RELATIVE ABUNDANCE OF *CULEX QUINQUEFASCIATUS* (DIPTERA: CULICIDAE) WITH REFERENCE TO INFECTION AND INFECTIVITY RATE FROM THE RURAL AND URBAN AREAS OF EAST AND WEST GODAVARI DISTRICTS OF ANDHRA PRADESH, INDIA

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Abstract. This paper describes the seasonal abundance of *Culex quinquefasciatus* in the rural and urban areas of the East and West Godavari districts (EGDT and WGDT) of Andhra Pradesh, India. The per man-hour density (PMHD) was collected from seven units in EGDT and two units in WGDT, which comprised rural and urban areas. The highest infection and infectivity rates were found in the rural areas of Rajahmundry (43.6%) and Amalapuram (13.2%) respectively. In urban areas, the highest infection and infectivity rates were found in Rajahmundry: 7.5% and 3.6% respectively. There was considerable difference in the infection rate and infectivity rates between the rural areas and urban areas in each unit.

INTRODUCTION

Bancroftian filariasis was recognized as a problem in rural India during the 1962-1971 phase of the National Filariasis Control Program (NFCP, 1971). It is regarded as being an urban disease because the vector, *Culex quinquefasciatus*, is a recognized urban mosquito with ubiquitous breeding sites and a close association with man and his surroundings. Rural filariasis has received far less attention (Rajagopalan *et al*, 1981). The present control methods of the National Filariasis Control Program (NFCP) are confined to urban areas which house about 11% of the population that is exposed to a risk of infection. Approximately 74% of the rural population are to be covered under the integrated control programs (VCRC, 1998). The control measures adopted in urban areas cannot be extended to rural areas due to the vastness of the areas, operational problems, and cost considerations (Ramaiah *et al*, 1989). *Cx. quinquefasciatus* seasonal population density fluctuations have been studied extensively in many parts of the world (Ramaiah and Das, 1992). Bancroftian filariasis is endemic in the coastal districts of Andhra Pradesh (Raghavan, 1957); the study areas, East and West Godavari districts (EGDT and WGDT), are endemic for Bancroftian filariasis.

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MATERIALS AND METHODS

Study areas

The study areas of East and West Godavari districts lie on the Bay of Bengal (16.25ºN, 18.10ºE and 80.75ºN, 82.65ºE) (Fig 1). The study areas comprised of nine NFCP units; seven units in EGDT and two units in WGDT. A Unit is a place where the people come during the night time once in a week for

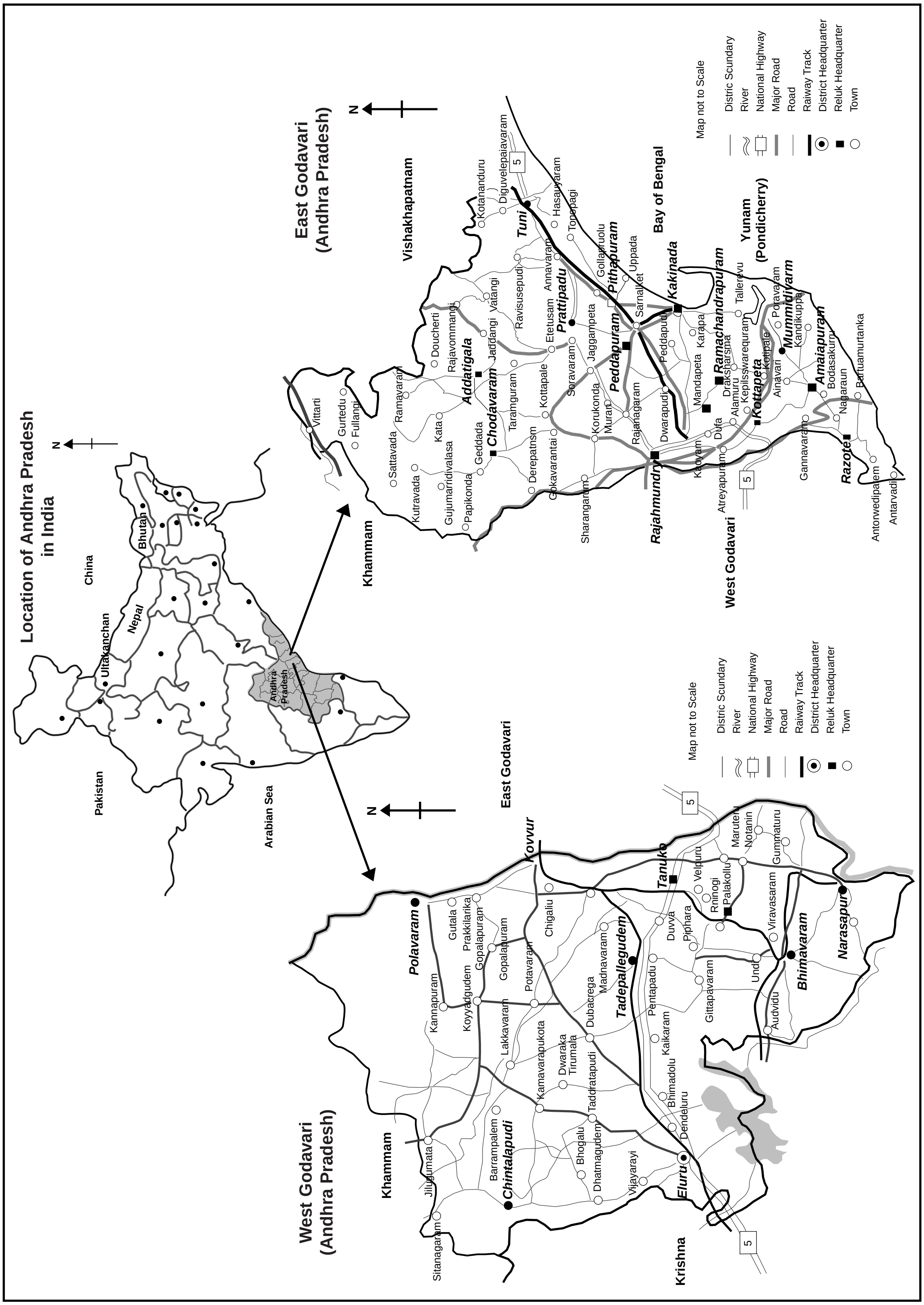
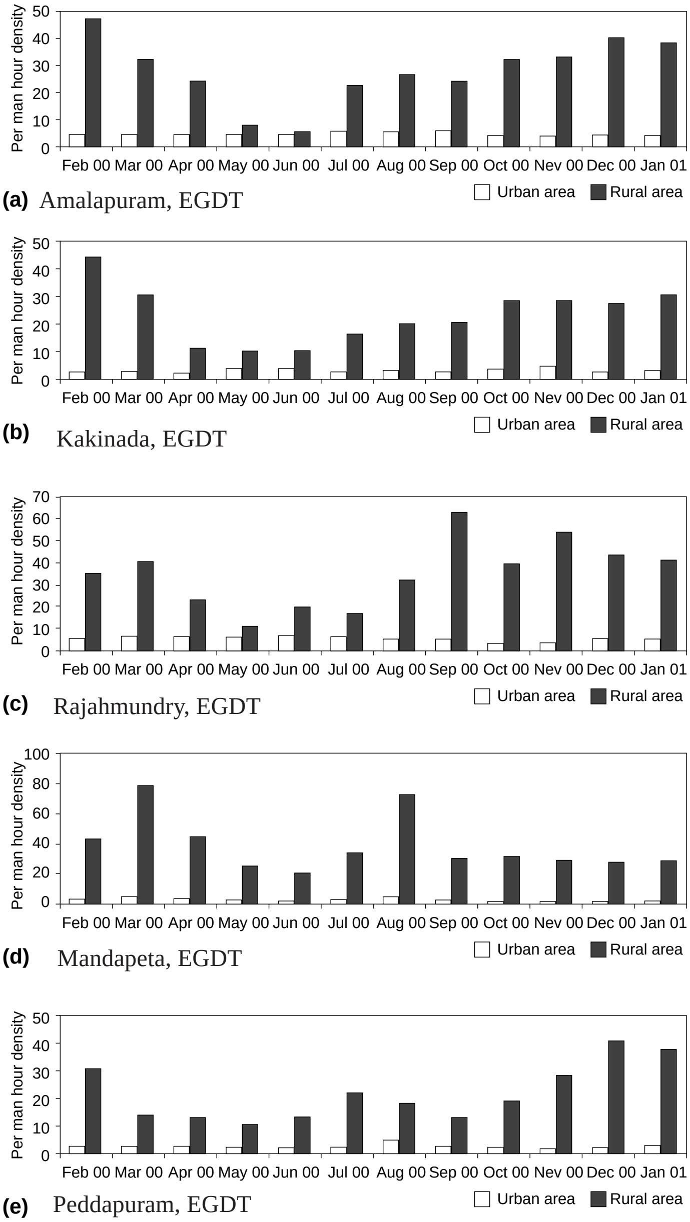


Fig 1–Map of study areas.

medication and screening for filariasis. The nine units in these two districts were identified by NFCP as study areas. The areas have a humid summer (20º-46ºC), a mild winter (11º-32ºC), and an annual monsoon (June-December).

Entomological studies

Between February 2000 and January 2001, indoor-resting mosquitos were collected at fortnightly intervals with the help of mechanical aspirators (Hausherr's Machine Works, NJ, USA); collections were between 06.00 and 09.00 hours at the 108 (9x12) fixed catching stations of urban and rural areas of all the nine National Filaria Control Program units. Only female *Cx. quinquefasciatus* mosquitos, the principal vectors of Bancroftian filariasis (Dash *et al*, 1988) were identified using the key developed by Reuben *et al* (1994). The vector abundance is expressed as the number of female *Cx. quinquefasciatus* mosquitos collected per man per house.



(a) Amalapuram, EGDT

(b) Kakinada, EGDT

(c) Rajahmundry, EGDT

(d) Mandapeta, EGDT

(e) Peddapuram, EGDT

Cx. quinquefasciatus females were dissected in order to identify stage of their microfilaria, using the key developed by Nelson (1959) and Yen *et al* (1982). All stages were recorded and mature infected larvae were identified on the basis of the morphology of their caudal papillae. The infection rate was calculated by the presence of any stage of microfilaria; the infectivity rate was based on the presence of third stage microfilaria only.

Statistical methods

Means and standard errors (SE) were calculated separately for both infection and infectivity rates in order to study the differences in the mean values between rural and urban areas.

ANOVA was utilized separately for all the nine units. ANOVA was applied separately to the infection and infectivity rate data. The F-test values from these analyses allowed us to establish whether the differences in the mean values of the rural and urban areas of each unit were statistically significant (at a 5% level of

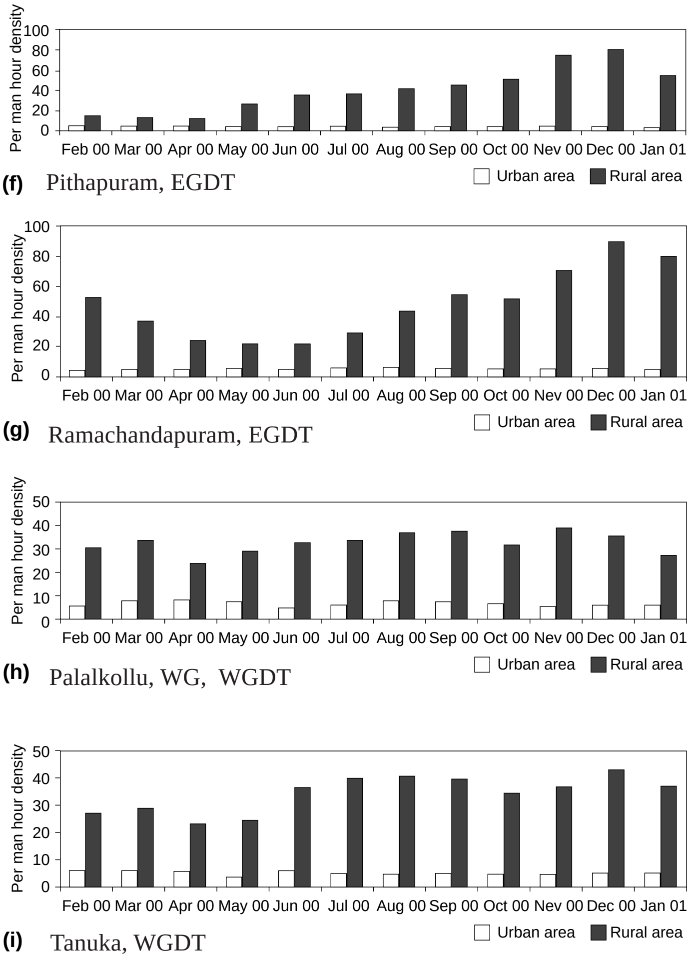


Fig 2–Monthly abandance of *Culex quinquefasciatus* in the urban and rural areas of East and West Godavari District, 2000-2001. (a) Amalapuram, (b) Kakinada, (c) Rajahmundry, (d) Mandapeta, (e) Peddapuram, (f) Pithapuram, (g) Ramachandrapuram (h) Palalkollu (WGDT), (i) Tanuku (WGDT)

significance), in other words, if the calculated F-values from these models are high and the associated level of significance is less than 5% ($p<0.05$) then the observed differences between the mean values of urban and rural areas are significant.

RESULTS

The mean per man hour density (PMHD) of *Cx. quinquefasciatus* varied among the urban and rural areas of EGDT and WGDT. In the rural areas of EGDT, the highest mean PMHD (47.7) was recorded in Ramachandrapuram; the lowest (21.3) was recorded in Peddapuram. In urban areas of EGDT, Ramachandrapuram had the highest mean PMHD (5.5), while Peddapuram had the lowest mean PMHD (2.4). Similarly in the rural areas of WGDT, the highest mean PMHD (34.1) was recorded in the Tanuku and the lowest (32.3) in Palakollu. In the urban areas of WGDT, Palakollu had the highest mean PMHD (6.5) followed by Tanuku (5.2).

The rural areas of EGDT showed a range of high PMHDs: 38.7 to 89.5 (recorded in the months of February, March, November and December 2000); the lowest were recorded in the months of April, May and June 2000. The rural areas of WGDT showed the highest PMHDs ranging from 38.7 to 42.9, in the months of November and December 2000; the lowest were recorded in April 2000.

The results from urban areas of EGDT and WGDT were at variance with those from the rural areas. The highest PMHDs were recorded in the months of February, April, June, August and November 2000 and January 2001 ranging from 4.2 to 7.8; the lowest PMHDs were recorded in February, May, June, October and November 2000 and January 2001. The monthly PMHDs of the principal vector, *Cx. quinquefasciatus*, are presented in Fig 2(a-i).

The infection and infectivity rates ranges from 0-43.6% and 0%-13.2% (Tables 1 and 2) respectively. From the rural areas of EGDT and WGDT, the highest infection rate was recorded in the month of June (43.6%) from Rajahmundry unit (Table 1). The highest infectivity rate was observed in the month of

Table 1
Month and unit wise infection rates of *Culex quinquefasciatus* in the urban and rural areas of East and West Godavari districts, Andhra Pradesh, India.

Month & Year	East Godavari district														West Godavari district			
	Amalapuram		Kakinada		Rajahmundry		Peddapuram		Pithapuram		RC Puram		Mandapeta		Palakollu		Tanuku	
	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R
Feb 2000	2.4	8	1.8	11.4	2.3	15.1	2.4	14	0.8	13.5	1.2	11.2	0	4.2	1.6	15.2	2.5	21.2
Mar 2000	3.6	8.8	0.7	6.4	4.3	28.7	1.8	15.4	0.8	11.2	1.1	4.1	0.4	4.7	1.3	13.5	1.2	23.5
Apr 2000	3.1	12.2	0.9	4.7	7.5	18	2.9	9.0	1.6	9.5	1.7	4.0	1.3	3.8	1.5	12.6	1.3	21.0
May 2000	3.3	8.6	2.9	0	1.9	17.6	4.4	5	2.3	16.2	0	3.5	0	3.4	0	11.6	2.7	19.8
Jun 2000	1.4	6.5	0	6.3	1.7	43.6	5.5	6.8	0	29.5	0	3.2	0	4.0	0	17.5	1.5	16.7
Jul 2000	0	1.6	0	5.5	0	15.3	0	5.1	0	42.7	0	6.2	0	2.6	1.08	12.6	2.5	13.8
Aug 2000	0.7	0.5	0	3.0	0	32.1	2.5	10.2	2.2	39.6	0	18	0	3.6	0.3	16.5	1.3	15
Sep 2000	0.6	6.1	0	2.9	8	33.0	4.8	6.7	0	14.8	0	3	0	7.7	0.9	13	2.7	0
Oct 2000	3.3	7.1	5	3.8	5	35.2	0	5.4	2.7	21.5	0	38.6	0	7.3	1	16	0	7.7
Nov 2000	0	8.9	0	2.8	0	38	0	6	0	16.7	0	36.7	0	7.9	0.8	14	0	7.5
Dec 2000	1.2	10	0	5.8	1.3	22	0	6.8	0	12.3	0	28	0	8.3	0.5	11	0	11
Jan 2001	0	3	0	3.8	0	25.7	0	14	0	13.1	0	43.2	0	6.6	0.5	9	0	11.3

RC Puram: Ramachandrapuram; U: Urban; R: Rural

November (13.2%) from Amalapuram unit (Table 2).

In the urban areas of East and West Godavari districts the highest infection rate was found in Rajahmundry Unit in the month of September 2000 (8%) and April 2000 (7.5%).

The means and standard errors (SE) for the infection and infectivity rates belonging to the nine units are presented in Table 3. The highest infection rate among rural areas is observed in Rajahmundry unit with an infection rate of 26.01 and SE 2.845 followed by Pithapuram unit (EGDT) with a mean value of 20.050 and SE of 3.235. Among the rural areas, the lowest infection rate was observed in Kakinada unit (EGDT) with a mean infection rate of 4.700 and SE 0.805. The urban area's infection rate in all the units was found to be less than 2.5, except in the case of Rajahmundry unit (EGDT) where the mean infection rate was 2.667.

The infectivity rate among urban areas were found to be less than 0.5 except in the case of Palakollu unit (WGDT) with a mean value was 0.562. It was observed that among rural areas, Rajahmundry unit (EGDT) had reported highest infectivity rate with a mean value of 6.742 followed by Amalapuram unit (EGDT) with a mean value of 6.350. Tabel 3 also revealed that there was considerable difference in the infection rate and infectivity rate between the rural areas and the urban areas in each unit.

ANOVA one-way models have been applied to both the infection and infectivity rate data and the results are presented in Tables 4. The mean values of rural and urban

Table 2
Month and unit wise infectivity rates of *Culex quinquefasciatus* in the urban and rural areas of East and West Godavari districts, Andhra Pradesh, India.

Month & Year	East Godavari district														West Godavari district			
	Amalapuram		Kakinada		Rajahmundry		Peddapuram		Pithapuram		RC Puram		Mandapeta		Palakollu		Tanuku	
	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R	U	R
Feb 2000	0.4	7	0	0	0.9	2.1	0.8	11	0	0	0.8	0.9	0	0	0.4	0	1.6	0
Mar 2000	0.8	3.1	2.1	0	2.4	5.4	0.8	5.6	0	2.9	0.7	2.0	0.4	0	0.6	0	0	0.9
Apr 2000	0.7	4.4	0.9	0	3.6	3	0	5.1	0	0	0.4	0	0.6	0	0.9	0	0.6	6.8
May 2000	0	0	2.9	1.1	0	3.2	0	0	0.7	0	0.5	0	0	0	0.9	0	0	2.9
Jun 2000	0.7	2.3	0	3.1	1.7	6.4	0	4.9	0	7.5	0	0	0	0	0.7	1.3	0	0
Jul 2000	0	4.5	0	3.3	0	5.5	0	3.06	0	5.7	0	3	0	0	0.5	0	0	0
Aug 2000	0	7.8	0	1.0	0	7.6	2.5	6.12	0.6	6.7	0	0	0	0	0.04	0	0	0
Sep 2000	0.6	6.7	0	0.9	4	6.2	0	4.0	0	2.5	0	5	0	0.5	0.4	2.9	0	0
Oct 2000	0	11.2	0	0.7	0	11.2	0	4.3	0.9	4.6	0	8.1	0	1.3	0.5	4.2	0	0
Nov 2000	0	13.2	0	0.5	0	13.0	0	5.3	0	0.2	0	11.2	0	0	0.8	2.3	0	3.1
Dec 2000	0	11	0	0	0	9.7	0	6.8	0	0	0	6.06	0	0	0.5	0.9	0	0.9
Jan 2001	0	5	0	0.6	2.7	7.6	0	8.8	0	0	0	9.01	0	2.3	0.5	1.1	0	0

RC Puram: Ramachandrapuram; U: Urban; R: Rural

infection rates were statistically significant. Among the nine units and for Amalapuram, Rajahmundry Peddapuram, Pithapuram and Ramachandapuram, the F test values were significant, whereas the F test values for Kakinada, Mandapeta, Palakollu, and Tanuku were not significant.

DISCUSSION

In the present investigation, the highest mean PMHD, 47.7 was observed from the rural areas of EGDT. Previous records of entomological surveys, the highest PMHDs from rural areas of EGDT were 13.2 (September, 1957), 17.8 (October, 1973), 20.0 (December, 1975), 21.1(February,1976), 10.5 (March, 1982), and 16.9 (January, 1983). (Rao *et al*, 1976, 1980; Krishna Rao, 1985). Dhar *et al* (1968) made similar observations that the abundance of *Culex quinquefasciatus* was highest in December and lowest in June in Rajahmundry, EGDT. High density of *Culex* is due to the presence of big drains and cesspits in the villages: these are the breeding places chosen by *Cx. quinquefasciatus* (Rajagopalan *et al*, 1981). A steady increase of mean PMHD from 13.2 in 1957 to 89.5 in 2000 showed the rate of proliferation in vector density.

The trend clearly shows that in the rural areas, vector density is positively associated with monsoon months since the abundance was high in monsoon season. The villages have very favorable conditions for mosquito breeding mainly for filariasis vector during post-monsoon months. Irrigational channels, cesspits, cesspools were contributing to heavy breeding of

Table 3
Mean and standard errors (SE) for infection and infectivity - unit wise.

Name of the unit	Area	Sample size	Infection		Infectivity	
			Mean	Standard error (SE)	Mean	Standard error (SE)
East Godavari district						
Amalapuram	Rural	12	6.775	1.009	6.350	1.138
	Urban	12	1.633	0.411	0.267	0.098
Kakinada	Rural	12	4.700	0.805	0.933	0.328
	Urban	12	0.942	0.455	0.492	0.285
Rajahmundry	Rural	12	26.01	2.845	6.742	0.958
	Urban	12	2.667	0.834	1.050	0.437
Peddapuram	Rural	12	8.700	1.099	5.415	0.796
	Urban	12	2.025	0.597	0.342	0.215
Pithapuram	Rural	12	20.050	3.235	2.508	0.844
	Urban	12	0.867	0.305	0.183	0.098
RC Puram	Rural	12	16.642	4.536	3.773	1.158
	Urban	12	0.333	0.110	0.200	0.089
Mandapeta	Rural	12	5.342	0.593	0.342	0.210
	Urban	12	0.142	0.110	0.083	0.057
West Godavari district						
Palakollu	Rural	12	13.542	0.709	1.058	0.405
	Urban	12	0.79	0.156	0.562	0.069
Tanuku	Rural	12	14.042	1.999	1.217	0.604
	Urban	12	1.308	0.321	0.183	0.138

RC Puram : Ramachandrapuram

Cx. quinquefasciatus mosquitos. The trend may lead to increase in vector abundance in post-monsoon months, which favored the transmission of filariasis. It was observed from this investigation that the vector abundance was high during northeast monsoon *ie*, middle of October. The same pattern was observed in Vellore District. (Erstwhile North Arcot District of Tamil Nadu) where *Cx. vishnui* subgroup predominated during northeast monsoon (Reuben, 1971). A similar increase in the abundance *Cx. vishnui* subgroup was noticed during monsoon season in Sarvak (Hill *et al*, 1970).

Similarly, 9.8% of infection rate in 1957 has gone up to 43.6% in 2000. Infectivity rate also showed the identical increase from 0.2% in 1957 to 13.2% in 2000. The continuous increase of these parameters in 3 decades reveals that the rural areas were given no priority in anti-larval and anti- adult spray operations.

Earlier studies showed that the highest infection rates were 9.8% in September 1957, 10.3% in January 1973, 13.1% in July 1975, 9.3% in May 1976, 12.9% in January 1982, 14.3% in May 1983 and in this study the highest infection rate was recorded as 43.6% in June 2000. While the infectivity rates were also reported, 0.2% in October 1957, 0.9% in January 1973, 3.4% in August 1975, 2.3% in May 1976, 8.2% in August 1982, 10.0% in April 1983 and in this study the highest infectivity rate was recorded as 13.2% in November 2000 from the rural areas of EGDT (Rao *et al*, 1976; 1980; Krishna Rao, 1985). Similar observations were reported by Dhar *et al* (1968) from Rajahmundry unit and stated that the ranges of infection and infectivity rates *ie*, 10.2 to 13.2 and 2.1 to 2.4 respectively.

Table 4
ANOVA model results for infection and infectivity - unit wise in EGDT and WGDT.

Name of the unit	Infection F value	Infection df	Infection p	Infectivity F value	Infectivity df	Infectivity p
East Godavari district						
Amalapuram	22.27	(1,23)	0.000104[a]	28.35	(1,23)	0.000024[a]
Kakinada	16.51	(1,23)	0.000517[a]	1.03	(1,23)	0.320[b]
Rajahmundry	16.77	(1,23)	0.000479[a]	29.23	(1,23)	0.000020[a]
Peddapuram	28.47	(1,23)	0.000023[a]	45.11	(1,23)	0.000001[a]
Pithapuram	34.86	(1,23)	0.000006[a]	7.49	(1,23)	0.01203[a]
Ramchandrapuram	11.93	(1,23)	0.002379[a]	9.46	(1,23)	0.005525[a]
Mandapeta	74.21	(1,23)	0.000000[a]	1.41	(1,23)	0.248387[b]
West Godavari district						
Palakollu	38.54	(1,23)	0.000000[a]	1.46	(1,23)	0.239276[b]
Tanuku	39.57	(1,23)	0.000002[a]	2.78	(1,23)	0.109401[b]

a = Significant; b = Not significant

The efficiency of the vector species depends upon the high biting density, anthropophily and high survival rates (Wattal, 1976).

Table 4 contains the ANOVA model results for the infection and infectivity data of all units belonging to the EGDT and WGDT. Generally if the F test value calculated from the ANOVA model is high and its associated level of significance p is less than 0.05, it can be concluded that the observed differences in the mean values are significant. Table 4, indicates that in the case of all the units, the F test values are high and significant at 5% level. This, inturn, means that the differences observed in the infection rate of rural and urban areas of all the units are quite significant and that the control measures applied in the urban areas are quite effective. Similarly, among the nine units under consideration, and for the following units Amalapuram, Rajahmundry, Peddapuram, Pithapuram, and Ramachandrapuram, the F test values are significant, whereas for the units Kakinada, Mandapeta, Palakollu, and Tanuku, the F test values are not significant.

Conclusion

The present investigation will lead to the understanding of the transmission dynamics of filariasis and vector abundance. Studies from the different areas indicate that seasonal prevalence of *Cx. quinquefasciatus* varies widely. A significant difference of abundance was observed between rural and urban areas, which indicate an immediate need of vector control operations to reduce the man vector contact.

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