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Mosquito diversity in Keeriparai and Mundanthurai hill ranges of the Western Ghats, southern India

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Abstract: After a gap of 25 years the Centre for Research in Medical Entomology (CRME) surveyed the mosquito biodiversity in the tail-end hill ranges of the Western Ghats, viz., Kanyakumari (Keeriparai) and Tirunelveli districts (Kalakkad-Mundanthurai Tiger Reserve (KMTR) and Courtallam) of Tamil Nadu between July 2010 and June 2013. The altitude of the hills ranged from 100–950 m covered by evergreen forests. A major emphasis was given to collect the immature stages of mosquitoes, from various breeding habitats, viz., slow flowing streams, spring pool, rocky pool, leaf axils, latex cup, tree hole, bamboo stumps, etc. Altogether 4602 immature individuals were collected, reared individually to be identified at the adult stage. A total of 3583 specimens belonging to 50 species classified under 21 genera and 18 subgenera were recorded. The major vector species found in these hill ranges were *Stegomyia aegypti, S. albopicta* (Dengue and Chikungunya), *Culex bitaeniorhynchus, C. tritaeniorhynchus* (Japanese encephalitis), *Downsiomyia nivea* (diurnally subperiodic filariasis) and *Anopheles mirans* (Simian malaria) vectors were recorded.

Keywords: Habitats, mosquito biodiversity, vectors, Western Ghats.

Several studies on the mosquito fauna have been carried out in several parts of India for Anopheline and Culicines (Christophers 1933; Barraud 1934; Rao 1984; Nagpal & Sharma 1995; Tewari & Hiriyan 1995; Reuben 1969), western Himalaya (Rao et al. 1973), northeastern India (Dutta et al. 2003), eastern and western coasts (Rajavel et al. 2005a,b), northwestern India (Gujarat and the Thar Desert region in northwestern Rajasthan) (Tyagi 1984a,b, 1990, 2002) and southern India (Western Ghats and Eastern Ghats) as well as Andaman and Nicobar Islands (Reuben et al. 1993; Tewari et al. 2007; Tyagi et al. 2009).

Material and Methods

Study area

Mosquito biodiversity in the tail-end hill ranges of the Western Ghats in Kanyakumari (Keeriparai) and Tirunelveli districts (Kalakkad-Mundanthurai Tiger Reserve (KMTR) and Courtallam) of Tamil Nadu, were studied from July 2010 to June 2013. The altitude of the hills ranged from 100–950 m covered by evergreen forests, which receive rains from both the southwest

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Image 1. Sampling immature from tree holes.

Image 2. Sampling immature at a pool.

Image 3. Sampling immature in hoof marks.

and northeast monsoons. Major emphasis was given to collect the immature stages of mosquitoes, from various breeding habitats, viz., slow flowing streams, spring pool, rocky pool, leaf axils, latex cup, tree hole and bamboo stumps (images 1–3). Nomenclature and chaetotaxy from Harbach & Knight (1980, 1982) and Bickley & Ward (1989) were used in the survey.

Results and Discussion

The Centre for Research in Medical Entomology, Madurai carried out mosquito prevalence studies in the hill ranges of the Western Ghats in Kanyakumari and Tirunelveli districts (Keeriparai and Mundanthurai hills) during the year 1986 and recorded 57 mosquito species (Tewari et al. 2007). After a gap of 25 years, in 2010 a team of CRME resurveyed the mosquito fauna in the same hill ranges to determine the fauna in the present situation, where many of the deep evergreen forests were deforested and dams were constructed, and converted to agricultural lands. Many parts of the hill ranges are now tourist spots. A part of the forest is now declared as a Tiger Reserve (KMTR). Altogether 4602 immature specimens were collected. While rearing them a >20% mortality (1st stage larvae) was observed. IV stage larvae were reared individually up to the adult stage. A total of 3583 specimens belonging to 50 species classified under 21 genera and 18 subgenera were recorded (Table 1). Tree holes (22 species) and bamboo stumps (18 species) were the most favourable habitats for mosquito breeding in these hill ranges (Fig. 1). Following vector species deserve a special mention:

Vectors for Dengue and Chikungunya:

Aedes (Stegomyia) aegypti is a highly anthropophilic, daytime biting mosquito species and principal vector of Dengue and dengue hemorrhagic fever in Southeast Asia including India. Various strains of Dengue and Chikungunya viruses have been isolated from this species (Huang 1979). All the four serotypes were isolated from this species in southern India (Reuben et al. 1988; Tewari et al. 2004) including a demonstration of vertical transmission of the dengue virus (Thenmozhi et al. 2000).

Aedes (Stegomyia) albopictus is commonly called the “Asian Tiger Mosquito” due to its vigorous habits of biting humans during the daytime in wooded areas. It is a typically rural dengue vector that causes a mild or asymptomatic dengue virus infection in humans (Hawley 1988). A strain of dengue virus (Dengue-4) was isolated from this species in India (Reuben et al. 1988). Dengue virus (DEN 2) was isolated from rural areas of Vellore District in southern India where it was considered as a secondary vector (Tewari et al. 2004). In Kerala (southwestern India) it was abundantly found biting humans in the outdoors near human habitations. Recently, a resurgence of dengue was reported where DEN2 was isolated from this species (Tyagi 2004; Tyagi et al. 2006).

Table 1. List of mosquito species collected from Kanniyakumari and Tirunelveli districts foothills of Western Ghats 2010–2013 (in bold are species recorded only during 2010–2013 study).

	Species	No. of specimens
1	***Anopheles (Anopheles) sintoni* Puri, 1929**	1
2	*Anopheles* (*Cellia*) *jamesii* Theobald, 1901	1
3	***Anopheles (Cellia) karwari* (James, 1902)**	2
4	*Anopheles* (Cellia) *maculatus* (Theobald, 1901)	26
5	***Anopheles (Cellia) mirans* Sallum & Peyton, 2005**	2
6	*Anopheles (Cellia) tessellatus* Theobald, 1901	2
7	*Anopheles* (*Cellia*) *vagus* Donitz, 1902	8
8	*Anopheles* (Cellia) *varuna* Iyengar, 1924	1
9	*Armigeres* (*Armigeres*) *aureolineatus* (Leicester,1908)	442
10	*Armigeres* (*Armigeres*) *subalbatus* (Coquillett, 1898)	91
11	***Armigeres (Leicesteria) magnus* (Theobald, 1908)**	4
12	*Bruceharrisonius greenii* (Theobald, 1903)	8
13	*Christophersiomyia annulirostris* (Theobald, 1905)	21
14	*Christophersiomyia thomsoni* (Theobald,1905*)*	45
15	*Collessius (Alloeomyia) pseudotaeniatus* (Giles, 1901)	188
16	*Culex (Culex) gelidus* Theobald, 1901	2
17	*Culex (Culex) mimulus* Edwards,1915	7
18	***Culex (Culex) tritaeniorhynchus* Giles, 1901**	4
19	***Culex (Culiciomyia) fragilis* Ludlow, 1903**	2
20	*Culex (Eumelanomyia) brevipalpis* (Giles,1902)	34
21	***Culex (Lophoceraomyia) mammilifer* (Leicester, 1908)**	3
22	***Culex (Lophoceraomyia) minor* (Leicester,1908)**	11
23	*Culex (Lophoceraomyia) minutissimus* (Theobald, 1907)	21
24	*Culex (Oculeomyia) bitaeniorhynchus* Giles,1901	27
25	*Danielsia albotaeniata* Leicester, 1904	6
26	***Downsiomyia nivea* (Ludlow,1903)**	24
27	*Fredwardsius vittatus* (Bigot,1861)	844
28	***Heizmannia (Heizmannia) chandi* Edwards,1922**	12
29	*Heizmannia (Heizmannia) greenii* (Theobald, 1905)	2
30	***Heizmannia (Matinglyia) discrepans* (Edwards, 1922)**	6
31	***Hodgesia bailyi* Barraud,1929**	2
32	*Hulecoeteomyia chrysolineata* (Theobald, 1907)	12
33	***Malaya genurostris* Leicester, 1908**	4
34	***Orthopodomyia anopheloides* (Giles, 1903)**	5
35	***Orthopodomyia flavicosta* Barraud, 1934**	20
36	***Orthopodomyia flavithorax* Barraud,1927**	2
37	*Phagomyiagubernatoris* (Giles, 1901)	3
38	*Stegomyia (Stegomyia) aegypti* (Linnaeus,1762)	5
39	*Stegomyia albopicta* (Skuse,1895)	1559
40	***Stegomyia krombeini* (Huang, 1975)**	27
41	***Stegomyia pseudalbopicta* Borel, 1928**	2
42	***Stegomyia w-alba* Theobald, 1905**	38
43	*Tewarius agastyai* (Tewari & Hiriyan, 1992)	1
44	*Toxorhynchites (Toxorhynchites) splendens* (Wiedemann, 1819)	21
45	*Tripteroides (Rachionotomyia) affinis* (Edwards, 1913)	6
46	***Tripteroides (Rachionotomyia) aranoides* (Theobald, 1901)**	10
47	*Uranotaenia (Pseudoficalbia) recondita* Edwards, 1922	10
48	***Uranotaenia (Uranotaenia) annandalei* Barraud 1926**	1
49	***Verrallina (Neomacleaya) cauta* (Barraud, 1928)**	7
50	***Verrallina (Neomacleaya) indica* (Theobald, 1907)**	1
	Total	3583

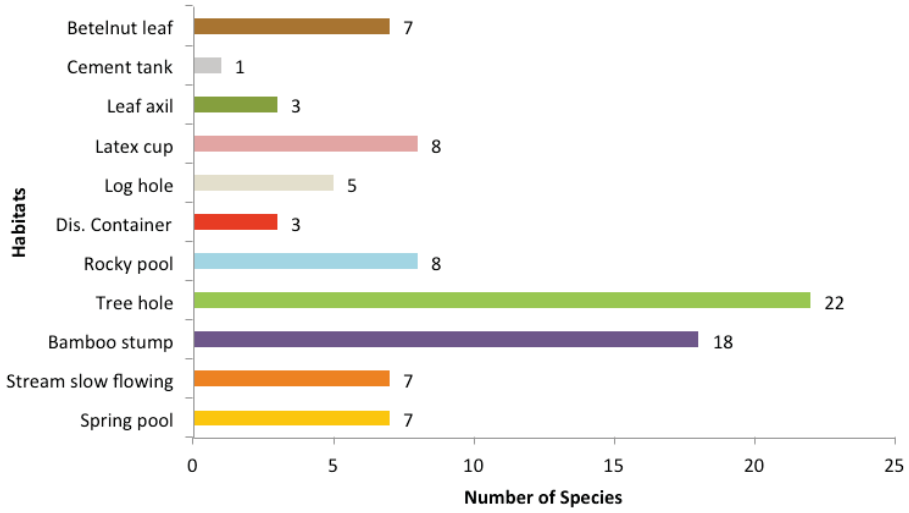

Figure 1. Mosquito species recorded from different habitats

Table 2. List of mosquito species collected from Kanniyakumari and Tirunelveli districts foothills of Western Ghats - 1986. (CRME Mosquito Museum Book, Tewari et al. 2007)

	Species
1	*Anopheles* (*Anopheles*) *aitkenii* James, 1903
2	*Anopheles (Anopheles)barbirostris* van der Wulp, 1884
3	*Anopheles (Anopheles)barbumbrosus* Strickland & Chowdhury, 1927
4	*Anopheles (Anopheles)peditaeniatus* (Leicester, 1908)
5	*Anopheles (Cellia) culicifacies* Giles, 1901
6	*Anopheles (Cellia) fluviatilis* James, 1902
7	*Anopheles (Cellia) jamesii* Theobald, 1901
8	*Anopheles (Cellia) maculatus* Theobald, 1901
9	*Anopheles (Cellia) moghulensis* Christophers, 1924
10	*Anopheles (Cellia) subpictus* Grassi, 1899
11	*Anopheles (Cellia) tessellatus* Theobald, 1901
12	*Anopheles (Cellia) theobaldi* Giles, 1901
13	*Anopheles (Cellia) vagus* Donitz, 1902
14	*Anopheles (Cellia) varuna* Iyengar, 1924
15	*Armigeres (Armigeres) aureolineatus* (Leicester, 1908)
16	*Armigeres* (*Armigeres*) *subalbatus* (Coquillett, 1898)
17	*Bruceharrisoniusaureostriatus* (Doleschall, 1857)
18	*Bruceharrisonius greenii* (Theobald, 1903)
19	*Christophersiomyia annulirostris* (Theobald, 1905)
20	*Christophersiomyia thomsoni* (Theobald, 1905)
21	*Collessius (Alloeomyia) pseudotaeniatus* (Giles, 1901)
22	*Culex (Culex) barraudi* Edwards, 1922
23	*Culex (Culex) fuscocephala* Theobald, 1907
24	*Culex (Culex) gelidus* Theobald, 1901
25	*Culex (Culex) mimeticus* Noe, 1899
26	*Culex (Culex) mimuloides* Barraud, 1924
27	*Culex (Culex) mimulus* Edwards, 1915
28	*Culex (Culex) pseudovishnui* Colless, 1957
29	*Culex (Culex) quinquefasciatus* Say, 1823

	Species
30	*Culex (Culex) vishnui* Theobald, 1901
31	*Culex (Culex) whitmorei* (Giles, 1904)
32	*Culex (Culiciomyia) nigropunctatus* Edwards, 1926
33	*Culex (Culiciomyia) pallidothorax* Theobald, 1905
34	*Culex (Eumelanomyia) brevipalpis* (Giles, 1902)
35	*Culex (Lophoceraomyia) minutissimus* (Theobald, 1907)
36	*Culex (Lophoceraomyia) uniformis* (Theobald, 1905)
37	*Culex (Oculeomyia) bitaeniorhynchus* Giles, 1901
38	*Culex (Oculeomyia) infula* Theobald, 1901
39	*Danielsia albotaeniata* Leicester, 1904
40	*Downsiomyia albolateralis* (Theobald, 1908)
41	*Fredwardsius vittatus* (Bigot, 1861)
42	*Heizmannia (Heizmannia) greenii* (Theobald, 1905)
43	*Hulecoeteomyia chrysolineata* (Theobald, 1907)
44	*Lutzia* (*Metalutzia*) *halifaxii* (Theobald, 1903)
45	*Phagomyia gubernatoris* (Giles, 1901)
46	*Stegomyia* (*Stegomyia*) *aegypti* (Linnaeus, 1762)
47	*Stegomyia albopicta* (Skuse, 1895)
48	*Stegomyia novalbopicta* (Barraud, 1931)
49	*Stegomyia subalbopicta* (Barraud, 1931)
50	*Tewarius agastyai* (Tewari & Hiriyan, 1992)
51	*Toxorhynchites (Toxorhynchites) splendens* (Wiedemann, 1819)
52	*Tripteroides* (*Rachionotomyia*) *affinis* (Edwards, 1913)
53	*Uranotaenia (Pseudoficalbia) luteola* Edwards, 1934
54	*Uranotaenia (Pseudoficalbia) recondita* Edwards, 1922
55	*Uranotaenia (Pseudoficalbia) stricklandi* Barraud, 1926
56	*Uranotaenia (Uranotaenia) campestris* Leicester, 1908
57	*Uranotaenia (Uranotaenia) orientalis* Barraud, 1926

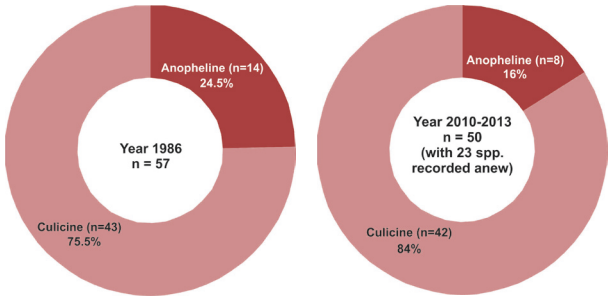

Figure 2. Ratio between anopheline and culicine species collected during 1986 and 2010–2013

Vector for subperiodic filariasis

Downsiomyia nivea: This species was found naturally infected with *Wuchereria bancrofti* in the Nancowry group of Islands, where it plays the role as a vector of diurnally subperiodic filariasis (Tewari et al. 1995).

Vectors of Japanese encephalitis

Culex (Culex) tritaeniorhynchus is one of the primary vectors of JE in India (Reuben et al. 1994). *Culex tritaeniorhynchus* is extremely common and widespread. It has been incriminated as a major vector in India, Sri Lanka and Thailand (Rodrigues 1984; Leake et al. 1986; Amerasinghe et al. 1988; Gingrich et al. 1992), and outside the region in Japan, Korea, and Taiwan (Pant 1979).

Culex (Oculeomyia) bitaeniorhynchus: There have

been two isolations of JE virus from it in nature from Karnataka and West Bengal in India (Samuel et al. 2000).

Culex (*Culex*) *gelidus*: This species is considered to be one of the most important vectors of JE in Sri Lanka, Thailand, Malaysia, Vietnam, and Sarawak (Gould et al. 1962). Relatively few isolates have been made in India (Reuben et al. 1988).

When a comparison was made with the CRME survey carried out two decades ago in the same area, it was noted that 31 species were not collected in the present survey. As per the previous survey report, 14 Anopheles species were reported; in the present survey only eight anopheles species were recorded. At the same time the culicine mosquito species did not show up as different species, indicating a decline in mosquito biodiversity, especially in anopheles species density (Fig. 2). But it is noteworthy to mention that, during the present survey 23 additional species were collected and highlighted in Table 1 and Table 2. An additional survey, however, needs to be made in the post monsoon season, to confirm this change in mosquito biodiversity.

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