 16, 15, 13 and 12 states respectively. This is followed by *S. insularis*, *G. (Grassomyia) indica*, *P. (Phlebotomus) papatasi*, *P. (Paraphlebotomus) sergenti* and *S. (Sintonius) clydei*, respectively. Thirty-five species of sandflies have been recorded from single states of India. These species may be distributed to other states too, but not yet recorded owing to the lack of entomological surveys. Species

which are vectors and non-vectors for leishmaniasis prevalent in different parts of the country are consolidated in Table 3.

4. Discussion

The Phlebotomine fauna of India has been widely explored in terms of their epidemiological significance. Systematic investigations on the taxonomy of Indian sandflies began with the description of *P. argentipes* by Annandalei and Brunnetti in 1908. All the species till date identified and reported in India are based on the standard taxonomic keys comprising the microscopic examination of morphological and anatomical features. Over the past few years, in-depth morphological observations revealed intraspecific variations and forecasted the probabilities of species complex within some sandfly species. Later on, the advanced molecular methods involving DNA barcoding were also incorporated into the sandfly taxonomy^[15,61], which strengthened the routinely practiced identification strategies, and reduced the ambiguities in species delimitation^[61,62].

The latest available checklist of Indian sandflies was consolidated by Ilango in 2009 with a record of 45 species in the article entitled “Moth Flies & Sand Flies (Diptera: Psychodidae) of India”[33]. Whereas, this current study enlightens the faunistic diversity of sandflies recorded in India with an updated list of 69 species. The difference of 24 species which was added in a span of a decade indicates that India have a high species diversity. Exploring this extremely diverse and unexplored areas, there will be an intriguing opportunities to add new species to the present list. Among the total species so far recorded, 25% were an addition to the global sandfly diversity[3]. In addition to the taxonomic descriptions, DNA barcodes were also developed for the major species and is accessible through the GenBank[15].

In 2020, an updated checklist of 22 species of sandflies belonging to two genera was published in Sri Lanka[64]. The country has a biogeographic similarity to the southern region of India. In comparison with this, the 69 species so far recorded in India signifies the species richness and habitat diversity of the country. Along with this the presence of species complex within the populations of *P. argentipes*[65] and *S. babu*[58] were also reported from India. The importance of sandfly diversity and bionomics is much relevant as it is endemic for leishmaniasis[11], which is solely transmitted by Phlebotomine sandflies.

P. argentipes, is the only species proven to transmit the *Leishmania* parasites (*L. donovani*) causes visceral leishmaniasis in India[15], whereas *P. papatasi*, is the vector *L. tropica* and causes cutaneous leishmaniasis in various parts of India like Rajasthan, and Jammu and Kashmir[49,66,67]. Typically, *L. donovani* causes visceral leishmaniasis whereas, *L. major* and *L. tropica* (anthropogenic form) causes cutaneous leishmaniasis, but recently *L. donovani* have been reported to also transmit cutaneous leishmaniasis among the tribal population of Kerala. The vector species of this atypical variant of *L. donovani* is reported to be *P. argentipes* and Himachal Pradesh[21,49]. In addition, many species of sandflies may have the potential for transmitting *Leishmania* parasites and could act as a secondary vector e.g., *P. salehi*, experimentally proven for its vector competence for *L. major* parasite in Iran and India[50,51].

Phlebotomus sp. are the potential vectors for leishmaniasis. However, members of the genus *Sergentomyia* are also known to be involved in the transmission of other viral and bacterial diseases[68,69]. *S. punjabensis* was suspected to be the vector responsible for the outbreak of chandipura virus[34]. Whereas in southern parts of Sri Lanka, *S. zeylanica* is suspected of transmitting leishmaniasis[35]. In Thailand, *S. barraudi* is considered as main suspected vector for both cutaneous leishmaniasis and visceral leishmaniasis[36,37]. The zoonotic transmission of parasite holds great significance in the Western Ghats region where the

tribal population are in constant contact between the forest and wildlife[13]. Many *Sergentomyia* sp. are responsible for causing leishmaniasis in animals which could act as reservoir host for the disease among the indigenous tribal population[13]. *S. baghdadis* is suspected vector of leishmaniasis in reptiles, whereas, *S. dentata* is proven to be the vector of leishmaniasis in lizards[38,39]. *S. gemmea*, on the other hand, contributes to the animal transmission of cutaneous leishmaniasis[54].

5. Limitations

The present review comprehends the information on updated checklist of Indian sandfly fauna retrieved from published resources (online and print) only. Therefore, the unpublished and entomological data related to sandfly survey conducted by various states authorities were not included in this review. Hence, spatial distribution and records of sandfly from different states may be under reported.

5. Conclusions

The India National Health Policy-2002 had set the goal of kala-azar elimination by the year 2010 which was revised to 2015 later and still the target remains elusive. Now the elimination of kala-azar has been targeted to 2030[70]. The most important component on the elimination strategies include integrated vector management. Apart from *P. argentipes* many other sandfly species which are proven and suspected vectors of visceral leishmaniasis and cutaneous leishmaniasis (zoonotic and anthroponotic) have been reported from India. This arena warrants a systematic knowledge on biology, bionomics, diversity and distribution of the sandflies. So, the present study aims at compilation of an updated checklist on the biodiversity and distribution of sandflies across the country from the available literature, may have important implications on the effective elimination goal of leishmaniasis.

Conflict of interest statement

Authors hereby declared that no conflict of interest is involved in this study.

Data availability

All data generated or analyzed during this study are included in this published article.

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Authors' contributions

P.S designed the study, analysed data and corrected the manuscript, H.K.S and F.P.A searched literature and wrote the manuscript, N.P.K and A.K critically reviewed the manuscript.

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