

# Role of *Anopheles (Kerteszia) bellator* as Malaria Vector in Southeastern Brazil (Diptera: Culicidae)

Oswaldo Paulo Forattini<sup>+</sup>, Iná Kakitani, Roseli La Corte dos Santos, Helene Mariko Ueno, Keilla Miki Kobayashi

Departamento de Epidemiologia, Núcleo de Pesquisa Taxonômica e Sistemática em Entomologia Médica, Faculdade de Saúde Pública, Universidade de São Paulo, Av. Dr. Arnaldo 715, 01246-904 São Paulo, SP, Brasil

*New research concerning Anopheles bellator in the southeast of the State of São Paulo, Brazil, are reported. Adult females of this mosquito showed remarkable endophily and endophagy which was even greater than An. cruzii. The epidemiological role of this anopheline as a malaria vector is discussed.*

Key words: *Anopheles - Kerteszia* - malaria vectors

Among the *Kerteszia* subgenus of Anophelinae, *Anopheles bellator* has been considered as a vector of endemic malaria in southeastern Brazil. Despite the endemic situation at the present time declining to a low epidemiological level, the potential role of this vector has been a matter for assessment by investigations, particularly with respect to the anthropic environment represented by human dwellings in comparison to the sylvan behaviour of *An. cruzii*, another sympatric species of the same subgenus.

Early data regarding blood-seeking and general parity patterns have already been published (Forattini et al. 1993, 1996). According to these findings, despite there being no tendency towards resting within dwellings, both mosquitoes were present in man-made settlements. Even if the *An. cruzii* was more abundant, the local population of *An. bellator* showed greater endophagy, higher parity rates and maintained a greater abundance in natural environment.

To clarify the regional environmental influence and to confirm the behaviour of this population, new observations were planned and undertaken in the same region. The results obtained are presented and discussed below.

*Study area* - Adult catches were performed in the same study area as described elsewhere

(Forattini et al. 1996). At the "Sítio Gentil" (Gentil Farm) mosquito collections were undertaken in the same previously mentioned house. This dwelling is located nearly 20 m, in a straight line, from the Atlantic Rain Forest which covers the regional Paratiu mountain slopes. To determine the influence of the estuary system hypothesis on *An. bellator* behaviour, a place near Pedrinhas village in the Ilha Comprida County covered by woody coastal lowland vegetation ("restinga"), situated nearly 4 km away from any house was chosen to perform catches.

With the objective of observing mosquito behaviour in a natural environment but contiguous to an urban center, the "Morro de São João" (Saint John's Hill) was selected. This hill is completely covered by Atlantic Rain Forest and is surrounded by Cananéia town, except on the seaward side.

## MATERIAL AND METHODS

Biting activity was monitored fortnightly using two human bait collectors working simultaneously, one of them indoors and the other outdoors near the house. Mosquitoes landing on the host were collected with a hand-held aspirator. Landing collections began at sunset and continued for 2 hr. Due to seasonal variation, daily crepuscular data were obtained from the Nautical Almanac tables issued annually for local time. Mosquito collections started in May 1996 and continued until September 1997.

For purposes of comparison, other adult collections were undertaken in the natural environment with the use of a Shannon trap also operating fortnightly from 17:00 to 20:00 hr. At the "Sítio Gentil" forest, catches were carried out over the same period. In the Pedrinhas region, into the "restinga" (coastal lowland vegetation), collections were undertaken from May to September 1996. At Cananéia city, collections were made in the forest, on the "Morro de São João" during the evening

This work was supported by funds from the Fundação de Amparo à Pesquisa do Estado de São Paulo, grants 95/0381-4, 96/08991-9 and 96/09174-4, Conselho Nacional de Desenvolvimento Científico e Tecnológico, Process 300225/95-4 and Fundação Coordenação de Aperfeiçoamento de Pessoal de Nível Superior.

<sup>+</sup>Corresponding author. Fax: +55-11-282.1898. E-mail: opforati@usp.br

Received 15 April 1999

Accepted 24 June 1999

hours 17:00-20:00 hr, starting in May 1996 and ending in August 1997.

The data obtained from all collections were analyzed statistically by the Man-Whitney test.

### RESULTS

In the human dwelling environment the human bait yielded a total of 7,886 females of the two *Kerteszia* combined and including both indoor and outdoor catches. Among these mosquitoes, 2,546 were captured from inside the house and 5,340 were collected outside. The *p* value was 0.019 and therefore showed significance for the latter. Notwithstanding the results obtained for the two species, demonstrated the prevalence of *An. bellator* in the anthropic environment (Table I). The *p* values for the indoor and outdoor data were 0.009 and 0.004 respectively, verifying that as the differences observed between the two anopheline species were statistically significant.

Data on the collections made in the natural environments are presented in Tables II and III. In the "Sítio Gentil" slope forest, no significant differences were detected between *An. cruzii* and *An. bellator* as the *p* value was 0.770. The same evidence was found in the Pedrinhas lowland vegetation with a *p* value of 0.347. However, fewer collections were made there and this fact may have influenced the results. For Cananéia town (Morro de São João) the difference was significant (*p* = 0.030), suggesting that *An. cruzii* was the most abundant species.

### DISCUSSION

As is generally recognized in southeastern Brazil, the behaviour of the *Kerteszia* anopheline is essentially sylvan, particularly *An. cruzii* that specifically is charged with the maintenance of hypoendemic malaria in the Atlantic Rain Forest region of the State of São Paulo (Carvalho et al. 1988, Branquinho et al. 1997). However, another local species, *An. bellator* has not merited any special attention since the early observations of Rachou (1958). For this reason we undertook the present study, since earlier observations in the Ribeira Valley (Forattini et al. 1993) indicated that this mosquito to exhibited a degree of endophily and endophagy.

The degree of endophagy of *An. bellator* was found to be greater and to occur about four times more frequently in dwellings than that seen for *An. cruzii*. Therefore, from the epidemiological point of view, it fulfils at least one of the requirements to be considered as a malaria vector. Additionally, more than 30% of *An. bellator* females attracted to human bait are parous, i.e., seeking at least a second blood meal (Forattini et al. 1996).

The observations reported here confirm those previously published and mentioned above. Un-

der natural environment conditions and depending upon the circumstances, both *An. bellator* and *An. cruzii* may occur in equal numbers. Data suggest that primitiveness, i.e., an undisturbed natural environment favours *An. cruzii* dominance. The results obtained from the catches at Pedrinhas may represent the true pattern because few collections were made there and included a monthly period with low adult production at the Shannon trap (Forattini et al. 1996). However, regarding the man-made surroundings, *An. bellator* seems to present a greater tendency to frequent dwellings. This synanthropic behaviour may reflect an ability to adapt to new environmental conditions resulting from man-made transformations, i. e., to the anthropic environment.

Another point that must be taken into account is the existence in the region of *An. homunculus*. This is necessary because it is morphologically closely related to *An. cruzii* and it has been hypothesized that this mosquito is a sibling species in a possible *cruzii* complex (Rosa-Freitas et al. 1998).

In conclusion, at least with respect to the population of the southeast of the State of São Paulo, *An. bellator* shows remarkable ecological and behavioural characteristics that could allow it to be considered as an epidemiologically important vector of malaria.

### REFERENCES

- Branquinho MS, Marrelli MT, Curado I, Natal D, Barata JM, Tubaki R, Carreri-Bruno GC, de Menezes RT, Kloetzel JK 1997. Infecção de *Anopheles (Kerteszia) cruzii* por *Plasmodium vivax* e *Plasmodium vivax* variante VK247 nos municípios de São Vicente e Jquitiba, São Paulo. *Rev Panam Salud Pública* 2: 189-193.
- Carvalho ME, Glasser CM, Ciaravolo RMC, Etzel A, Santos LA, Ferreira CS 1988. Sorologia de malária vivax no foco Aldeia dos Índios, município de Peruibe, São Paulo, de 1984 a 1986. *Cad Saúde Públ* 4: 276-292.
- Forattini OP, Kakitani I, Massad E, Gomes A de C 1993. Studies on mosquitoes (Diptera: Culicidae) and anthropic environment. 1 - Parity of blood seeking *Anopheles (Kerteszia)* in South-Eastern Brazil. *Rev Saúde Pública* 27: 1-8.
- Forattini OP, Kakitani I, Massad E, Marucci D 1996. Studies on mosquitoes (Diptera: Culicidae) and anthropic environment. 11 - Biting activity and blood-seeking parity of *Anopheles (Kerteszia)* in South-Eastern Brazil. *Rev Saúde Pública* 30: 107-114.
- Rachou RG 1958. Anofelinos do Brasil. Comportamento das espécies vetoras de malária. *Rev Bras Malariol Doenças Trop* 10: 145-181.
- Rosa-Freitas MG, Lourenço-de-Oliveira R, Carvalho-Pinto CJ de, Flores-Mendoza C, Silva-do-Nascimento T 1998. Anopheline species complexes in Brazil. Current knowledge of those related to malaria transmission. *Mem Inst Oswaldo Cruz* 93: 651-655.

TABLE I  
 Numbers of *Anopheles (Kerteszia)* females caught landing on human bait at the Sítio Gentil (May 1996 - September 1997)

Year Month	<i>An. cruzii</i>					<i>An. bellator</i>					Total					
	Indoor		Outdoor			Indoor		Outdoor			Indoor		Outdoor			
	No.	%	No.	%	T	no.	%	No.	%	T	No.	%	No.	%	T	
1996																
May	31	4.2	87	6.0	118	183	9.7	257	6.6	440	214	8.4	344	6.4	558	
June	9	12.2	150	10.3	159	40	2.1	230	5.9	270	49	1.9	380	7.1	429	
July	47	6.4	246	17.0	293	86	4.6	237	6.1	323	133	5.2	483	9.0	616	
August	0	0.0	5	0.3	5	6	0.3	25	0.6	31	6	0.2	30	0.6	36	
September	40	5.4	34	2.3	74	127	6.7	189	4.9	316	167	6.6	223	4.2	390	
October	8	1.1	39	2.7	47	39	2.1	161	4.1	200	47	1.8	200	3.7	247	
November	5	0.7	16	1.1	21	101	5.3	117	3.0	218	106	4.2	133	2.5	239	
December	64	8.7	104	7.2	168	100	5.3	671	17.3	771	164	6.4	775	14.5	939	
1997																
January	218	29.6	414	28.5	632	556	29.4	713	18.3	1269	774	30.4	1127	21.1	1901	
February	20	2.7	35	2.4	55	177	9.4	567	14.6	744	197	7.7	602	11.3	799	
March	128	17.4	68	4.7	196	151	8.0	149	3.8	300	279	11.0	217	4.1	496	
April	5	0.7	18	1.2	23	134	7.1	193	5.0	327	139	5.5	211	4.0	350	
May	29	3.9	62	4.3	91	66	3.5	109	2.8	175	95	3.7	171	3.2	266	
June	4	0.5	13	0.9	17	10	0.5	43	1.1	53	14	0.5	56	1.0	70	
July	12	1.6	13	0.9	25	81	4.3	57	1.5	138	93	3.7	70	1.3	163	
August	0	0.0	12	0.8	12	3	0.2	47	1.2	50	3	0.1	59	1.1	62	
September	35	4.8	135	9.3	170	31	1.6	124	3.4	155	66	2.6	259	4.9	325	
Total	655	100.0	1451	100.0	2106	1891	100.0	3889	100.2	5780	2546	100.0	5340	100.0	7886	

TABLE II  
Numbers of *Anopheles cruzii* females caught in Shannon traps in several natural environments (1996-1997)

Year	Month	Sítio Gentil		Pedrinhas		Cananéia <sup>a</sup>		Total		
		No.	%	No.	%	No.	%	No.	%	
1996	May	35	1.5	262	45.0	12	0.8	309	7.1	
	June	29	1.3	16	2.7	45	3.0	90	2.1	
	July	86	3.8	249	42.8	48	3.2	383	8.8	
	August	54	2.4	8	1.4	82	5.5	144	3.3	
	September	169	7.4	47	8.1	17	1.1	233	5.3	
	October	283	12.4			6	0.4	289	6.6	
	November	47	2.1			17	1.1	64	1.5	
	December	123	5.4			204	13.6	327	7.5	
	1997	January	990	43.3			137	9.1	1127	25.8
		February	171	7.5			20	1.3	191	4.4
		March	34	1.5			294	19.5	328	7.5
		April	37	1.6			38	2.5	75	1.7
May		22	1.0			23	1.5	45	1.0	
June		25	1.1			415	27.6	440	10.1	
July		33	1.4			141	9.4	174	4.0	
August		74	3.2			5	0.3	79	1.8	
September		76	3.3			0	0.0	76	1.7	
Total		2288	100.0	582	100.0	1504	100.0	4374	100.0	

a: Morro de São João

TABLE III  
Numbers of *Anopheles bellator* females caught in Shannon traps, in several natural environments (1996-1997)

Year	Month	Sítio Gentil		Pedrinhas		Cananéia <sup>a</sup>		Total		
		No.	%	No.	%	No.	%	No.	%	
1996	May	76	4.2	89	49.7	12	2.9	177	7.4	
	June	40	2.2	1	0.6	35	8.6	76	3.2	
	July	29	1.6	54	30.2	9	2.2	92	3.9	
	August	50	2.8	6	3.4	16	3.9	72	3.0	
	September	227	12.6	29	16.2	15	3.7	271	11.4	
	October	173	9.6			5	1.2	178	7.5	
	November	64	3.6			6	1.5	70	2.9	
	December	100	5.6			108	26.5	208	8.7	
	1997	January	552	30.7			51	12.5	603	25.3
		February	118	6.6			9	2.2	127	5.3
		March	45	2.5			33	8.1	78	3.3
		April	132	7.3			44	10.8	176	7.4
May		20	1.1			10	2.5	30	1.3	
June		31	1.7			29	7.1	60	2.5	
July		55	3.1			20	4.9	75	3.1	
August		46	2.6			5	1.2	51	2.1	
September		38	2.1			0	0.0	38	1.6	
Total		1796	100.0	179	100.0	407	100.0	2382	100.0	

a: Morro de São João