# AN UPDATE ON INVENTORY AND BIODIVERSITY OF MOSQUITO-FAUNA (DIPTERA: INSECTA) OF JAMMU, KASHMIR AND LADAKH HIMALAYA, INDIA

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#### ABSTRACT

This paper deals with 44 species of mosquitoes, under 8 genera and 12 sub-genera, occurring in diverse localities of Jammu, Kashmir and Ladakh Himalayan regions. These species belong to two main sub-families of family Culicidae, *viz*. Anophelinae and Culicinae. The culicine taxa accounts for 56.81% and anopheline taxa as 43.18 % of the total mosquito-fauna of J & K State The Kashmir Province has shown the prevalence of 27 spp. (17 spp. of anophelines, 10 spp. of culicines) of mosquitoes, followed by Jammu Province, having 18 spp. (4 spp. of anophelines, 14 spp. of culicines) and Ladakh Province, showed the occurrence of 10 spp. of culicines. The main mosquitoes of medical importance in this State are: *Anopheles culicifacies, A. fluviatilis*as vectors of human malaria and*Stegomyia (S.) aegypti* and *S. albopicta*as vectors of Dengue/ Dengue haemorrahagic fever. An up-to-date systematic inventory of mosquito specieshas been provided. In addition to this, faunal distribution and diversity have been discussed.

Keywords: Mosquito-Fauna, Inventory, Biodiversity, J&K State

#### INTRODUCTION

Mosquitoes belong to insect order Diptera, sub-order Nematocera, Infra-order Culicomorpha and family Culicidae. The adult mosquitoes are elongated, long-legged, having long forwardly directed proboscis and presence of scales on most part of the body. The larval stages are aquatic. The adult female mosquitoes are blood-sucking parasites, whereas adult males feed on vegetation and plant material. Mosquitoes have medical and veterinary importance because female annoy human and other animals besides, as biological vectors of important human, domestic animals and poultry diseases. The pathogens transmitted by mosquitoes include viruses (arbo viruses), filarial worms (helminths) and protozoans.

The earliest studies on mosquito-fauna of Jammu, Kashmir and Ladakh Himalayan regions were accomplished by Gill (1920), Barraud (1924a, 1924b, 1924c, 1934), Covell (1927, 1931), Christopher (1933), Puri (1948) and James and Liston (1954). The previous faunal records of about 30 species of mosquitoes of J& K Himalayan regions, belonging to various districts, *viz*. Doda, Udhampur, Rajouri (Jammu Privince), Srinagar, Anantnag, Baramula (Kashmir) and Kargil and Leh (Ladakh), have been given by Rao *et al.*, (1973). Later, Bhat and Kulkarni (1971, 1983), recorded the occurrence of 27 species of mosquitoes from J & K State. In the recent years, the papers of Nair (1973), Rao (1981), Buhroo and Chishti (1999), Kaur (1992, 2003) and Jabansen *et al.*, (2012), have provided additional records of mosquito species as well as detailed distribution of mosquito-fauna pertaining this region.

#### MATERIALS AND METHODS

The database presented in this paper pertains to 44 species of mosquitoes, occurring in diverse habitats, in vast localities of Jammu and Kashmir State. This State is situated in the northern part of the Indian subcontinent in the Karakorum and western Himalayan mountain ranges. This State is divided into three geographically and climatically different Provinces, *viz*. Ladakh (cold desert), Kashmir (temperate) and Jammu (sub-tropical). The database of mosquito-fauna and biodiversity of these regions of paramount zoo-geographical importance has been updated in the light of latest taxonomical changes and present status. In this direction, recently published research articles on mosquitoes of these regions and world online data on inventory, systematic catalogue (Culicidae) and as vector of diseases, have been consulted.

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The valid mosquito species and sub-species of Jammu, Kashmir and Ladakh Himalayan regions, are listed under systematic inventory. In this inventory, the synonyms of taxa are listed under valid species, given in parentheses. The references pertaining to authors reporting and describing taxa are in the form of code numbers, given in the long brackets, in front of each listed valid species and also synonyms. In addition to these, abbreviations in connection with local distribution of mosquito taxa, have been used. The keys to the code numbers and abbreviations are cited at the end of the systematic Inventory. For the purpose of updation of nomenclatural and systematic changes of mosquito-fauna, the online data and the catalogues on mosquitoes of the world, given by Knight and Stone (1977), Gaffigan *et al.*, (2013) and Harback (2014), have been followed.

#### **RESULTS AND DISCUSSION**

Systematic Inventory Order: Diptera Family: Culicidae Subfamily 1: Anophelinae Genus: Anopheles Subgenus: Anopheles 1. Anopheles (Anopheles) barianensis James ()[11] (=Anopheles barianensis James) [8,9,10] Distribution: K (Nas, Sri) 2. Anopheles (Anopheles) barberi Coquillett [9] Distribution: K (Gul, Hok, Kha) 3. Anopheles(A.) gigas Giles [ 5, 8, 9, 11, 18 ] (=Anopheles (Anopheles) gigassimlensis) [5, 15] (=Anopheles simelensis Giles) Gill(10) Distribution: K (Bar, Gul) 4. Anopheles(A.) hyrcanus (Pallas) [18] Distribution: K (Karn) 5. Anopheles(A.) lindesayi Giles[11] (=Anopheles lindesayiGiles) [5,9,10,14] Distribution:K (Gul) 6. Anopheles(Anopheles) maculipalpis Giles [11] (=Anopheles maculipalpisGiles)[9, 10] Distribution: K 7. Anopheles (Anopheles) plumbeus Stephens [11] (= Anophelesplumbeus Stephens)[10] Distribution:K (Nas, Sri) Subgenus: Cellia 8. Anopheles(Cellia) annularis vanderWulp] [11] (=Anopheles annularisvanderWulp) [5] Distribution: J & K 9. Anopheles(C.) culicifacies Giles [ 5,9,18 ] Distribution: J (Udh), K (Karn) 10. Anopheles (C.) dthali Patton [13] Distribution: K 11. Anopheles(C.) fluviatilis James [5, 17, 18] Distribution: J (Udh), K (Han, Karn, Uri) 12. Anopheles (C.) karwari (James) [11] (=Anopheles karwari James) [ 14 ] (=Anopheles (Myzomyia) karwari James (7)

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Distribution: K 13.Anopheles(C.) leucosphyrus Donitz [17, 18] Distribution: K (Karn) 14. Anopheles(C.) maculatus Theobald [11] (=Anopheles maculatuswillmorei James [7] (=Anopheles maculatus James)[ 5,9 ] Distribution: K (Dal) 15. Anopheles(C.) moghulensis Christopher [13] Distribution: K (Gan) 16. Anopheles(C.) splendidusKoidzumi [17] Distribution: K (Han) 17. Anopheles(C.) stephensi Liston[11] (=Anopheles stephensi Liston) [9, 10, 12] Distribution: K (Gul, Hok, Kha) 18. Anopheles(C.) subpictusGrassi [18] Distribution: J 19. Anopheles(Cellia) willmori (James) [11] (=Anopheles (Myzomyia) wilmoriJames) [8] (=Anopheleswilmori James) [ 10 ] Distribution: K (Dal, Gul, Sin, Sri) Subfamily 2:Culicinae **Tribe 1.:Aedini Genus:Aedimorphus** 20. Aedimorphusvexans(Meigen) [11] (=Aedes (Aedimorphus) vexans (Meigen) [4, 5, 16] Distribution: L (Kar, Leh) Genus:Collessius Subgenus:Collessius 21. Collessius(C.) elsiae (Barraud) [11] (=Aedes(Finlaya) elsiae (Barraud) [ 5, 18 ] Distribution: J (Raj) Genus: Fredwardsius 22. Fredwardsiusvittatus(Bignot) [11] (= Aedes(Fredwardsius) vittatus (Bignot) [16] (=Aedes (Stegomyia)vittatus(Bignot) [ 18 ] Distribution: J (Raj) Genus: Ochlerotatus Subgenus:Culicelsa 23.Ochlerotatus(C.) taeniorhynchus (Wiedemann) [11] (=*Culextaeniorhynchus*Wiedemann)[12] Distribution: K (Gul, Hok, Kha) Subgenus:Finlaya 24. Ochlerotatus(F.) oreophilusEdwards [11] (=Aedes (F.) oreophilus Edwards) [4, 5, 16] Distribution: L (Kar, Leh) 25. Ochlerotatus(F.) sintoni (Barraud) [11] (= *Finlayasintoni*Barraud)[1] (=Aedes (F.) sintoni (Barraud) [5, 15] Distribution: K (Tan), L 26. Ochlerotatus(F.) versicolor (Barraud) [11, 16]

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(= Aedes(Ochlerotatus) versicolor Barraud)[2] (=*Finlayaversicolor*Barraud) [18] Distribution: K (Yus) Genus:Stegomvia Subgenus:Stegomyia 27. Stegomyia(S.) aegypti (Linnaeus) [11] (=Aedesaegypti (Linnaeus) [ 6, 12 ] Distribution: J& K (Gul, Hok, Kha) 28. Stegomyia (subgenus uncertain) albopicta (Skuss) [11] (=Aedesalbopictus(Skuss) [ 12 ] (=Aedes(Stegomyia) albopictus (Skuss) [5, 18] Distribution: J (Udh), K (Gul, Hok, Kha), L 29. Stegomyia(uncertain subgenus) w-alba Theobald [11] (=Aedes (S.) w-albus (Theobld) [ 5, 15, 17 ] Distribution: J (Udh) **Tribe 2: Culicini** Genus:Culex Subgenus: Barraudius 30. Culex(Barraudius) modestus Fiscalbi [11] (=*Culexeadithae*Barraud)[3] Distribution: K (Sop, Wul) Subgenus:Culex 31. Culex(C.) barraudi Edwards [ 5, 18 ] Distribution: J (Udh) 32. Culex(C.) fuscocephala Theobald [5, 18] Distribution: J (Udh) 33.Culex (C.) mimeticusNoe [ 5, 18 ] Distribution: J (Dod), K (Sri), L 34. *Culex(C.) pipiens* Linnaeus [11] (= *Culexpipiens*Linnaeus)[6] Distribution: J & K 35. Culex(C.) pseudovishuiColless [18] Distribution:L 36. Culex(C.) quinquefasciatus Say [ 5, 18 ] (=*Culexfatigans*)[12] Distribution: J, K (Ban, Bar, Gul, Hok, Kha) 37*Culex*(*C*.) *theileri*Theobald [4, 5, 18] Distribution: L (Kar, Leh) 38. Culex(C.) vagansWiedermann [4,5,18] Distribution: K (Ana, Bar), L (Kar, Leh) 39. Culex(C.) vishnui Theobald [ 5, 18 ] Distribution: J(Udh) Subgenus:Culiciomvia 40. Culex(C.) pallidothoraxTheobald [5, 18] Distribution: J 41. Culex(C.) viridiventer Giles [5, 18] Distribution: J (Udh), K (Ana, Pah) Subgenus: Oculeomyia 42. Culex(O.) bitaeniorhynchu sGiles [11] (=*Culex*(*Culex*) *bitaeniorhynchus* Giles)[5,18]

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Distribution: J (Udh) **Subgenus:***Maillotia* 43. *Culex*(*M*.) *hortensis* Ficalbi [ 11 ] (=*Culex* (*Neoculex*) *hortensis* Facalbi)[ 4, 5 ] Distribution: L (Kar, Leh) **Tribe 3:**Culisetini **Genus:***Culiseta* **Subgenus:***Allotheobaldia* 

44. *Culiseta*(*A*.) *longiareolata* (Macquart) [ 4, 18] Distribution: L (Kar, Leh)

#### Keys to Author (s) and Localities (Distribution):

Key to the author (s), given as numericals in long brackets in the above given systematic Inventory: 1= Barraud (1924a); 2= Barraud (1924b); 3=Barraud(1924c); 4= Bhat and Kulkarni (1971); 5= Bhat and Kulkarni (1983=);6= Buhroo *et al.*, (1997); 7= Christopher (1933); Gill (1920); 8=Covell (1927); 9=Covell (1931); 10 =Gill (1920); 11=Harbach(2014); 12=Jabanesan *et al.*, (2012); 13= Jacob (1950); 14=James and Liston (1904); 15= Kaur (1992); 16= Kaur (2003); 17= Nair (1973); 18 = Rao *et al.*, (1973)

Key to the localities of mosquito species, distributed in Jammu, Kashmir and Ladakh region, given in the form of abbreviations in parentheses in above Inventory: Ana = Anantnag; Ban= Bandipore; Bar = Baramula; Dal = Dal Lake Dod = Doda;Gan = Ganderbal; Gul = Gulmarg; Han= Handwara; Hok = Hokersar; J= Jammu; J & K= Jammu and Kashmir; Jeh= Jehlum River; K= Kashmir; Kar= Kargil; Karn = Karnah; Kha = Khag; L= Ladakh; Leh = Leh; Nas= NaeemBagh; Pah= Pahalgam; Raj = Rajouri; Sop = Sopore; Sin = Sind Valley; Sri =Srinagar; Tan= Tangmarg; Udh= Udhampur; Ur= Uri;Wul.= Wular Lake; Yus= Yusmarg

As per the above given Inventory, as many as 44 species of mosquitoes belonging to 8 genera and 12 subgenera, are known to occur in diverse areas and localities of Jammu, Kashmir and Ladkah Himalayan regions. These species come under two main sub-families Culicidae, *viz*. Anophelinae and Culicinae (tribe Aedini, Culicini, Culisetini).

The anopheline taxa included a total of 19 species, belonging to genus *Anopheles*, whereas culicine taxa covered 25 species, pertaining to 7 genera. The genera, with total number of species, coming under various tribes of culicine are: Aedini – *Aedimorphus* (1sp.), *Collessius* (1 sp.), *Fredwardsius* (1 sp.), *Ochlerotatus* (4 spp.), *Stegomyia* (3 spp.); Culicini – *Culex* (14 spp.) and Culisetini- Culiseta (1 sp.). The culicine taxa accounts for 56.81% and anopheline taxa as 43.18% of the total mosquito faunal composition of the J & K Himalayan region of the Indian sub-continent.

Of the various tribes of the subfamily Culicinae, tribe Culicini was found to be dominant in species richness and accounted for 56%, followed by Aedini as 40 % and Culisetini as 4 % of the total culicine-fauna of the region. Kashmir division has shown the prevalence of 27 spp. of mosquitoes (17 spp. of anophelines and 10 spp. of culicine). This is followed by Jammu Division, having occurrence of a total of 18 spp. (4 spp. of anophelines, 14 spp. of culicines). Ladakh Division has shown the occurrence of 10 spp. of culicines.

# Mosquitoes of Medical Importance, as Vector of Human Malaria and Dengue/Dengue Haemorrhagic Fever:

Six species of anopheles, *viz. An.culicifacies, An. dirus, An. fluviatilis, An.minimus, An.sundaicus, An. stephensi*, are major malaria vectors in India (Das *et al.*, 2007; Dev and Sharma, 2013). Except for *An.minimus* and *A.sundaicus*, all the four species are reported from Jammu and Kashmir. *An. dirus*, recorded by Nair (1973) from Jammu and Kashmir, is not a valid species, a complex species including at least seven species. This species is not enlisted in the present inventory of valid species.

The earliest report regarding prevalence of malaria in Kashmir (Baramulla, Uri, Domel) was given by Gill (1920). Anopheline mosquito- *An.* (*C.*) *willmorei* was shown to be as a vector of indigenous malaria in these localities. Jacob (1950), conducted a detailed survey of malaria in Kashmir and found that the

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incidence of endemic and hyperendemic malaria, in patchy distribution, with transmission period from July – September, existed in many villages at altitude above 6,000 ft. On the basis of presence of An. *fluviatilis* in the houses, it was strongly suspected as vector of malarial disease. However, *An.culicifacies*, which had been previously incriminated, was not encountered, during the course of the surveys in the localities above the elevation 4,000 ft.

Detailed epidemiological study of malaria in Kashmir was made by Nair (1973), in the villages of Karnah, Uri and Handwara of district Baramulla of North Kashmir. The most widely prevalent malarial parasite species in these localities was reported to be as*Plasmodium vivax*(88.4%) and *P. falaciparum* (11.6%). *An. fluviatilis* was identified as vector of malaria in these localities. An unstable malaria existed in north Kashmir at an elevation from 1,676 - 2,134 mts. Investigations on malaria and its control in Jammu region have been made by Verma and Magotra (1976), Dwivedi *et al.*, (1979) and Kaul *et al.*, (1995).

Two important vectors of Dengue / Dengue haemorrhagic fevers, viz.Stegomyia(S.) aegypti(= Aedesaegypti) and St. albopicta, also as invasive (exotic) mosquito species, are known to be prevalent in Jammu and Kashmir, however, absent from Ladakh. The prevalence of S. albopicta was shown by Kalra *et al.*, (1997) as scanty in Kashmir (South) and widely prevalent in north Kashmir (Jabanesan *et al.*, 2012). The existence of this species has also been reported from Jammu.

The occurrence *S. aegypti* from Jammu as well as Kashmir, has been reported by Buhroo and Chishti (1999), Gookhale and Mourya(2003) and Jabanesan *et al.*, (2012). The out breaks of dengue / dengue haemorrhagic fever, have been reported from Jammu (Pedbidri *et al.*, 1996 and Cecilla *et al.*, 2003). However, there is no case of Dengue reported from Kashmir region, despite the existence of disease vectors in the region.

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