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ANOPHELINES (DIPTERA : CULICIDAE) OF THREE DISTRICTS (EAST KAMENG, LOWER SUBANSIRI AND UPPER SUBANSIRI) OF ARUNACHAL PRADESH AND THEIR PERSPECTIVE IMPACT ON HUMAN AND NONHUMAN HOSTS

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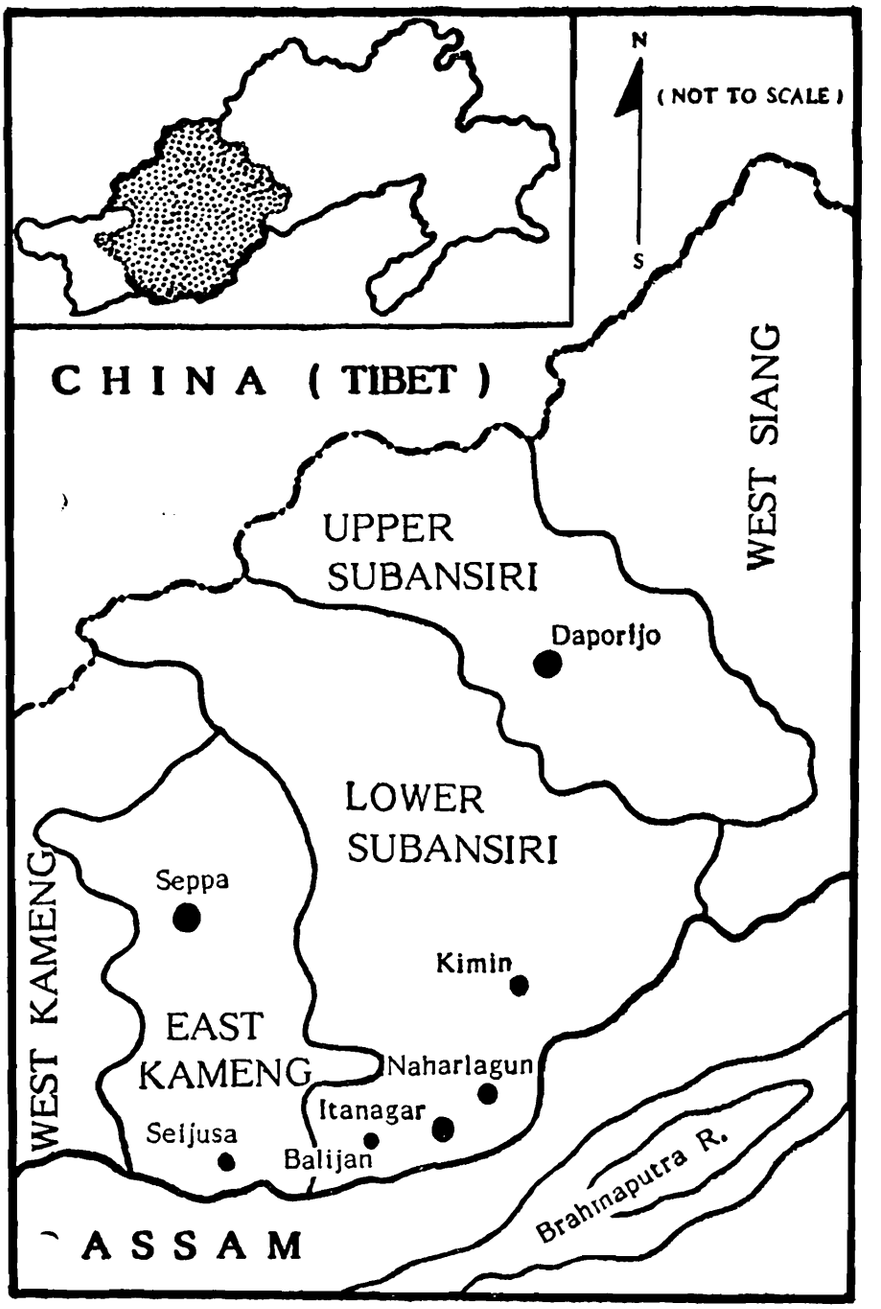
INTRODUCTION

East Kameng, Lower Subansiri and Upper Subansiri Districts form a part of the western side of Arunachal Pradesh. This area is bounded by China (Tibet) and West Kameng District (Arunachal) in the north, West Siang District (Arunachal) in the east, Assam in the south and West Kameng District (Arunachal) in the west. The entire area is a mountainous terrain (alt. 200-5500 m.). The area comp rises a cross-section of the foot hills, the plateau and the lofty mountains extending northward in a succession of steep and towering ridges receding a away to the snow-clad peaks of the Himalayas along the international border. From the northern height flow a number of rivers down to south. These rivers form the main river system which in its southward course meet the river Brahmaputra in Assam. The climatic conditions offering high rainfall, favourable temperature gradients and humidity have caused a rich assemblage of floral resources. The total population of these districts enumerated 195,428 as per 1981 census (Jha, 1985). The life style of the people along with social fabric is found to be responsive to and compatible with the physical environment.

Information on the mosquitoes of Arunachal Pradesh as a whole is very scanty. The study of the anopheline fauna in Arunachal made practically no headway except a few by Misra (1956) and Sen *et al.* (1972). Misra (*loc. cit.*) reported 6 species while Sen *et al.* recorded 14 species from the Tirap areas. The present survey and observations were undertaken to update this faunal information. Moreover, rapid developmental changes have taken place in this region during last decade. The perspective impact of this anopheline

fauna on total health status of this region was also assessed. A key to the available species of the area is appended for easy recognition of the species.



Text-fig. 1. Sketch map of East Kameng, Lower Subanasiri and Upper Subansiri Districts showing the places of mosquito collections; inset : map of Arunachal Pradesh showing the area of above three Districts (shaded space).

Material and Methods

The surveys were carried out in 86 days in 21 villages and township areas of the districts of East Kameng, Lower Subansiri and Upper Subansiri during different seasons of 1986 and 1987. Adult mosquitoes resting outdoors, indoors (human plus mixed dwellings), in cattlesheds and biting cattles were collected by suction tube in the mornings and evenings.

Outdoor resting adult mosquitoes were collected from the shrubs around cattle and human dwellings, forests and tree holes. Collections were made from each village or locality from a minimum of 10 cattlesheds and human dwellings. All field collected mosquitoes were brought to the Kimin laboratory of NMEP for identification and preservation. Mosquitoes were identified using the keys of Christophers (1933) and Rao (1984). The system of stone and Delfinado (1973) was followed for nomenclature of the species.

SYSTEMATIC ACCOUNT

Family CULICIDAE

Subfamily ANOPHELINAE

Tribe ANOPHELINI

1. **Anopheles aconitus** Donitz

1902. *Anopheles aconitus* Dönitz, *Z. Hyg. Insekt Krankh* **41** : 70 (Type-loc. : Sumatra, Indonesia).
1903. *Myzomyia albirostris* Theobald, *Monogr. Cul.* 3 : 24 (Type-loc. : Malaysia).
1912. *Myzomyia brahmachari* Christophers, *Paludism* 5 : 11 (Type-loc. : Calcutta, West Bengal, India).
1933. *Anopheles* (*Myzomyia*) *aconitus* : Christophers, *Fauna Br. India*, Diptera 4 : 216.
1973. *Anopheles* (*Cellia*) *aconitus* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 273.

Material examined : 585 ♀ ♀. INDIA : ARUNACHAL PRADESH, East Kameng District, Seijusa area, 149 ex., ii., iii. & xi. 1986 : Lower Subansiri District, Balijan, 5 ex., iv. 1986 ; Naharlagun 323 ex., vii. & viii. 1987 ; Itanagar, 65 ex., vii. & viii. 1987 ; Kimin and Lora Basti, 43 ex., xi. 1987 (detail vide Tables 1 & 2).

Distribution : INDIA : Arunachal Pradesh, Assam, West Bengal, Bihar, Madhya Pradesh, Uttar Pradesh, Tamil Nadu, Kerala, Karnataka, Andaman Is. ; BANGLADESH ; BURMA ; SRI LANKA ; MALAYSIA ; INDONESIA (Sumatra) ; SULAWESI.

2. **Anopheles annularis** Van der Wulp

1884. *Anopheles annularis* Van der Wulp, *Notes Leyden Mus.* 6 : 249 (Type-loc. : Java, Indonesia).
1900. *Anopheles fuliginosus* Giles, *Handbook Gnats or Mosquitoes* ed. 1 : 161 (Type-loc. : Calcutta, West Bengal, India).
1901. *Anopheles jamesii* Liston, *Indian Med. Gaz.* 36 : 444 (Type-loc. : Maharastra, India).
1901. *Anopheles leucopus* Dönitz, *Insektenbörse* 18 : 37 (Type-loc. : Sumatra, Indonesia).
1908. *Chagasia* ? *lineata* Ludlow, *Can. Ent.* 40 : 50 (Type-loc. : Philippines).
1911. *Nyssorhynchus fuliginosus* var. *adiei* James & Liston, *Monogr. anoph. mosq. India*, ed. 2 : 90 (Type-loc. : Maharastra, India).
1933. *Anopheles* (*Myzomyia*) *annularis* : Christophers, *Fauna Br. India*, Diptera 4 : 300.
1973. *Anopheles* (*Cellia*) *annularis* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 273.

Material examined : 1953 ♀ ♀. INDIA : ARUNACHAL PRADESH, East Kameng District, Seijusa area, 181 ex., ii., iii. & xi. 1986 ; Seppa, 22 ex., iv. 1987 ; Lower Subansiri

Table 1. Results of entomological survey showing prevalence of diffrent anopheline species in different biotopes in places of East Kameng District, Arunachal Pradesh.

Places (Localities)	Period	Biotopes	Total time spent (hrs.)	ANOPHELINE SPECIES COLLECTED																		TOTAL
				aconitus	annularis	barbirostris	balabacensis	culicifacies	gigas	nigerrimus	jamesii	jeyporiensis	karwari	kochi	maculatus	philippinensis	splendidues	subpictus	vagus			
Seijusa area & Bali Basti	17.2.86 to 28.2.86	outdoor resting	58	11	14	23	–	–	–	35	–	17	—	26	79	15	76	—	28			324 (8.74)
		indoor resting	66	8	7	18	–	–	–	22	–	11	—	15	42	7	51	—	16			197 (5.31)
		cattleshed resting	37	15	22	31	–	–	–	37	–	16	—	27	144	12	79	—	28			411 (11.09)
		cattle biting	35	13	12	21	–	–	–	30	–	17	—	22	78	14	57	—	30			294 (7.93)
Seijusa area (Township)	1.3.86 to 7.3.86	outdoor resting	31	9	9	15	–	–	–	23	–	9	—	13	53	6	33	—	12			182 (4.91)
		indoor resting	33	6	8	13	–	–	–	15	–	7	—	11	31	3	22	—	12			128 (3.45)
		cattleshed resting	18	8	19	24	–	–	–	29	–	11	—	18	71	11	53	—	27			271 (7.31)
		cattle biting	20	11	13	20	–	–	–	24	–	9	—	15	68	8	41	—	23			232 (6.26)
Seijusa area & Mobusa vill.	21.11.86 to 30.11.89	outdoor resting	17	14	16	20	–	–	–	29	7	11	—	6	41	12	53	—	26			235 (6.34)
		indoor resting	22	20	21	25	–	–	–	29	–	16	—	5	31	10	33	—	20			210 (5.66)
		cattleshed resting	19	21	28	68	–	–	–	84	11	23	—	29	95	25	112	—	39			535 (14.43)
		cattle biting	35	13	12	21	–	–	–	30	5	17	—	22	78	14	57	—	30			299 (8.06)
Seppa (Pabua vill., Tassamlora vill. & Nari camp)	4.4.87 to 13.4.87.	outdoor resting	18	–	6	11	–	–	3	14	–	–	—	—	16	5	—	—	10			65 (1.75)
		indoor resting	24	–	4	13	–	–	2	9	–	–	—	4	20	3	—	—	7			62 (1.67)
		cattleshed resting	–	–	–	–	–	–	–	–	–	–	—	—	—	—	—	—	—			—
		cattle biting	55	–	12	45	–	–	7	59	–	–	—	13	91	6	—	—	28			261 (7.04)
		TOTAL	488	149	203	368	–	–	12	469	23	164	—	226	938	151	667	—	336			3706
				(4.02)	(5.47)	(9.23)	(–)	(–)	(0.32)	(12.65)	(0.62)	(4.42)	(—)	(6.09)	(25.31)	(4.07)	(18.00)	(—)	(9.06)			(100)

Figures in parentheses indicate the percentage

Table 2. Results of entomological survey showing prevalence of diffrent anopheline species in different biotopes in places of Lower Subansiri District, Arunachal Pradesh.

Places (Localities)	Period	Biotopes	Total time spent (hrs.)	ANOPHELINE SPECIES COLLECTED																TOTAL
				aconitus	annularis	barbirostris	balabacensis	culicifacies	gigas	nigerrimus	jamesii	jeyporiensis	karwari	kochi	maculatus	philippinensis	splendidus	subpictus	vagus	
Balijan	18.4.86	outdoor resting	55	—	12	21	—	—	—	27	—	2	—	18	67	5	—	—	18	170 (1.87)
(Tagung vill.	to	Indoor resting	63	—	22	31	—	—	—	26	—	—	—	23	84	12	—	—	17	215 (2.36)
& Nishi Basti)	29.4.86	crttleshed resting	41	2	15	35	—	5	—	42	—	—	—	23	79	14	—	4	40	259 (2.85)
		cattle biting	38	3	13	27	—	—	—	27	—	—	—	22	993	9	—	2	36	332 (2.55)
Naharlagun	24. 7.87	outdoor resting	118	120	122	206	3	—	—	257	108	112	105	183	278	71	147	—	312	2024 22.30)
(Model vill.	to	indoor resting	130	50	68	83	—	—	—	100	64	48	52	99	177	44	83	—	156	1024 (11·28)
Likhi vill.	5.8.87	cattleshed resting	45	71	69	138	—	—	—	187	61	54	65	87	178	42	118	—	229	1299 (14·31)
& Township)		cattle biting	47	82	76	151	—	—	—	218	76	72	83	136	190	57	142	—	249	1532 (16·87)
Itanagar (Ganga	24.7.87	outdoor resting	25	19	22	29	—	—	—	37	16	18	24	28	57	13	39	—	49	351 (3.86)
vill. & Township)	to	Indoor resting	32	14	16	23	—	—	—	21	12	14	19	19	42	11	27	—	32	251 (2·75)
	5. 8.87	cattleshed resting	13	15	10	31	—	—	—	38	15	12	10	37	48	7	23	—	41	287 (3.16)
		cattle biting	15	17	13	28	—	—	—	45	13	10	18	21	60	9	36	—	47	317 (3.40)
Kimin & Lora	21.11.87	outdoor resting	37	9	17	37	—	—	–	48	14	3	18	26	59	8	27	—	47	313 (3.44)
Basti	to	indoor resting	47	3	11	19	—	—	—	28	4	—	9	15	42	3	21	—	31	186 (2.04)
	26.11.87	cattleshed resting	18	17	9	33	—	—	—	48	19	4	12	25	67	7	33	—	57	331 (3·64)
		cattle biting	19	14	8	27	—	—	—	52	13	—	17	37	48	11	20	—	40	287 (3.16)
		TOTAL	743	436	503	919	3	5	—	1201	415	349	432	799	1569	323	716	6	1401	9077
				(4.80)	(5.54)	(10.12)	(0.03)	(0.05)	—	(13.23)	(4.57)	(3.84)	(4.75)	(8.80)	(17.28)	(3.55)	(7.88)	(0.06)	(15.43)	(100)

Figures in parentheses indicate the percentage

District, Balijan, 62 ex., iv. 1986 ; Naharlagun, 335 ex., vii. & viii. 1987 ; Itanagar, 61 ex., vii. & viii. 1987 ; Kimin and Lora Basti, 45 ex., xi. 1987 ; Upper Subansiri District, Daporijo area, 1247 ex., vi. 1986 & v. 1987 (detail vide Tables 1 to 3).

Distribution : INDIA : Arunachal Pradesh, Assam, West Bengal, Bihar, Uttar Pradesh, Delhi, Rajasthan, Maharastra, Karnataka, Madhya Pradesh, Gujarat, Andhra Pradesh, Khshmir, Punjab, Goa, Tamil Nadu, Kerala ; BANGLADESH ; BURMA ; SRI LANKA ; NEPAL ; PAKISTAN ; CHINA ; TAIWAN ; MALAYSIA ; INDONESIA ; PHILIPPINES ; THAILAND ; VIET-NAM.

3. **Anopheles barbirostris** Van der Wulp

1884. *Anopheles barbirostris* Van der Wulp, *Notes Leyden Mus.* 6 : 248 (Type-loc. : Java, Indonesia).
1902. *Anopheles marlini* Laveran, *C. r. Se´nac. Soc. Biol.* 54 : 907 (Type-loc. : Kampuchea).
1933. *Anopheles (Anopheles) barbirostris* : Christophers, *Fauna Br. India,* Diptera 4 : 155.
1973. *Anopheles (Anopheles) barbirostris* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 268.

Material examined : 2139 ♀ ♀ INDIA : ARUNACHAL PRADESH, East Kameng District, Seijusa area, 299 ex., ii., iii. & xi. 1986 ; Seppa, 69 ex., iv. 1987 ; Lower Subansiri District, Balijan, 114 ex., iv 1986 ; Naharlagun, 578 ex., vii. & viii. 1987 ; Itanagar, 111 ex., vii. & viii. 1987 ; Kimin and Lora Basti, 116 ex., xi. 1987 ; Upper Subansiri District, Daporijo area, 852 ex., vi. 1986 & v. 1987 (detail vide Tables 1 to 3).

Distribution : INDIA : Arunachal Pradesh, Assam, Meghalaya, West Bengal, Bihar, Karnataka, Maharastra, Madhya Pradesh, Gujarat, Uttar Pradesh, Delhi, Punjab, Haryana, Kashmir, Andhra Pradesh, Orissa, Goa, Tamil Nadu, Kerala, Andaman Is., Lakshadweeps ; BANGLADESH ; NEPAL ; BURMA ; SRI LANKA ; PAKISTAN ; INDONESIA (Java) ; KAMPUCHEA.

4. **Anopheles balabacensis** Baisas

1936. *Anopheles leucosphyrus* var. *balabacensis* Baisas, *Philipp. J. Sci.* 59 : 65 (Type-loc. : Philippines).
1973. *Anopheles (Cellia) balabacensis* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 273.

Material examined : 3 ♀ ♀ INDIA : ARUNACHAL PRADESH, Lower Subansiri District, Naharlagun, 3 ex., vii & viii. 1987 (detail vide Table 2).

Distribution : INDIA : Arunachal Pradesh, Assam, Meghalaya, Tripura, West Bengal, Punjab, Karnataka, Kerala, Tamil Nadu, Andaman Is. ; BANGLADESH ; BURMA ; INDONESIA ; MALAYSIA ; PHILIPPINES ; THAILAND ; KAMPUCHEA ; CHINA ; TAIWAN.

5. **Anopheles culicifacies** Giles

1901. *Anopheles culicifacies* Giles, *Entomologist's mon. Mag.* 37 : 197 (Type-loc. : Hoshangabad, Madhya Pradesh, India).
1901. *Anopheles indica* Theobald, 1901, *Monogr. Cul.* 1 : 183 (Type-loc. : Madras, India).
1901. *Anopheles Listoni* Giles, *Entomologist's mon. Mag.* 37 : 197 (Type-loc. : Maharastra, India).

1911. *Myzomyia culifacies* var. *punjabensis* James, *in* James & Liston, *Anopheline mosquitoes of India*, ed. 2 : 72 (Type-loc. : Punjab, India).
1933. *Anopheles* (*Myzomyia*) *culicifacies* : Christophers, *Fauna Br. India*, Diptera 4 : 216.
1973. *Anopheles* (*Cellia*) *culicifacies* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 274.

Material examined : 5 ♀ ♀. INDIA : ARUNACHAL PRADESH, Lower Subansiri District, Balilan, 5 ex., iv, 1986 (detail vide Table 2).

Distribution : INDIA : Arunachal Pradesh (New record), Assam, Meghalaya, West Bengal, Bihar, Orissa, Madhya Pradesh, Maharastra, Karnataka, Goa, Gujarat, Delhi, Uttar Pradesh, Haryana, Rajasthan, Punjab, Kashmir, Andhra Pradesh, Kerala, Tamil Nadu ; BANGLADESH ; BURMA ; NEPAL ; PAKISTAN ; SRI LANKA ; AFGHANISTHAN ; IRAN ; OMAN ; CHINA ; VIET-NAM.

6. **Anopheles gigas** Giles

1901. *Anopheles gigas* Giles, *Entomologist's mon. Mag.* 37 : 196 (Type-loc. : Coonoor, Tamil Nadu, India).
1933. *Anopheles* (*Anopheles*) *gigas* : Christophers, *Fauna Br. India*, Diptera 4 : 130.
1973. *Anopheles* (*Anopheles*) *gigas* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 268.

Material examined : 12 ♀ ♀. INDIA : ARUNACHAL PRADESH, East Kameng District, Seppa area, 12 ex., iv. 1987 (detail vide Table 1).

Distribution : INDIA : Arunachal Pradesh (New record), Assam, Meghalaya, Sikkim, West Bengal, Madhya Pradesh, Gujarat, Uttar Pradesh, Haryana, Kashmir, Himachal Pradesh, Punjab, Tamil Nadu ; BANGLADESH ; SRI LANKA ; PAKISTAN ; SULAWESI.

7. **Anopheles nigerrimus** Giles

1900. *Anopheles nigerrimus* Giles, *Handbook Gnats or mosquitoes* ed. 1 : 161 (Type-loc. : Calcutta, West Bengal, India).
1902. *Anopheles bentleyi* Bentley, *Indian med. Gaz.* 37 : 15 (Type-loc. : Assam, India).
1903. *Myzorhynchus minutus* Theobald, *Monogr. Cul.* 3 : 91. (Type-loc. : Lahore, Pakistan).
1933. *Anopheles hyrcanus* var. *nigerrimus* : Christophers, *Fauna Br. India*, Diptera 4 : 145.
1936. *Anopheles hyrcanus* var. *williamsoni* Baisas and Hu, *Mon. Bull. Philipp. Hlth. Ser.* 16 : 222 (Type-loc. : Malaysia).
1951. *Anopheles venhuisi* Bonne-Wepster, *Docum. neerl. indones. Morb. trop.* 3 : 284 (Type-loc. : Java, Indonesia).
1973. *Anopheles* (*Cellia*) *nigerrimus* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 270.

Material examined : 3090 ♀ ♀. INDIA : ARUNACHAL PRADESH, East Kameng District, Seijusa area, 387 ex., ii., iii. & ix. 1986 ; Seppa, 82 ex., iv. 1987 ; Lower Subansiri District, Balijan, 122 ex., iv. 1986 ; Naharlagun, 762 ex., vii & viii. 1987 ; Itanagar, 141 ex., vii & viii. 1987 ; Kimin and Lora Basti, 176 ex., xi. 1987 ; Upper Subansiri District, Daporijo area, 1427 ex., vi. 1986 & v. 1987. (detail vide Tables 1 to 3).

Distribution : INDIA : Arunachal Pradesh, Assam, Meghalaya, Manipur, Nagaland,

West Bengal, Bihar, Madhya Pradesh, Haryana, Himachal Pradesh, Maharastra, Karnataka, Uttar Pradesh, Delhi, Punjab, Gujarat, Goa, Orissa, Andhra Pradesh, Kerala, Tamil Nadu, Lakshadweeps ; BANGLADESH ; BURMA ; SRI LANKA, PAKISTAN ; CHINA ; MALAYSIA ; INDONESIA ; THAILAND.

8. **Anopheles jamesii** Theobald

1901. *Anopheles jamesii* Theobald, *Monogr. Cul.* **1** : 134 (Type-loc. : Quilon, Kerala, India).
1901. *Anopheles jamesii* Liston, *Indian med. Gaz.* 36 : 444 (=*A. annularis* Van der Wulp).
1902. *Anopheles jamesii* : Stephens & Christophers, *Repts. Mal. Comm. R. Soc.*, series 6 & 7.
1904. *Anopheles jamesii* : James & Liston, *Anopheline Mosquitoes of India* ed. 1 : 93.
1911. *Anopheles jamesii* : James & Liston, *Anopheline mosquitoes of India* ed. 2 : 91.
1929. *Anopheles jamesii* : Borel, *Arch. Inst. Past. Indochine* no. 9 : 55.
1933. *Anopheles (Myzomyia) jamesii* : Christophers, *Fauna Br. India*, Diptera 4 : 291.
1973. *Anopheles (Cellia) jamesii* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 274.

Material examined : 438 ♀ ♀ INDIA : ARUNACHAL PRADESH, East Kameng District, Seijusa area, 23 ex., xi. 1986 ; Lower Subansiri District, Naharlagun, 309 ex., vii. & viii. 1987 ; Itanagar, 56 ex., vii. & viii. 1987 ; Kimin and Lora Basti, 50 ex., xi. 1987 (detail vide Tables 1 and 2).

Distribution : INDIA : Arunachal Pradesh (New record), Assam, Meghalaya, West Bengal, Orissa, Andhra Pradesh, Karnataka, Maharastra, Goa, Kerala, Tamil Nadu ; BANGLADESH ; BURMA ; SRI LANKA ; MALAYSIA ; VIET-NAM ; CHINA.

9. **Anopheles jeyporiensis** James

1902. *Anopheles jeyporiensis* James, *Scient. Mem. offrs. med. sanit. Deps. India* 2 : 32. (Type-loc. : Jeypore Hill tracts, Vizagapatnam Dist., Andhra Pradesh, India).
1903. *Anopheles jeyporiensis* : Theobald, *Monogr. Cul.* 3 : 66.
1933. *Anopheles (Myzomyia) jeyporiensis* : Christophers, *Fauna Br. India*, Diptera 4 : 220.
1973. *Anopheles (Cellia) jeyporiensis* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 275.

Material examined : 513 ♀ ♀ INDIA : ARUNACHAL PRADESH, East Kameng District, Seijusa area, 164 ex., ii., iii. & xi. 1986 ; Lower Subansiri District, Balijan, 2 ex., iv. 1986 ; Naharlagun, 286 ex., vii. & viii. 1987 ; Itanagar, 54 ex., vii. & viii. 1987 ; Kimin and Lora Basti. 7 ex., xi. 1987 (detail Vide Tables 1 and 2).

Distribulion : INDIA : Arunachal Pradesh, Assam, Meghalaya, West Bengal, Bihar, Orissa, Madhya Pradesh, Uttar Pradesh, Gujarat, Maharastra, Karnataka, Andhra Pradesh, Tamil Nadu, Kerala ; BURMA ; VIET-NAM ; KAMPUCHEA ; TAIWAN.

10. **Anopheles karwari** (James)

1903. *Nyssorhynchus karwari* James *in* Theobald, *Monogr. Cul.* 3 : 102 (Type-loc. : Karwar, Maharastra, India).
1904. *Anopheles karwari* : James & Liston, *Anopheline mosquitoes of India* ed. 1 : 89.
1908. *Anopheles karwari* : Leicester, *Stud. Inst. Med. Res. F. M. S.* 3 : 39.
1921. *Anopheles karwari* : Rodenwaldt, *Tijds. Ent.* 64 : 155.

1933. *Anopheles* (*Myzomyia*) *karwari* : Christophers, *Fauna Br. India*, Diptera 4 : 288.
1973. *Anopheles* (*Cellia*) *karwari* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 275.

Material examined : 432 ♀ ♀ INDIA : ARUNACHAL PRADESH, Lower Subansiri District, Naharlagun, 305 ex., vii. & viii. 1987 ; Itanagar, 71 ex., vii. & viii. 1987 ; Kimin and Lora Basti, 56 ex., xi. 1987 (detail vide Table 2).

Distribution : INDIA : Arunachal Pradesh (New record), Assam, Meghalaya, West Bengal, Bihar, Orissa, Maharastra, Karnataka, Goa, Andhra Pradesh, Tamil Nadu, Kerala ; Widespread in the Oriental Region up to New Guinea.

11. **Anopheles kochi** Donitz

1901. *Anopheles kochi* Dönitz, *Insektenbörse* 18 : 36 (Type-loc. : Sumatra, Indonesia).
1901. *Anopheles ocellalus* Theobald, *Monogr. Cul.* 1 : 174 (Type-loc. : Malaysia).
1908. *Cellia flava* Ludlow, *Can. Ent.* 40 : 32 (Type-loc. : Philippines).
1910. *Christophersia halli* James, *Paludism* 1 : 33 (Type-loc. : Sylhet, Bangladesh).
1933. *Anopheles* (*Myzomyia*) *kochi* : Christophers, *Fauna Br. India*, Diptera 4 : 172.
1973. *Anopheles* (*Cellia*) *kochi* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 275.

Material examined : 1474 ♀ ♀. INDIA : ARUNACHAL PRADESH, East Kameng District, Seijusa area, 209 ex., ii., iii. & xi. 1986 ; Seppa, 17 ex., iv. 1987 ; Lower Subansiri District, Balijan, 86 ex., iv. 1986 ; Naharlagun, 505 ex., vii. & viii. 1987 ; Itanagar, 105 ex., vii. & viii. 1987 ; Kimin and Lora Basti, 103 ex. , xi. 1987 ; Upper Subansiri District, Daporijo area, 149 ex., vi. 1986 & v. 1987 (detail vide Tables 1 to 3).

Distribution : INDIA : Arunachal Pradesh, Assam, Meghalaya, West Bengal, Andaman Is., BANGLADESH ; BURMA ; MALAYSIA ; PHILIPPINES ; INDONESIA ; MOLUCCAS.

12. **Anopheles maculatus** Theobald

1901. *Anopheles maculatus* Theobald, *Monogr. Cul.* 1 : 171 (Type-loc. : Hong Kong).
1910. *Nyssorhynchus pseudowillmori* Theobald, *Monogr. Cul.* 5 : 65 (Type-loc. : Jalpaiguri Duars, West Bengal, India).
1911. *Anopheles maculatus* : James & Liston, *Anopheline mosquitoes of India* ed. 2 : 87.
1924. *Anopheles maculatus* var. *dravidicus* Christophers, *Indian J. med. Res.* 12 : 297 (Type-loc. : Nilgiri Hills, Tamil Nadu, India).
1925. *Myzomyia hanabusai* Yamada, *Scient. Rep. Govt. Inst. infect. Dis. Tokyo Univ.* 4 : 471 (Type-loc. : Taiwan).
1933. *Anopheles* (*Myzomyia*) *maculatus* : Christophers, *Fauna Br. India*, Diptera 4 : 278.
1973. *Anopheles* (*Cellia*) *maculatus* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 275.

Material examined : 3921 ♀ ♀. INDIA : ARUNACHAL PRADESH, East Kameng District, Seijusa area, 811 ex., ii., iii., & xi. 1986 ; Seppa, 127 ex., iv. 1987 ; Lower Subansiri District, Balijan, 323 ex., iv. 1986 ; Naharlagun, 823 ex., vii. & viii. 1987 ; Itanagar, 207 ex., vii & viii. 1987 ; Upper Subansiri District, Daporijo area, 1414 ex., vi. 1986 & v. 1987 (detail vide Tables 1 to 3).

Table 3. Results of entomological survey showing prevalence of different anopheline species in different biotopes in places of Upper Subansiri District, Arunachal Pradesh.

Places (Localities)	Period	Biotopes	ANOPHELINE SPECIES COLLECTED																	TOTAL
			Total time spent (hrs.)	aconitus	annularis	barbirostris	balabacenssis	culicifacies	gigas	nigerrimus	jamesii	jeyporiensis	karwari	kochi	maculatus	philippinensis	splendidus	subpictus	vagus	
Daporijo	13.6.86	outdoor resting	61	—	307	179	—	—	—	356	—	—	—	107	341	69	53	—	149	1561 (23.87)
(township)	to	indoor resting	68	—	193	85	—	—	—	106	—	—	—	42	177	36	—	—	64	703 (10.75)
	29.6.86	cattleshed resting	41	—	299	171	—	—	—	330	—	—	—	57	262	48	25	—	175	1367 (20.90)
		cattle biting	43	—	266	185	—	—	—	277	—	—	—	81	302	53	19	—	167	1350 (20.64)
Daporijo	21.5.87	outdoor resting	24	—	47	54	—	—	—	115	—	—	—	42	91	11	23	—	33	416 (6.36)
(Forest colony,	to	indoor resting	28	—	40	34	—	—	—	57	—	—	—	24	52	11	18	—	26	262 (4.00)
Ligu vill. &	29.5.87	cattleshed																		
Sikarajo vill.)		resting	26	—	58	74	—	—	—	101	—	—	—	53	105	18	31	—	40	480 (7.34)
		cattle biting	25	—	37	70	—	—	—	85	—	—	—	43	84	11	31	—	39	400 (6.11)
		TOTAL	316	—	1247	852	—	—	—	1424	—	—	—	449	1414	257	200	—	693	6539
				(—)	(19.07)	(13.02)	(—)	(—)	(—)	(21.82)	(—)	(—)	(—)	(6.86)	(21.62)	(3.93)	(3.05)	(—)	(10.59)	(100)

Figures in parentheses indicate the percentage

Distribution : INDIA : Arunachal Pradesh, Assam, Meghalaya, Nagaland, West Bengal, Bihar, Orissa, Madhya Pradesh, Uttar Pradesh, Haryana, Punjab, Himachal Pradesh, Kashmir, Maharastra, Goa, Karnataka, Andhra Pradesh, Tamil Nadu, Kerala ; BANGLADESH ; BURMA ; NEPAL ; SRI LANKA ; PAKISTAN ; HONG KONG ; CHINA ; Lesser SUNDA IS.

13. **Anopheles philippinensis** Ludlow

9012. *Anopheles philippinensis* Ludlow, *J. Am. med. Ass.* 39 : 426 (Type-loc. : Philippines).
1906. *Pyretophorus freerae* Banks, *Philipp. J. Sci.* (D) 1 : 993.
1920. *Anopheles pampangensis* Brunetti, *Rec. Indian Mus.* 17 : 114 (n. name for *philippinensis* (Ludlow, in error).
1933. *Anopheles (Myzomyia) philippinensis* : Christophers, *Fauna Br. India,* Diptera 4 : 307.
1973. *Anopheles (Cellia) philippinensis* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 277.

Material examined : 731 ♀ ♀. INDIA : ARUNACHAL PRADESH, East Kameng District, Seijusa area, 137 ex., ii., iii. & xi. 1986 ; Seppa, 14 ex., iv. 1987 ; Lower Subansiri District, Balijan, 40 ex., iv. 1986 ; Naharlagun, 214 ex., vii. & viii. 1987 ; Itanagar, 40 ex., vii. & viii. 1987 ; Kimin and Lora Basti, 29 ex., xi. 1987 ; Upper Subansiri District, Daporijo area, 257 ex., vi. 1986 & v. 1987 (detail vide Tables 1 to 3).

Distribution : INDIA : Arunachal Pradesh, Assam, Meghalaya, Manipur, West Bengal, Bihar, Orissa, Karnataka, Maharastra ; BANGLADESH ; MALAYSIA ; THAILAND ; VIET-NAM ; CHINA.

14. **Anopheles splendidus** Koidzumi

1920. *Anopheles splendidus* Koidzumi, *Daiwan Kenkyujo Hokoku* 8 : 23 (Type-loc. : Taiwan).
1903. *Nyssorhynchus maculipalpis* var. *indiensis* Theobald, *Monogr. Cul.* 3 : 99 (Type-loc. : Nagpur, Maharastra, India ; nec. *A. sinensis* var. *indiensis* Theobald, 1901).
1904. *Anopheles maculipalpis* James & Liston, *Anopheline mosquitoes of India* ed. 1 : 95 (Type-loc. : India ; nec. *A. maculipalpis* Giles, 1902).
1933. *Anopheles (Myzomyia) splendidus* : Christophers, *Fauna Br. India,* Diptera 4 : 296.
1973. *Anopheles (Cellia) splendidus* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 277.

Material examined : 1583 ♂♂, ♀ ♀. INDIA : ARUNACHAL PRADESH, East Kameng District, Seijusa area, 667 ex., ii., iii. & xi. 1986 ; Lower Subansiri District, Naharlagun, 490 ex., vii. & viii. 1987 ; Itanagar, 125 ex., vii. & viii. 1987 ; Kimin and Lora Basti, 101 ex., xi. 1987 ; Upper Subansiri District, Daporijo area, 200 ex., vi. 1986 and v. 1987 (detail vide Tables 1 to 3).

Distribution : INDIA : Arunachal Pradesh, West Bengal, Bihar, Orissa, Madhya Pradesh, Uttar Pradesh, Delhi, Punjab, Haryana, Himachal Pradesh, Kashmir, Gujarat, Maharastra, Goa, Karnataka, Andhra Pradesh, Tamil Nadu, Kerala ; NEPAL ; BURMA ; PAKISTAN ; VIET-NAM ; KAMPUCHEA ; TAIWAN ; CHINA.

15. Anopheles subpictus Grassi

1899. *Anopheles subpictus* Grassi, *Rc. R. Acad. Lincei* 8 : 101 (Type-loc. : Calcutta, West Bengal, India).
1899. *Anopheles rossii* Giles, *J. Trop. Med.* 2 : 63 (Type-loc. : Calcutta, West Bengal, India).
1903. *Aldrichia error* Theobald, *Monogr. Cul.* 3 : 353 (Type-loc. : Calcutta, West Bengal, India).
1904. *Anopheles subpictus* : James & Liston, *Anopheline Mosquitoes of India* ed. 1 : 109.
1933. *Anopheles (Myzomyia) subpictus* : Christophers, *Fauna Br. India*, Diptera 4 : 231.
1973. *Anopheles (Cellia) subpictus* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 278.

Material examined : 6 ♀ ♀ INDIA : ARUNACHAL PRADESH, Lower Subansiri District, Balijan, 6 ex., iv. 1986 (detail vide Table 2).

Distribution : INDIA : Arunachal Pradesh, Assam, Meghalaya, Tripura, West Bengal, Bihar, Orissa, Madhya Pradesh, Uttar Pradesh, Punjab, Haryana, Himachal Pradesh, Rajasthan, Gujarat, Maharastra, Goa, Karnataka, Andhrh Pradesh, Tamil Nadu, Kerala, Lakshadweeps ; BANGLADESH ; BURMA ; NEPAL ; SRI LANKA ; PAKISTAN ; AFGHANISTHAN ; IRAN ; CHINA ; MALAYSIA ; INDONESIA ; THAILAND ; MALDIVE ; BISMARCK IS. ; NEW GUINEA.

16. Anopheles vagus Dönitz

1902. *Anopheles vagus* Dönitz, *Z. Hyg. Infektkrankh* 41 : 80 (Type-loc. : Sumatra, Indonesia).
1902. *Anopheles formosaensis* I. Tsuzuki, *Saikingaku Zasshi* 75 : 28 (Type-loc. : Formosa).
1902. *Anopheles immaculata* James, *Scient. Mem. Offrs. med. sanit Deps. India* 2 : 35 (Type-loc. : Ennur, Tamil Nadu, India).
1903. *Anopheles immaculatus* Theobald, *Monogr. Cul.* 3 : 23 (Type-loc. : Goa, India).
1907. *Anopheles formosaensis* var. *trimaculatus* Tsuzuki, *Zool. Jb.* (1) 25 : 549 (Type-loc. : Formosa).
1917. *Myzomyia indefinita* var. *flava* Swellengrebel, *Geneesk, Tijdschr. Ned.-Indie* 57 : 807 (Type-loc. : Java, Indonesia).
1923. *Anopheles vagus* : Senior-White, *Catalog Indian Ins.* Pt. 2 : 34.
1933. *Anopheles (Myzomyia) vagus* : Christophers, *Fauna Br. India*, Diptera 4 : 241.
1973. *Anopheles (Cellia) vagus* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 279.

Material examined : 2430 ♀ ♀ INDIA : ARUNACHAL PRADESH, East Kameng District, Seijusa area, 291 ex., ii., iii. & xi. 1986 ; Seppa, 45 ex., iv. 1987 ; Lower Subansiri District, Balijan, 111 ex., iv. 1986 ; Naharlagun, 946 ex., vii. & viii. 1987 ; Itanagar, 169 ex., vii. & viii. 1987 ; Kimin and Lora Basti, 175 ex., xi. 1987 ; Upper Subansiri District, Daporijo area, 693 ex., vi. 1986 & v. 1987 (detail vide Tables 1 to 3).

Distribution : INDIA : Arunachhl Pradesh, Assam, Meghalaya, Manipur, Tripura, West Bengal, Bihar, Orissa, Madhya Pradesh, Maharastra, Karnataka, Goa, Gujarat, Andhra Pradesh, Tamil Nadu, Kerala, Pondicherry, Andaman Is., Lakshadweeps ; ANGLADESH ; BURMA ; SRI LANKA ; TAIWAN ; MOLUCCAS ; and Widespread in Oriental Region.

Key to the Anopheline species (females) to the area

1. Wing with dark areas involving costa, subcosta, and first longitudinal vein (R_1) less than four in numbers. (Subgenus *Anopheles*) ... 2
— Wing with dark areas involving costa, subcosta and first longitudinal vein (R_1) at least four in numbers. (Subgenus *Cellia*) ... 4
2. Inner quarter of costa with pale interruption, a large pale spot on the wing fringe between 5·2 and 6. ... *gigas* Giles
— Inner quarter of costa mainly dark, though there may be a few scattered pale scales. ... 3
3. Palpi with distinct pale markings. ... *nigerrimus* Giles
— Palpi devoid of any pale markings ... *barbirostris* Van der Wulp
4. Tip of hind tarsi (5th tarsal segment) white ... 9
— Tip of hind tarsi (5th tarsal segment) not white ... 5
5. Apical and subapical pale bands of palpi nearly of equal length. ... 6
— Pale apical band of palpi always broader than subapical pale band. ... 7
6. Intermediate dark area between apical and subapical pale bands of palpi much broader than either of the two bands. ... *culicifacies* Giles
— Intermediate dark area between apical and subapical pale bands of palpi much proader either of the two bands. ... *aconitus* Dönitz
7. Pale apical band of palpi a little broader than subapical pale band, the intermediate dark area much broader than either of two bands. ... *jeyporiensis* James
— Pale apical band of palpi distinctly broader than subapical pale band ; the intermediate dark area either of the same size of apical band or smaller than that. Tarsi of front legs with broad pale bands. ... 8
8. Dark intermediate area between two pale bands at apex of palpi is almost equal in length of the apical pale band. ... *subpictus* Grassi
— Dark intermediate area between two pale bands at apex of palpi markedly narrow and less than one-third of apical pale area. ... *vagus* Dönitz
9. Hind tarsi with only one segment or less white, commonly with white bands above this. ... 10
— Hind tarsi with a continuous white area on at least two terminal segments. ... 13
10. Femora and tibiae speckled. ... 11
— Femora and tibiae not speckled ... *karwari* (James)
11. Sixth vein (2nd A) of wing with more than three dark spots. ... *balabacensis* Baisas
— Sixth vein (2nd A) of wing with not more than three dark spots. ... 12
12. Half 5th hind tarsal segment of whitish ; palpi with four pale bands. Prominent black scale tufts on ventral side of each abdominal segment. ... *kochi* Dönitz
— Whole of 5th hind and one-third of 4th hind tarsal segments white with a dark band on 4th segment ; palpi with three pale bands. ... *maculatus* Theobald
13. Femora and tibiae speckled. ... 14

— Femora and tibiae not speckled. ... 15

14. Palpi with two broad apical pale bands equal, palpi speckled. ... *splendidus* Koidzumi
— Palpi with two apical pale bands unequal. At least two segments of dorsum of abdomen clothed with golden scales. ... *jamesii* Theobald
15. Ffth vein (Cu) of wing mainly dark with a dark spot at its bifurcation ... *annularis* Van der Wulp
— Fifth vein (Cu) of wing continuously pale and no dark spot at its bifurcation. Distal end of tarsal segment 1 of hind leg inconspicuously white-marked. ... *philippinensis* Ludlow

RESULTS

During these surveys, a total of 19,322 anopheline mosquitoes (females) belonging to 16 species were collected. Among them *A. maculatus* was most common (East Kameng—25·31% ; Lower Subansiri—17·28% ; Upper Subansiri—21·62%) and only slight morphological variations were seen in different population, *A nigerrimus*, *A vagus* and *A barbirostris* were found in large number from all the localities. *A. annularis* and *A. philippinensis* were collected in considerable number from almost all villages and human settlements (Tables 1 to 3). Of 4 new introductions in Arunachal Pradesh only *A. culicifacies* is a primary vector of malaria in parts of its range of distribution.

DISCUSSION

The protocol described in this paper provides a basis for realizing the extent or probablity of contact between human, nonhuman hosts and mosquitoes in various biotopes. However, the quantification obtained be carefully qualified as the variation in housing and surrounding conditions in various localities may also influence the number of mosquito biting/catching.

The results of this survey should of course be supplemented by more pertinent data so as to quantitate the actual degree of concurrence between mosquitoes and hosts in studies of the 'Feeding Index' (Kay *et al.*, 1979). It would also help in order to put forward a more thorough analysis of host-feeding patterns based on precipitin-test analysis. The host-mosquito concurrence factor may be derived from data on the relative availability of hosts and the mosquitoes indoors and outdoors. This, in turn, can point out to the overall risk to the human population. For example, from the Upper Subansiri District's data of *A. annularis* it revealed that, in Daporijo township during June 1986, the relative proportion of occurrence indoors and outdoors was 1 : 1·77 (Table 3). During the first quarter of night when *A. annularis* was most active, approximately whole of the human population used to remain indoors. The risk of human being affected by malaria parasite through *A. annularis* thus appears to be considerably greater in outdoors than in indoors. On the

basis of relative risk assessment appropriate measures are required to be taken up. In fact, the zooprophylactic effect of domestic pigs and wild or semidomesticated mammals indispersed among social gatherings or aborigines stay outdoor, seem to suppress the transmission of malaria to some extent in Arunachal Pradesh.

Entomological observations in outdoor conditions, in cattlesheds and inside the human residence reveal that *A. maculatus*, *A. nigerrinmus*, *A. vagus* and *A. barbirostris* are the most commonly encountered anopheline species. None of these species is recorded to be a primary or secondary vector of malaria throughout its zone of distribution. However,

Table 4. Statement showing epidemiological situation of malaria in Kameng, Lower Subansiri and Upper Subansiri Districts of Arunachal Pradesh

Name of the Districts	Year	Blood slide collected/ examined	Blood slide positive for malarial parasite	Presence of P falciparum	Death due to malaria
Kameng (East plus West)	1985	13168	1370	203	—
	1986	9644	1072	188	—
	1987	8544	514	144	—
	1988 (up to Nov.)	7226	558	130	—
Lower Subansiri	1985	34194	1595	213	—
	1986	32746	2046	270	—
	1987	29722	2047	225	—
	1988 (up to Nov.)	30786	2267	267	—
Upper Subansiri	1985	25087	3322	205	—
	1986	27564	3036	119	—
	1987	19025	1723	119	—
	1988 (up to Nov.)	20148	2166	102	—
	TOTAL	257854	21716	2275	—

Source : Directorate of Health Service, Govt. of Arunachal Pradesh

recent surveys reveal high incidence of malaria in this region (Table 4). It is noteworthy that most of the malaria cases were due to *Plasmodium vivax* but during last few years

incidence of *P. falciparum* has been increasing. Of the recognised vector species in the country and those present in this area, the population of *A. balabacensis* and *A. culicifacies* are extremely low and may not be responsible for any significant malaria transmission. *A. philippinensis* is not a vector of malaria in this part of the country but increases in its densities especially after rains, may be causing considerable nuisance. This species is virtually disappeared (NMEP, 1970) and lost its influence of transmitting malaria in many areas like, southern West Bengal. *A. annularis* which was regarded to be a secondary vector in certain areas of India (Timber, 1935 ; Viswanathan *et. al.*, 1941 ; Panigrahi, 1942 ; Senior-White *et al.*, 1943) has now replaced the former species of primary importance like, *A. philippinensis* to become the vector of primary importance, as in rural West Bengal (Ghosh, *et al.*, 1985). The densities of *A. annularis* are reasonably high from May to at least August in this area. Though neither *A. philippinensis* nor *A. annularis* has been found incriminated with the parasite but there are ample circumstancial evidence that indicate towards these two species as the candidate vector species. This however must be regarded as an inconclusive opinion. On the other hand there is record that in the absence of the principal vector species in Nepal, sporadic malaria transmission was caused by *A. annularis* (Parajuli *et al.*, 1981). This fact indicates the wide area of vectorial efficiency of *A. annularis*.

Repaid development, large scale construction and many other opportunities induced people to come to Arunachal in large numbers. Inter alia, many labour groups come from many malaria endemic areas, including region with *Plasmodium falciparum* incidence. They often stay in temporary huts and settle down in clusters ('bastis'). These bastis have enough malariogenic potential. The anti-parasitic and anti-mosquito measures for malaria are inadequately implemented. Thus the present situation poses reasonable threat to the overall health status of the State. There is, therefore, an urgent need for visualizing the problem and to reorganise anti-mosquito as well as malaria control operation in this part of the country so as to protect the people from the ravages of malaria.

SUMMARY

The paper deals with the anopheline mosquito collection from the districts of East Kameng, Lower Subansiri and Upper Subansiri of Arunachal Pradesh. It is based on by some recent collections made by the NMEP team of Kimin (Arunachal Pradesh). A total of 16 species of *Anopheles* are recorded of which, *A. culicifacies*, *A. gigas*, *A. jamesii* and *A. karwari* are noted for the first time from this State.

The observations provided a moderate basis for assessing the extent of contact between human and nonhuman hosts and mosquitoes in different biotopes like, inside human residences, cattlesheds and outdoor conditions. Parasitological surveys in Arunachal Pradesh revealed that there is upsurge of malaria cases in different districts. Both *Plasmodium vivax* and *P. falciparum* cases were noted. Entomological observations brought out the importance of the available anopheline species in transmission of malaria in this area.

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