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## Mosquitoes (Diptera: Culicidae) of Jammu division of Jammu and Kashmir State, India, with new records

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### Abstract

Mosquito borne diseases, malaria and dengue are found in Jammu division of Jammu and Kashmir State. The information available on mosquito fauna occurring in Jammu division of Jammu and Kashmir dates back to 1983. Towards generating information on the current mosquito species diversity in the region, mosquito faunistic surveys were conducted from 2012 to 2015. Forty one species of 11 genera and 12 subgenera have been documented, of which 17 species were known earlier while 24 species are reported for the first time from the region. Six species reported earlier have not been collected in the present survey. Together with those 6 species, a total of 47 mosquito species have been documented in Jammu division.

**Keywords:** Mosquitoes, new records, Jammu division, India

### 1. Introduction

Mosquitoes belonging to family Culicidae and order Diptera are a large group of insects present throughout the temperate and tropical regions and even beyond the Arctic Circle of the world [1]. They are the vectors of many diseases like malaria, dengue, Japanese encephalitis, etc., which have been of grave concern due to the morbidity and mortality they cause around the globe. Detailed information (distribution, identification and description) regarding the mosquitoes of India was first compiled by Christophers [2] on anophelines and Barraud [3] on culicines in two monographs. Though Christophers [2] and Barraud [3] mentioned the mosquito species from Kashmir division, they have not included any mosquito species from Jammu division of Jammu and Kashmir State, India. The first report of mosquitoes from Jammu division dates back to Puri [4], who reported 8 anopheline species. High malaria prevalence in the State also drew the attention of Jacob [5] whose list of anopheline fauna in Jammu division included 10 species during malaria survey in Jammu and Kashmir State. These taxonomic surveys were focused only on anophelines due to high malaria prevalence. Then almost two decades later, a survey of haematophagous arthropods in Western Himalayas, Sikkim and Hill districts of West Bengal from 1967 to 1969 was carried out by Rao *et al.* who published their work in subsequent years, 1973, 1983 and 1984 [6-8]. They recorded 18 species of mosquitoes from the region consisting of 6 species of anophelines and 12 species of culicines. This was the only survey reporting both anopheline and culicine fauna of mosquitoes following which no faunistic surveys of mosquitoes in the region were done except for some studies confined to vector species and mosquito borne diseases (malaria and dengue) in Jammu division [9-16]. Thus, till 1969, 23 mosquito species were recorded from the division. Since then, the region has gone through much environmental changes particularly in the context of developmental activities and global warming. The current study is aimed at updating the mosquito fauna of Jammu division.

### 2. Materials and Methods

The area of Jammu and Kashmir State, India comprises of three divisions is 1, 01, 387 km<sup>2</sup>. The divisions, Jammu, Kashmir and Ladakh differ from each other in geography and climate. Jammu, one of the administrative divisions of Jammu and Kashmir State, India with a geographical area of 26293 km<sup>2</sup> (25.93% of State area) borders Kashmir to the north, Ladakh to the east, and Punjab and Himachal Pradesh to the south. In the west, the Line

of Control separates Jammu from Pakistani-administered Jammu and Kashmir. Most of the land is hilly or mountainous, including the Pir Panjal range which separates it from the Kashmir Valley.

The climate of Jammu division varies with altitude. In and around the region, the climate is similar to the nearby Punjab region with hot summers, rainy monsoon and mildly cold winters. The higher hills and mountains are snow-capped during the winter. Jammu region has two different climatic zones depending primarily on altitude. Lower hills and plains bear subtropical climate with hot dry summer lasting from April to July. In the high reaches of Chenab Valley, the climate is moist temperate, winters are severe and varied quantity of snow is received.

Present mosquito survey was carried out in two districts, Jammu and Udhampur, which represent most of the Jammu division in the context of geography and climate. Total of seven collections were made, in which four collections were made in Jammu district in November 2012, July 2013, October 2013 and May 2014. Fifth, sixth and seventh collections were made in both Jammu and Udhampur districts in November

2014, May-June 2015 and September 2015 respectively. In the surveys, a total of 47 locations were inspected for mosquitoes as shown in Table 1. Immatures were collected from breeding sources with the help of dipper and pipette and 4<sup>th</sup> stage larvae and pupae were reared individually to obtain larval and/or pupal exuviae and associated adults. Adult specimens were collected from indoor and outdoor shelters with oral and/or mechanical aspirator and sweep net.

Identifications of larvae and adults were carried out, following the keys and descriptions of Christophers [2], Barraud [3], Bram [17], Reid [18], Yiau-Min Huang [19], Sirivanakaran [20-22], Rattarithikul and Green [23], Reuben *et al.* [24], Nagpal *et al.* [25] and Becker *et al.* [26]. Males were used to confirm species identification, based on the observation of genitalia. Generic and sub generic classification of Culicidae was based on WRBU [27] or Harbach [28]. Generic and subgeneric abbreviations were used according to Reinert [29]. Adult specimens were pinned, and immature and male genitalia were mounted on microscope slides in Hoyer's medium. All the specimens are housed in the mosquito museum of Vector Control Research Centre, Puducherry, India.

**Table 1:** Study sites with geographical attributes

District	Study site	Coordinates	Altitude (meters)
Jammu	Jewel Chowk	32°43'16.28"N 74°51'24.65"E	259
	SRTC Yard - Bikram Chowk	32°42'50.65"N 74°51'33.68"E	266
	MA Stadium	Not known	
	Dogra Hall	32°44'21.48"N 72°51'40.68"E	331
	Bantalab	32°50'38.76"N 74°56'35.88"E	492
	Nandni	32°51'07.20"N 74°57'12.60"E	475
	Dansal	32°51'54.00"N 74°59'46.68"E	460
	Badso – Baghe	32°52'22.80"N 74°59'40.92"E	390
	Jindrah – Challad	32°49'20.64"N 75°04'39.36"E	475
	Panjoda bridge	32°45'23.76"N 74°57'44.28"E	358
	Surinsar	32°46'21.72"N 75°02'06.36"E	588
	Surinsar	32°46'02.64"N 75°02'32.64"E	545
	Surinsar - Urkhal	32°46'36.48"N 75°01'35.76"E	586
	Mansar	Not known	
	Kumbi Morh	32°43'58.80"N 75°05'54.60"E	605
	Athem – View Point	32°46'39.61"N 74°59'28.27"E	500
	Jaithly	32°45'29.52"N 75°03'39.60"E	530
	Sagoon	32°44'27.24"N 75°05'20.04"E	603
	Adhuvana Mori	32°41'49.89"N 74°47'57.13"E	255
	Nai Basti – Sohanjana	32°41'30.84"N 74°44'0.24"E	230
	Raipur	32°48'11.16"N 74°49'3.72"E	335
	Barn Morh	32°50'52.80"N 74°48'39.60"E	410
	Barn Upper	32°50'41.20"N 74°46'50.52"E	300
	Deran	32°49'09.84"N 74°45'54.72"E	260
	Kangrail	32°49'32.88"N 74°45'51.84"E	270
	Mishriwala	32°48'56.16"N 74°46'35.76"E	273
	Daskal	33°54'39.24"N 74°44'36.96"E	310
	Satryan – RS Pura	32°35'21.72"N 74°42'53.27"E	225
	Sidra – RS Pura	32°35'54.20"N 74°43'35.61"E	225
	Nagrota – Chirwa bridge	32°47'51.54"N 74°54'46.26"E	309
Nagrota – Balani bridge	32°49'01.08"N 74°55'33.63"E	329	
Bagh-E-Bahu	32°43'30.81"N 74°52'46.05"E	339	
Kachi Chhawani	32°44'14.57"N 74°52'19.51"E	347	
Udhampur	Phalata	32°53'52.08"N 75°02'45.24"E	650
	Birma	32°54'56.83"N 75°06'20.81"E	590
	Patnitop	33°5'11.04"N 75°19'41.88"E	1980
	Kud	33°03'56.52"N 75°17'45.96"E	1453
	Dabra	33°03'07.87"N 75°17'16.46"E	1350
	Jakheni Park	32°56'20.04"N 75°09'14.76"E	735
	Ritti	32°50'28.68"N 75°09'27.04"E	504
	Kaghote	32°48'26.28"N 75°12'30.24"E	575
	Trilla	32°48'44.28"N 75°11'3.84"E	553
	Jallow	32°47'44.52"N 75°14'11.40"E	625
	Kirmoo	32°46'54.84"N 75°17'17.16"E	717
	Battal Ballian – Bypass bridge	32°52'24.24"N 75°06'30.24"E	563
	Battal Ballian	32°51'42.84"N 75°07'35.40"E	564
	Battal Ballian	32°51'38.52"N 75°07'41.88"E	586

### 3. Results

Total mosquito specimens collected and preserved from Jammu division are 1903, of which 1153 mosquito adults were reared from larvae, 211 mosquitoes were collected as adults and 539 larvae, larval skins and pupal skins were mounted on slides. Forty one species were identified under 11 genera and 12 subgenera, of which 17 species have been reported earlier from the division. Remaining 24 species are new records to the division. Twelve species belong to anophelines and 29 species to culicines. Six species which were reported by earlier

workers were not collected in the present survey. Together with those 6 species, total number of mosquito species of Jammu division increases to 47 as shown in Table 2.

The genus *Anopheles* was represented by 2 subgenera and the genus *Culex* by 5 subgenera. The genus *Culex* was more diverse, with 18 species followed by *Anopheles* with 12 species; *Lutzia* and *Stegomyia* with 2 species each; *Armigeres*, *Collessius*, *Fredwardsius*, *Gilesius*, *Malaya*, *Neomelaniconion* and *Toxorhynchites* with 1 species each.

**Table 2:** List of the total number of species reported from 1948 to 2015

S. No.	Species	Puri <sup>[4]</sup>	Jacob <sup>[5]</sup>	Rao <i>et al.</i> <sup>[6-8]</sup>	Authors	Remarks
1	<i>Anopheles (Anopheles) lindesayi</i>	×	×	×	×	
2	<i>An. (Ano.) peditaeniatus</i>				×	New record
3	<i>An. (Ano.) sinensis</i>				×	New record
4	<i>Anopheles (Cellia) annularis</i>	×	×	×	×	
5	<i>An. (Cel.) culicifacies</i>	×	×	×	×	
6	<i>An. (Cel.) dthali</i>		×			
7	<i>An. (Cel.) dravidicus</i>				×	New record
8	<i>An. (Cel.) fluviatilis</i>	×	×	×	×	
9	<i>An. (Cel.) maculatus</i>				×	New record
10	<i>An. (Cel.) pseudowillmori</i>				×	New record
11	<i>An. (Cel.) splendidus</i>	×	×	×	×	
12	<i>An. (Cel.) stephensi</i>	×	×		×	
13	<i>An. (Cel.) subpictus</i>	×	×	×		
14	<i>An. (Cel.) turkhudi</i>		×	×		
15	<i>An. (Cel.) willmori</i>	×	×	×	×	
16	<i>Armigeres (Armigeres) subalbatus</i>				×	New record
17	<i>Collessius (Alloeomyia) pseudotaeniatus</i>				×	New record
18	<i>Co. (Collessius) elsiae</i>			×		
19	<i>Culex (Culex) barraudi</i>			×	×	
20	<i>Cx. (Cux.) fuscocephala</i>			×	×	
21	<i>Cx. (Cux.) mimeticus</i>			×	×	
22	<i>Cx. (Cux.) mimulus</i>				×	New record
23	<i>Cx. (Cux.) murrelli</i>				×	New record
24	<i>Cx. (Cux.) perexiguus</i>				×	New record
25	<i>Cx. (Cux.) perplexus</i>				×	New record
26	<i>Cx. (Cux.) pseudovishnui</i>				×	New record
27	<i>Cx. (Cux.) quinquefasciatus</i>			×	×	
28	<i>Cx. (Cux.) theileri</i>				×	New record
29	<i>Cx. (Cux.) tritaeniorhynchus</i>				×	New record
30	<i>Cx. (Cux.) vagans</i>				×	New record
31	<i>Cx. (Cux.) vishnui</i>			×		
32	<i>Cx. (Culiciomyia) pallidothorax</i>			×	×	
33	<i>Cx. (Cui.) viridiventer</i>			×	×	
34	<i>Cx. (Eumelanomyia) brevipalpis</i>				×	New record
35	<i>Cx. (Eum.) malayi</i>				×	New record
36	<i>Cx. (Lophoceraomyia) minutissimus</i>				×	New record
37	<i>Cx. (Oculeomyia) bitaeniorhynchus</i>			×	×	
38	<i>Fredwardsius vittatus</i>			×	×	
39	<i>Gilesius pulchriverter</i>				×	New record
40	<i>Lutzia (Metalutzia) fuscana</i>				×	New record
41	<i>Lt. (Met.) halifaxii</i>				×	New record
42	<i>Malaya genurostris</i>				×	New record
43	<i>Neomelaniconion lineatopenne</i>				×	New record
44	<i>Stegomyia albopicta</i>			×	×	
45	<i>St. (Stegomyia) aegypti</i>				×	Cannot be considered a new record as it was reported by Mathew <i>et al.</i> <sup>[9]</sup> and Padbidri <i>et al.</i> <sup>[14]</sup> who worked on dengue outbreaks in Jammu division
46	<i>St. w-albus</i>			×		
47	<i>Toxorhynchites (Toxorhynchites) splendens</i>				×	New record

In subgenus *Cellia* of anophelines, 9 species, *An. annularis*, *An. culicifacies*, *An. dravidicus*, *An. fluviatilis*, *An. maculatus*, *An. pseudowillmori*, *An. splendidus*, *An. stephensi* and *An. willmori* were collected. Three species, *An. culicifacies*, *An. maculatus* and *An. willmori* were found breeding in association in most of the habitats. In subgenus *Anopheles*, 3 species, *An. lindesayi*, *An. peditaeniatus* and *An. sinensis* were collected. *An. dravidicus*, *An. maculatus*, *An. peditaeniatus*, *An. pseudowillmori* and *An. sinensis* are new records to the division.

Seven species collected, *Ar. subalbatus*, *Co. pseudotaeniatus*, *Fr. vittatus*, *Gi. pulchriventer*, *Ne. lineatopenne*, *St. aegypti* and *St. albopicta*, belong to the tribe Aedini, of which *Ar. subalbatus*, *Co. pseudotaeniatus*, *Gi. pulchriventer* and *Ne. lineatopenne* are new records to the division.

The genera *Culex* and *Lutzia* belong to tribe Culicini and in genus *Culex*, the species belonging to subgenera *Culex*, *Culicomyia*, *Eumelanomyia*, *Lophoceraomyia* and *Oculeomyia* were collected. Genus *Lutzia* and subgenera *Eumelanomyia* and *Lophoceraomyia* were reported first time from the division.

In the genus *Culex*, 18 species were collected of which 10 species, namely, *Cx. mimulus*, *Cx. murrelli*, *Cx. perplexus*, *Cx. pseudovishnui*, *Cx. theileri*, *Cx. tritaeniorhynchus*, *Cx. vagans*, *Cx. brevipalpis*, *Cx. malayi* and *Cx. minutissimus* are new

records to the division. In this genus, the species breeding in association with most of the species was *Cx. mimeticus* (22 species), *Cx. barraudi* (21 species) and *Cx. bitaeniorhynchus* (16 species). In the genus *Lutzia*, *Lt. fuscana* and *Lt. halifaxii* were the two species newly collected.

*Malaya genurostris* in the tribe Sabethini and *Toxorhynchites (Toxorhynchites) splendens* in the tribe Toxorhynchitini are also new records to the division.

Among 15 larval habitats surveyed (Table 3), streams are largely available in all the localities and stream margin constitutes one of the important larval habitats from which 18 species were collected. Equal number of species was collected from cement tanks used to store water for drinking, irrigation and other purposes. Seepages contributed 15 species, followed by rock pools (13 species), discarded tyres (11 species) and ground pools (9 species). Twenty three species were obtained from more than one larval habitat and 18 species were found only in one larval habitat. *Cx. tritaeniorhynchus* was collected from most of the larval habitats (8 types) followed by *An. culicifacies*, *An. fluviatilis*, *Cx. quinquefasciatus*, *Cx. barraudi* and *Cx. mimeticus* from 6 types of larval habitats each and *An. willmori*, *An. maculatus* and *Cx. bitaeniorhynchus* from 5 each.

**Table 3:** List of the larval habitats with the species collected in the present survey

Species	Larval Habitats														Total		
	Stream margin	River margin	Stream pool	Seepage	Rock pool	Rock hole	Irrigation canal	Ground pool	Spring pool	Bamboo	Arum plant	Storage containers		Discarded materials			
												Cement tank	Sintex tank	Tyre		Bucket	
<i>An. lindesayi</i>	x			x													2
<i>An. peditaeniatus</i>							x					x					2
<i>An. sinensis</i>												x					1
<i>An. annularis</i>	x			x				x				x					4
<i>An. culicifacies</i>	x	x	x	x	x							x					6
<i>An. dravidicus</i>	x																1
<i>An. fluviatilis</i>	x		x	x	x			x				x					6
<i>An. maculatus</i>	x		x	x	x										x		5
<i>An. pseudowillmori</i>	x			x													2
<i>An. splendidus</i>				x													1
<i>An. stephensi</i>	x			x	x												3
<i>An. willmori</i>	x		x	x	x										x		5
<i>Ar. subalbatus</i>											x					x	2
<i>Co. pseudotaeniatus</i>						x									x		2
<i>Cx. barraudi</i>	x		x	x	x		x					x					6
<i>Cx. fuscocephala</i>	x						x	x									3
<i>Cx. mimeticus</i>	x			x	x	x		x				x					6
<i>Cx. mimulus</i>	x				x							x					3
<i>Cx. murrelli</i>							x										1
<i>Cx. perexiguus</i>					x												1
<i>Cx. perplexus</i>												x					1
<i>Cx. pseudovishnui</i>	x			x								x					3
<i>Cx. quinquefasciatus</i>		x			x		x	x				x					6
<i>Cx. theileri</i>	x		x				x					x					4
<i>Cx. tritaeniorhynchus</i>	x		x	x	x	x	x	x				x					8
<i>Cx. vagans</i>					x		x					x					4
<i>Cx. pallidothorax</i>															x		1
<i>Cx. viridiventer</i>															x		1
<i>Cx. brevipalpis</i>															x		1
<i>Cx. malayi</i>												x					1
<i>Cx. minutissimus</i>			x														1
<i>Cx. bitaeniorhynchus</i>	x			x	x			x				x					5
<i>Fr. vittatus</i>															x		1



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