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Jagbir Singh Kirti
Department of Zoology &
Environmental Sciences, Punjabi
University, Patiala- 147002
(Punjab), India

Simarjit Kaur
Department of Zoology &
Environmental Sciences, Punjabi
University, Patiala- 147002
(Punjab), India

Culicinae diversity (Culicidae: Diptera) from Punjab (India) with reference to impact of ecological changes

Jagbir Singh Kirti and Simarjit Kaur

Abstract

Intensive and extensive collection-cum-survey tours were conducted in three major regions of Punjab (Malwa, Doaba and Majha) to study mosquito diversity of the state from 2009- 2011. A total number of 26 species referable to 13 genera were recorded during three years period. All these species were earlier known from Punjab except *Culex (Culex) sitiens* Wiedemann, *Culex (Eumelanomyia) brevipalpi* (Giles), *Lutzia (Metalutzia) vorax* Edwards and *Mansonia (Mansonioides) indiana* Edwards which are reported for the first time from this agriculture state. Larval characteristics, collection sites, bionomics and vector potential for each of these species are described. A list of Culicinae of Punjab state has also been provided.

Keywords: List, mosquitoes, Punjab, new records.

1. Introduction

Climate change and global warming are posing a serious threat to unusual social upheaval, population displacement, economic hardship and environment degradation. It has been proposed that humans are in the midst of a new epidemiological transaction in which globalization and ecological disruption appeared to be associated with newly emerging infectious as well as re-emerging infections previously thought to be under control. Such disruption and resurgences are especially important in the dramatic rise in zoonotic diseases. At the same time, greater mobility and trends in urbanization have contributed to the spread of various vectors and vector-borne diseases and have made them of global nature. The occurrences of these vectors and diseases in all parts of the globe have also been an integral part of human history. During recorded history, some insect vectors have dispersed to new habitats by "Phoresy" (i.e. one organism transporting another), flight or wind, but human aided transport has been responsible for the arrival and spread of most invasive vectors, such as mosquito, fleas and lice. Yellow fever, Dengue, Malaria and West Nile Encephalitis are some of the diseases that have breached biographic barriers through anthropogenic movements (Lounibos, 2002) ^[1]. The links between biodiversity and human health occur from the microbial level to that of the habitat. Mechanistic pathways that lead from changed biodiversity to human health can occur at genetic, microbial, organismal (host or vector species), community and habitat levels.

Ecological modifications induced by climatic changes and global warming in many Indian states warrant intensive and extensive collections, surveys for mosquito vectors in the country. Most of the faunistic studies on Culicidae taxonomy were conducted a long time back by workers like Christophers (1933) ^[2] and Barraud (1934) ^[3]. The population of India has already increased many times and reached more than one billion recently which has greatly affected the entire ecosystem.

Out of many Indian states, Punjab has experienced maximum deforestation due to green revolution for the last 50 years, or so. The ecology of the state has undergone tremendous changes and rice ecosystem has increased from 4.79% in 1960 to 33.37% in 2004-05. The recent emergence of diseases like Dengue in most parts of state and reporting of few cases of Japanese Encephalitis from a few areas are very serious concerns for the human health of the state.

Intensive and extensive collection cum survey tours were conducted from 2009-2011 to study Culicinae diversity and various ecological factors from the state. A total number of 26 species

For Correspondence:
Simarjit Kaur
Department of Zoology &
Environmental Sciences, Punjabi
University, Patiala- 147002
(Punjab), India

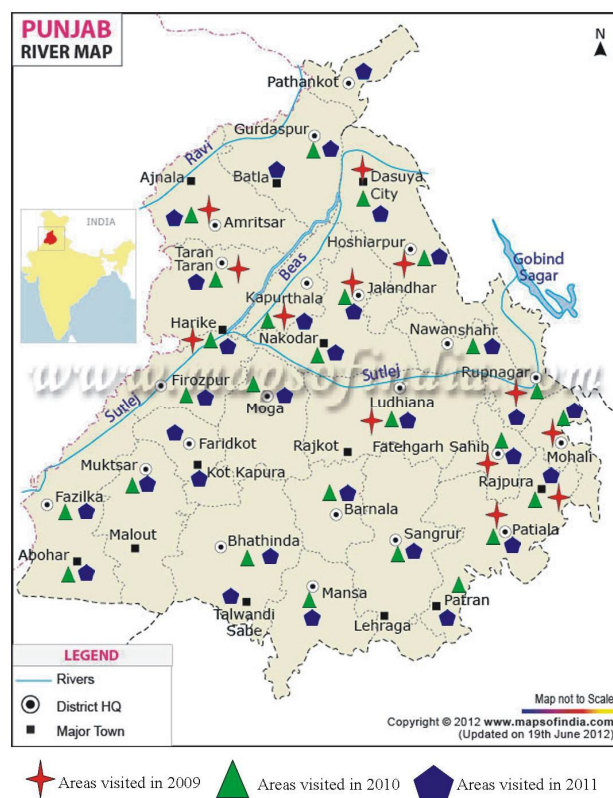
referable to 13 genera were collected, authentically identified and studied in details for various morphological characters including genitalic attributes. Four species *Culex* (*Culex*) *sitiens* Wiedemann, *Culex* (*Eumelanomyia*) *brevipalpi* (Giles), *Lutzia* (*Metalutzia*) *vorax* Edwards and *Mansonia* (*Mansonioides*) *indiana* Edwards have been reported for the first time from the boundaries of the state. It was very important to cite that as many as 21 species belonging to seven genera which existed earlier could not be procured during these surveys.

2. Materials and methods

2.1 Study area

Punjab is located in northwestern India, and has an area of 50,362 km². It is located at the latitude 30° 4' North and longitude 75° 5' East. It is bounded on the west by Pakistan, north by Jammu and Kashmir, northeast by Himachal Pradesh

and south by Haryana and Rajasthan. Most of the area of this state comprises of fertile plains, alluvial plain with three rivers and an extensive canal system for irrigation. A belt of undulating Lower Shivalik hills extends along the northeastern part of the state. Its average elevation is 300 meters above sea level, ranging from 180 meters in the southwest to more than 500 meters around the northeast border. The southwest of the state is semi-arid, eventually merging into the Thar Desert. Punjab is divided into three major regions, viz., Malwa, Majha and Doaba. Malwa region also called central Punjab covers as many as 11 districts. The major districts under this region are Ludhiana, Bathinda, Mansa, Sangrur and Patiala. Districts like Amritsar, Pathankot, Gurdaspur and Tarn Taran constitute the Majha region of Punjab. Whereas Doaba region of Punjab includes districts like Kapurthala, Jalandhar, Hoshiarpur and Shaheed Bhagat Singh Nagar (Nawashehar) (Map).



Map: Map of Punjab showing various Collection sites surveyed during 2009-2011.

2.2 Collection

In the present study, adult and larval stages were collected during following months from different localities of various districts of Punjab, India.

- Summer (April to June), when temperature typically rises as high as 43 °C.
- Monsoon season (July to September), when a majority of rainfall occurs.
- Winter (December to February), when temperatures typically falls as low as 4 °C.

There is a transitional period between winter and summer in March and early April (Spring season), as well as a transitional

season between monsoon and winter in October and November (Autumn season).

2.2.1 Adult collection

Adult mosquitoes were collected with the help of oral aspirators and torch light during dawn (06:00 – 09:30) and dusk hours (18:00 – 21:30) from human dwellings and cattle sheds. Apart from this, catches in outdoor shelters like gardens, nurseries and wild vegetation were also made during day time. Pertinent collection details were recorded in the field for each collected specimen. Adults were killed with the help of ethyl acetate vapors and then mounted on wedge of thick

paper supported by entomological pin. These specimens were preserved in collection boxes containing naphthalene balls. Sorting and determination of the specimens for quantitative and qualitative investigations was rendered in the laboratory.

2.2.2 Larval collection

Standard entomological dipping technique was followed for the collection of the immature stages from a range of breeding sites like paddy fields, artificial plastic containers, desert coolers, used tyres, mud pots, pitchers, tube-wells, open natural pools and pitfall which provide suitable breeding places for mosquitoes around the year. The immature stages brought from the field were reared in the laboratory until adult emergence.

2.3 Identification of mosquitoes

The following keys were followed for the identification of mosquitoes:

2.3.1 Adult Mosquitoes

Culicine and other anopheline species were separated by using standard taxonomic keys of Barraud (1934), Srivanakam (1976) [4], Huang (1972, 1979) [5, 6], Reuben *et al.* (1994) [7] and Reinert *et al.* (2004) [8].

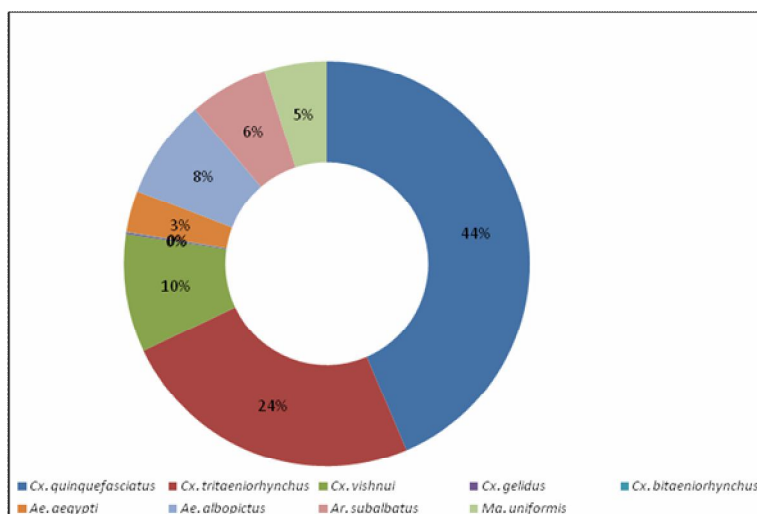
2.3.2 Immature Stages

The field collected larvae were separated up to species level with the help of keys by Rattarithikul (1982) [9] and Reuben *et al.* (1994).

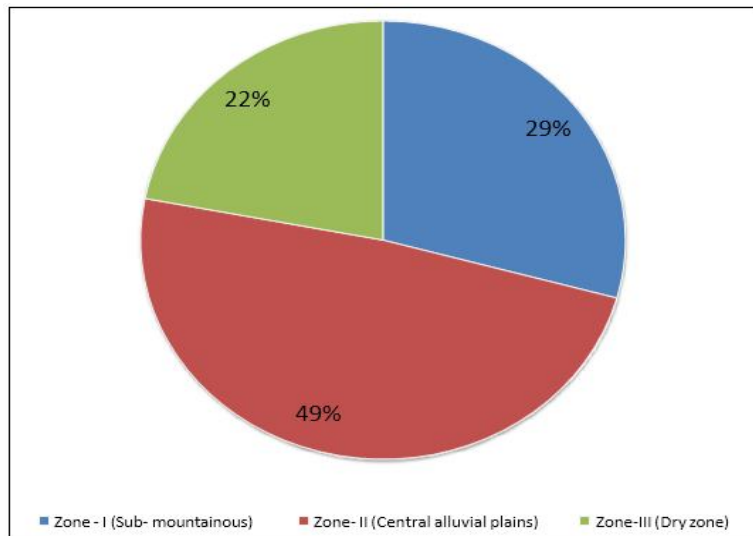
3. Results and Discussion

Intensive and extensive collection-cum-survey tours were conducted in three major regions of Punjab i.e. Malwa, Doaba and Majha to study mosquito diversity of the state from 2009-2011. These surveys yielded 10, 302 adult representatives of 26 species referable to 13 genera viz., *Aedes* Meigen, *Armigeres* Theobald, *Christophersiomyia* Barraud, *Coquillettidia* Dyar, *Culex* Linnaeus, *Fredwardsius* Reinert, *Lutzia* Theobald, *Mansonia* Blanchard, *Mimomyia* Theobald, *Mucidus* Theobald, *Neomelaniconion* Newstead, *Stegomyia* Theobald and *Verrallina* Theobald. Out of these genera, genus *Culex* was found to be the predominant taxa,

with record of 9 species. It was observed that all these species exploit a variety of habitats as shown in table- I. Genus *Culex* is followed by *Stegomyia* with 3 species and *Aedes*, *Lutzia* and *Mansonia*, each with 2 species. Rest of the each genera studied in present work are represented by a single species. *Culex quinquefasciatus* Say was the most dominant species followed by *Culex tritaeniorhynchus* Giles throughout Punjab (Graph 1). Maximum number of species was recorded from Central alluvial plains known as Zone II and least from Dry zone i.e. Zone- III (Graph 2). Out of 26 species, 10 are known vectors of various vector borne diseases in India. All these species viz., *Aedes aegypti* (Linnaeus), *Aedes albopictus* (Skuse), *Culex (Oculeomyia) bitaeniorhynchus* Giles, *Culex (Culex) gelidus*, *Culex (Culex) tritaeniorhynchus* Giles, *Culex (Culex) vishnui* Theobald, *Culex (Culex) pseudovishnui* Colless, *Culex (Culex) quinquefasciatus* Say, *Mansonia (Mansonioides) indiana* Edwards and *Mansonia (Mansonioides) uniformis* (Theobald) have been studied to considerable details. It is worth to mention here that Barraud (1934) recorded as many as 36 species of Culicinae from undivided Punjab. After this workers like Paul (1970) [10], Sagandeep (1990) [11], Sagandeep *et al.* (1994) [12] and Kirti and Kaur (1999 and 2004) [13, 14] recorded 7 additional species from the state. However, in the present study only 26 species of Culicinae could be collected and recorded which were earlier well known from this state except *Culex (Culex) sitiens* Wiedemann, *Culex (Eumelanomyia) brevivalpi* (Giles), *Lutzia (Metalutzia) vorax* Edwards and *Mansonia (Mansonioides) indiana* Edwards which have been reported for the first time. Besides this, many new habitats have been explored in the present work. Some of the habitats like artificial containers, discarded containers, flower pots, decoration pots, ditches, ground pool, tyres, paddy fields and cemented water storage tanks etc. have been surveyed. It has been observed that 2 species belonging to genus *Aedes* namely *Aedes aegypti* (Linnaeus) and *Aedes albopictus* (Skuse) which were earlier restricted to few areas like Ludhiana, but now can be found in almost all the parts of Punjab. Due to this reason more and more cases of dengue are being reported from various parts of the state.



Graph 1: Relative abundance of 9 Culicinae species collected from three regions of Punjab from 2009-2011



Graph 2: Number of culicine species collected from different geographical zones of Punjab

Table 1: Larvae & adult representatives of various mosquito species collected from different districts & wetlands of Punjab from 2009 -2011

Species	Habitats*										
	AC	D	GP	T	PF	WC	MP	C	CB	DC	OC
<i>Armigeres (Armigeres) subalbatus</i>	+								+	+	+
<i>Christophersomyia thomsoni</i>										+	
<i>Coquillettidia (Coquillettidia) crassipes</i>										+	
<i>Culex (Culex) gelidus</i>										+	
<i>Culex (Culex) pseudovishnui</i>										+	
<i>Culex (Culex) quinquefasciatus</i>	+	+				+	+		+	+	
<i>Culex (Culex) sitiens</i>										+	
<i>Culex (Culex) tritaeniorhynchus</i>		+			+	+			+	+	
<i>Culex (Culex) vishnui</i>										+	
<i>Culex (Culex) univittatus</i>										+	
<i>Culex (Eumelanomyia) brevipalpi</i>										+	
<i>Culex (Oculeomyia) bitaeniorhynchus</i>											+
<i>Fredwardsius vittatus</i>											+
<i>Lutzia (Metalutzia) fuscana</i>	+									+	
<i>Lutzia (Metalutzia) vorax</i>										+	
<i>Mansonia (Mansonioides) indiana</i>										+	
<i>Mansonia (Mansonioides) uniformis</i>										+	
<i>Mimomyia (Mimomyia) chamberlaini</i>										+	
<i>Mucidus scatophagoides</i>			+								
<i>Neomelaniconion lineatopenne</i>			+								
<i>Aedes aegypti</i>	+			+				+			+
<i>Aedes albopictus</i>	+			+			+	+			+
<i>Stegomyia gardnerii gardnerii</i>											+
<i>Stegomyia unilineata</i>											+
<i>Stegomyia w-albus</i>											+
<i>Verrallina (Neomacleaya) indica</i>										+	

*AC (Artificial containers), D (ditch), GP (ground pool), T (tyre), PF (paddy fields), WC (well/cemented tank), MP (mud pots), C (Coolers), CB (cattle biting), DC (Dusk and dawn collection), OR (outdoor resting), + (present).

Table 2: Culicinae diversity of Punjab including previously and presently (2009-2011) recorded species.

Sr No.	Name of the Species	Barraud (1934)	Aslamkhan (1971) [17]	Paul (1970) Sagandeep (1990, 1997) [18]	Kirti &Kaur (1999), Kaur (2001)[19]	Present status	Remarks
		British Punjab	Western Punjab	Indian Punjab			
1	<i>Aedes (Aedimorphus) culicinus</i>	+	+	-	-	-	
2	<i>Aedes (Aedimorphus) jamesi</i>	-	-	-	+	-	
3	<i>Aedes (Aedimorphus) taeniorhynchoides</i>	+	+	-	-	-	
4	<i>Aedes (Aedimorphus) pallidostratus</i>	+	+	-	-	-	
5	<i>Aedes (Aedimorphus) vexans</i>	+	+	-	-	-	
6	<i>Armigeres (Armigeres) subalbatus</i>	+	+	-	+	+	
7	<i>Armigeres (Armigeres) kuchingensis</i>	-	-	+	-	-	
8	<i>Christophersomyia thomsoni</i>	-	+	-	-	+	
9	<i>Coquillettidia crassipes</i>	+	+	-	-	+	
10	<i>Culex (Culex) barraudi</i>	+	+	-	-	-	
11	<i>Culex (Culex) fuscocephala</i>	+	+	-	-	-	
12	<i>Culex (Culex) gelidus</i>	+	+	-	+	+	
13	<i>Culex (Culex) pseudovishnui</i>	-	+	-	+	+	
14	<i>Culex (Culex) perplexus</i>	-	-	+	-	-	
15	<i>Culex (Culex) quinquefasciatus</i>	+	+	+	+	+	Common species
16	<i>Culex (Culex) sitiens</i>	-	+	-	-	+	New record
17	<i>Culex (Culex) tritaeniorhynchus</i>	+	+	+	+	+	Common species
18	<i>Culex (Culex) theileri</i>	+	+	-	-	-	
19	<i>Culex (Culex) vagans</i>	+	+	-	-	-	
20	<i>Culex (Culex) vishnui</i>	+	+	+	+	+	Common species
21	<i>Culex (Culex) univittatus</i>	+	+	-	-	+	
22	<i>Culex (Culex) whitmorei</i>	+	+	-	+	-	
23	<i>Culex (Culiciomyia) pallidothorax</i>	+	+	-	-	-	
24	<i>Culex (Eumelanomyia) brevipalpi</i>	-	-	-	-	+	New record
25	<i>Culex (Eumelanomyia) malayi</i>	+	+	-	-	-	
26	<i>Culex (Lophoceraomyia) minutissimus</i>	+	-	-	-	-	
27	<i>Culex (Oculeomyia) bitaeniorhynchus</i>	+	+	+	+	+	Common species
28	<i>Culex (Oculeomyia) epidesmus</i>	+	+	-	+	-	
29	<i>Fredwardsius vittatus</i>	-	+	+	-	+	
30	<i>Lutzia (Metalutzia) fuscana</i>	+	+	+	+	+	Common species
31	<i>Lutzia (Metalutzia) halifaxii</i>	+	+	-	+	-	
32	<i>Lutzia (Metalutzia) vorax</i>	-	-	-	-	+	New record
33	<i>Lutzia (Insulalutzia) raptor</i>	+	-	-	-	-	
34	<i>Mansonia (Mansonioides) indiana</i>	-	+	-	-	+	New record
35	<i>Mansonia (Mansonioides) longipalpi</i>	-	-	-	+	-	
36	<i>Mansonia (Mansonioides) uniformis</i>	+	+	-	+	+	
37	<i>Mimomyia (Mimomyia) chamberlaini</i>	+	+	-	+	+	

38	<i>Mucidus (Mucidus) scatophagoides</i>	-	+	-	+	+	
39	<i>Neomelaniconion lineatopenne</i>	+	+	-	+	+	
40	<i>Ochlerotatus (Finlaya) gubernatoris</i>	+	-	-	-	-	
41	<i>Ochlerotatus (Finlaya) pseudotaeniatus</i>	+	-	-	-	-	
42	<i>Ochlerotatus (Ochlerotatus) caspius</i>	+	+	-	-	-	
43	<i>Aedes aegypti</i>	+	+	+	+	+	Common species
44	<i>Aedes albopictus</i>	+	+	+	+	+	Common species
45	<i>Stegomyia gardnerii</i>	+	-	-	+	+	
46	<i>Stegomyia unilineata</i>	+	+	-	-	+	
47	<i>Stegomyia w-albus</i>	+	+	-	+	+	
48	<i>Verrallina (Neomacleaya) indica</i>	+	+	-	+	+	
49	<i>Verrallina (Verrallina) yusafi</i>	+	+	-	-	-	
	Total	37	38	10	22	26	

3.1 Remarks on new culicinae records from the state

3.1.1 *Culex (Culex) sitiens* Wiedemann

This species is native to entire oriental region with extensions from north and northeast as far as southern China, Japan and adjoining areas. It has also been reported from the Ethiopian region, Middle East, Micronesia, south Pacific, New Guinea and northern Australia (Sirivanakarn, 1976). The larvae of this species are found in brackish, salt and fresh groundwater habitats and some artificial containers along coastal areas. Females feed primarily on birds and pigs, but often bite man. Though the species is capable of transmitting Japanese Encephalitis virus in the laboratory but no more data is available for its role in the natural transmission of this virus. The species was reported naturally infected with *Brugia malayi* in Thailand by Harbach in 1988^[15]. During the present surveys, the species could only be located in districts of Ludhiana and Patiala.

3.1.2 *Culex (Eumelanomyia) brevipalpi* (Giles):

This species is known to occur in East Asia. As far as India is concerned, it was reported from Western Ghats (Tewari *et al.*, 2007)^[16]. Larvae of this species usually occur in tree holes and bamboo. In the present study, *Cx. brevipalpi* was collected during dawn and dusk hours from cattle sheds and mixed dwellings. There are no records available for this species as far as its vectorial capacity is concerned.

3.1.3 *Lutzia (Metalutzia) vorax* (Edwards):

This species was reported from India, Hong Kong and Japan by Barraud in 1934. The immature stages of this species are found in natural pools, shallow wells and domestic collections of water etc. Only two specimens could be collected during different surveys and it seems to be very rare in the state. The perusal of the literature shows that the species has not been listed as carrier/vector anywhere in the world.

3.1.4 *Mansonia (Mansonioides) indiana* Edwards:

The species *indiana* was earlier reported from Eastern and southern India (Barraud, 1934). The larvae of this species occur in swamps and pools, especially in overgrown dense

vegetations while clinging to the roots of plants in floating masses. Water lettuce (*Pistia*) is commonly used as a host plant. Larvae detach and re-attach to host plants quite readily. The females of this species are vicious nocturnal biters. This species was collected from Harike wetland during dusk hours in the present study. However, it could not be collected from any other area of Punjab.

It is worth to mention here that as many as 21 species referable to 7 genera i.e. *Aedes* Meigen, *Armigeres* Theobald, *Culex* Linnaeus, *Lutzia* Theobald, *Mansonia* Blanchard, *Ochlerotatus* Lynch Arribalzaga and *Verrallina* Theobald could not be traced during the surveys conducted in Punjab from 2009-2011 (Table 2).

Because of drastic ecological changes in Punjab due to large scale mono-culture of rice crop for the last three and half decades, the Culicinae fauna has altogether changed. Though there is a marginal decline in cases of Malaria in the state and whole North India but at the same time there is increase in Dengue and Japanese Encephalitis (JE) in parts of North India. It is recommended that intensive and extensive surveys have to be carried out in rest of the states as early as possible so that findings can be utilized by public health authorities of the state and the region for taking preventive measures against the outbreak of the vector borne diseases.

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