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Short Research Communication

Spatial distribution of *Aedes* mosquitoes with special attention to bionomics of *Aedes albopictus* subpopulations collected from various parts of Odisha

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The biodiversity of potential *Aedes* (Diptera: Culicidae) mosquitoes is strongly associated with the epidemiology of arboviral diseases transmitted by them. Risk factors for emergence of these diseases are continued urbanization, industrialization and transport development, all of which contribute to the maintenance and spread of major *Aedes* vectors; *Aedes aegypti* and *Aedes albopictus (Stegomyia albopictus)*[1–2]. Before any attempt is made to employ vector control measures, the density and biological attributes of *Aedes* vectors circulating in the region must be revealed. Vector density is presently evaluated using surveillance techniques based on larval indices to determine risk and to guide mosquito control activities[3]. However, recently pupal indices [pupae per person (PPP) and pupae per house (PPH)] are often used to assess vector density as these represent true mosquito productivity[4-5]. Therefore, entomological surveys targeting the most productive containers that contribute maximum pupae can rapidly alleviate the vector density thereby reducing the force of transmission.

Genetic differences have been observed among different subpopulations of *Aedes* mosquitoes throughout molecular marker studies, which are also linked to variability in vectorial competence among different subpopulations[6–7]. Different subpopulations of *Aedes* species show different responses in terms of biological behaviour, resistance to insecticides like temephos, host preference, vectorial abilities, *etc* which can be attributed to many biotic and abiotic elements and circumstances[8]. Hence, it is crucial to compare the behavioural attributes of geographically separated subpopulations of major *Aedes* vectors.

The recent emergence of chikungunya and dengue in Odisha state of India has warranted the need to explore the distribution of *Aedes* mosquitoes proliferating in Odisha[9-12]. The present study explores the spatial distribution of *Aedes* species in Odisha, along with revealing the bionomics of *Ae. albopictus,* the major arboviral vector in Odisha, based on replicate surveys in dry and wet seasons from 2010 to 2012[9-12].

The study was conducted in four distinct physiogeographical regions of Odisha; northern plateau, central tableland, coastal plains and eastern ghats (Fig. 1). *Aedes* species were collected from July to November (rainy and post-rainy seasons), and February to June (dry season) in arboviral affected areas (based upon medical records, Govt. of Odisha) of each district from 2010 to 2012. Households were selected by random walk method and data recorded according to house types (*e.g.* clustered houses, scattered houses, flats, huts/mud houses) and container types. Adult mosquitoes were collected using battery operated aspirators in the houses surveyed. All water containing indoor and outdoor containers were thoroughly searched for the presence of *Aedes* pupae, which were

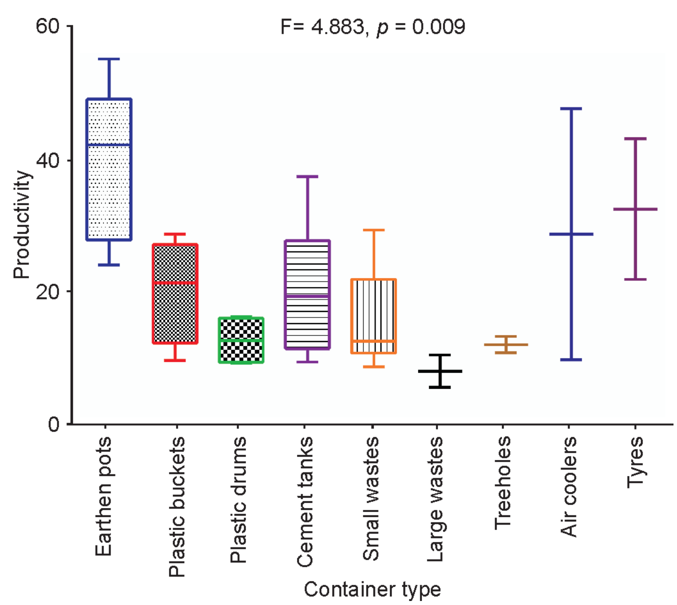

Fig. 1: Box plot showing the comparison of pupal productivity among different containers using one-way ANOVA.

collected by using pipettes and dippers. Adult mosquitoes and pupae collected from field were brought to the laboratory. Emerged adults from the collected pupae were identified as *Aedes* species[13] and pooled according to species and container types. The data on pupal survey were analyzed and calculated in terms of different pupal indices, *i.e.* pupal container index (PCI), PPP and PPH. Abundance of indoor and outdoor containers with *Aedes* pupae at the collection sites was assessed to know the most productive container in the areas surveyed. Productivity of a container type was estimated for each container that harboured *Aedes* pupae[5]. The relative abundance of PCI in different house types was analyzed by the one way analysis of variance (ANOVA). Similarly, pupal productivity among different containers was compared using ANOVA test.

For assessing the bionomics, a colony of each *Ae. albopictus* subpopulation, collected from different localities representing each of the four physiogeographic regions of Odisha was established in the laboratory from collected pupae; and the larval and pupal development time, larval and pupal survival, adult longevity, oviposition time, and fecundity were analyzed by ANOVA, followed by the Duncan's test, to detect significant differences among the four subpopulations studied.

A total of 4183 pupae and 672 adults of *Aedes* mosquitoes were collected from different regions of Odisha during 2010–2012. The collection comprised of 70.1% *Ae. albopictus*, 26.5% *Ae. aegypti*, 3.4% *Ae. vittatus* and 1.4% *Ae. edwardsii*. The percentage of male population (60.2%) was higher than female population (39.8%) for all *Aedes* species. Vector density was high during the rainy/post-rainy season while it was low in the dry season. *Ae. albopictus* was the most prevalent vector in all seasons in the surveyed areas, followed by *Ae. aegypti* and *Ae. edwardsii.* Species diversity was maximum in coastal plains, which reported all the four types of *Aedes* species and minimum in northern plateau. The coastal plains followed by central tablelands proved to harbour most *Aedes* vectors and hence can trigger more arboviral transmission, whereas *Aedes* species were very rare in the hilly areas of northern plateau. *Aedes* species prevalence by housing types was not notably different from those of exclusive human residences. The *Aedes* pupal indices were high for clustered houses, in comparison to other house types (Table 1), although statistically non-significant. The main *Aedes* breeding spots in the surveyed areas included earthen pots, cement tanks, plastic drums, discarded small plastic waste and large plastic waste. Earthen pots depicted the maximum overall productivity (38.5) and discarded large waste (plastic/glass) had the least productivity (5.6) in the surveyed areas (Table 1). This was supported by ANOVA test, which depicted that earthen pots had significantly high pupal productivity as compared to other containers ($p = 0.0009$) (Fig. 1).

Significant differences were found in the mean larval development time between *Ae. albopictus* subpopulations of coastal plains and northern plateau, the former having a lower development time for all larval instars than the latter. Pupal development time was also significantly low in coastal plains and central tableland as compared to northern plateau and eastern ghats' subpopulations (Table 2). The lowest survival was observed for the northern plateau subpopulation, for the larval stage (72.3%) as well as for the larval and pupal stages analyzed together (58.2%), differing significantly from the coastal plain subpopulation, which recorded the highest survival (95 and 85.8%, respectively) (Table 2). Mean male and female longevity varied from 16.6 days (central tableland) to 29.4 days (eastern ghats), and 33.2 days (northern plateau) to 45.6 days (coastal plains) respectively. Longevity of adults was similar among the four subpopulations. Females lived longer than males in all subpopulations. The longest oviposition time was recorded for females from the subpopulation of northern plateau (30.3 days), followed in decreasing order by females from the eastern ghats (29.2 days), central tableland (28.1 days) and the coastal plains (26.14 days) (Table 2). Significant differences were found in fecundity values ($p = 0.0008$), with the coastal plains females showing the highest daily fecundity (10.5 eggs/female/day) as well as total number of eggs laid. In decreasing order follow the subpopulations of central tableland (6.4 eggs/female/day), eastern ghats (2.5 eggs/female/day), and northern plateau (1.8 eggs/female/day). Mean net reproductive rate was highest for the coastal plains (R_o= 111.04), differing significantly from the central tablelands (R_o= 46.33), eastern ghats (R_o= 19.22) and northern plateau (R_o= 11.71) subpopulations (Table 2).

This study revealed differential landscape distribution of *Aedes* species in various physiographic regions of Odisha. The household types and/or nature of construction among the visited localities were heterogeneous. So, no single factor could account for the risk of *Aedes* prevalence in such localities. Exclusive human dwellings, particularly clustered households, mainly in rural areas had prolific *Aedes* breeding. Scattered households and flats demonstrated less *Aedes* species distribution because they were isolated and were separated about 300 m from each other (flight range of *Aedes* up to 250 m). In terms of microhabitats, earthen pots proved to be the most pro-

Table 1. Distribution of *Aedes* pupae in different house types along with their productivity, container, per house, per person and breteau index in the surveyed areas of Odisha

House type	Container type	No. of water filled containers	No. of containers with pupae	No. of pupae	Productivity of container	PCI	PPH	PPP	PBI
Clustered houses	Earthen pots	307	286	522	48.6	0.93			
(n = 450)	Plastic buckets	116	86	212	19.73	0.74			
(P = 2658)	Plastic drums	40	29	101	9.4	0.72			
	Cement tanks	55	27	96	8.93	0.49	1.95	0.4	1.07
	Discarded small wastes	65	46	88	8.19	0.7			
	Discarded large wastes	23	11	55	5.12	0.47			
	Total	606	485	1074					
Scattered houses	Earthen pots	115	88	190	38	0.76			
(n = 425)	Plastic drums	75	35	79	15.8	0.46			
(P = 2012)	Cement tanks	75	51	111	22.2	0.68	1.17	0.24	0.52
	Tree holes	38	17	64	12.8	0.44			
	Discarded small wastes	43	30	55	11	0.69			
	Total	346	221	500					
Flats	Air coolers	108	81	158	49.06	0.75			
(n = 400)	Plastic buckets	75	30	91	28.26	0.4			
(P = 2002)	Flower (earthen) pots	52	14	73	22.67	0.26	0.8	0.16	0.31
	Total	235	125	322					
Huts/Mud houses	Earthen pots	168	136	288	52.65	0.8			
(n = 470)	Plastic buckets	75	30	41	9.17	0.4			
(P = 2512)	Discarded small wastes	32	14	53	11.85	0.43	0.95	0.17	0.55
	Cement tanks	89	79	165	36.91	0.88			
	Total	364	259	547					

n = No. of houses inspected; P = No. of people in inspected houses; Productivity of container = No. of pupae in the container type × 100/Total No. of pupae; PPH (Pupae per house) = No. of pupae/No. of houses inspected; PPP (Pupae per person) = No. of pupae/No. of people in inspected houses; PCI = Pupal container index = No. of pupal positive containers/No. of containers searched.

Table 2. Mean and standard deviation of *Aedes albopictus* larval and pupal development time and survival, longevity, oviposition time, fecundity and net reproductive rate for four subpopulations studied. Two replicates were performed for each subpopulation

	Stages	Coastal plains	Northern plateau	Central tablelands	Eastern ghats	*p*-value
Development time (days)	Larva 1+2	2.41 ± 0.11^{a}	2.81 ± 0.09^{b}	2.43 ± 0.16^{a}	2.76 ± 0.25^{ab}	0.03
	Larva 3	2.07 ± 0.20^{a}	2.25 ± 0.28^{a}	2.05 ± 0.19^{a}	2.23 ± 0.30^{a}	0.08
	Larva 4	2.25 ± 0.21^{a}	2.71 ± 0.27^{ab}	2.21 ± 0.46^{a}	3.23 ± 0.29^{b}	0.01
	Total larva	7.08 ± 0.29^{a}	7.95 ± 0.18^{b}	6.81 ± 0.50^{a}	7.02 ± 0.22^{ab}	0.002
	Pupa	1.61 ± 0.33^{b}	2.41 ± 0.22^{a}	1.47 ± 0.29^{b}	2.25 ± 0.33^{a}	0.07
	Larva + Pupa	9.05 ± 0.25^{a}	9.18 ± 0.21^{a}	9.03 ± 0.59^{a}	9.14 ± 0.14^{a}	0.21
Immature stage survival (%)	Larva	95 ± 5.77^{c}	72.33 ± 6.38^{b}	85.33 ± 13.33^{a}	79.16 ± 6.87^{b}	0.01
	Pupa	90.37 ± 5.66^{a}	81.66 ± 6.07^{a}	83.21 ± 6.25^{a}	80.27 ± 12.78^{a}	0.26
	Larva+Pupa	85.83 ± 7.39^{c}	58.23 ± 5.69^{b}	82.16 ± 13.44^{c}	65.83 ± 5.01^{b}	0.003
Longevity (days)	Male	19.36 ± 7.55^{a}	21.33 ± 2.01^{a}	16.69 ± 9.42^{a}	29.47 ± 13.16^{a}	0.07
	Female	45.65 ± 21.56^{a}	33.22 ± 11.13^{a}	43.53 ± 24.64^{a}	37.19 ± 16.38^{a}	0.19
Oviposition time (days)		26.14 ± 7.57^{a}	30.31 ± 2.93^{a}	28.18 ± 19.47^{a}	29.24 ± 6.80^{a}	0.86
Daily fecundity		10.58 ± 1.37^{b}	1.88 ± 0.78^{a}	6.42 ± 0.64^{c}	2.53 ± 2.37^{a}	0.0008
Total No. of eggs		1234.5 ± 444.82^{b}	295.75 ± 306.16^{a}	676.34 ± 231.52^{c}	322.12 ± 147.08^{a}	0.0001
Net reproductive rate (R_o)		111.04^{b}	11.71^{a}	46.33^{c}	19.22^{a}	0.0001

Different letters among columns indicate significant differences (p <0.05).

ductive containers that contributed maximum *Aedes* pupae. Four species of *Aedes* (*Ae. albopictus, Ae. aegypti, Ae. vittatus* and *Ae. edwardsii*) were identified in the surveyed areas. The Asian tiger mosquito, *Ae. albopictus* outnumbered all other species in prevalence and distribution. Assessment of bionomics of *Ae. albopictus* populations revealed that the coastal plains subpopulation had shorter development times in comparison to other subpopulations. The differences obtained in larval-pupal survival between coastal plains and northern plateau subpopulations probably reflect differences in haplotype composition as a result of wide-scale immigration from different regions. The mean number of eggs laid by *Ae. albopictus* females belonging to coastal plains averaged 55.8 eggs/female/day. Daily fecundity obtained in this study was lower than the mean value of 4.5 eggs/female/day for the northern plateau subpopulation. The coastal plains subpopulations had the maximum survival time, highest fecundity and mean net reproductive rate as compared with subpopulations. The central tableland subpopulation stood second to coastal plains in terms of survival, fecundity and reproduction rate. Such findings indicated that the coastal plains subpopulation is biologically more fit than other subpopulations, which was also depicted in our earlier study and, hence can transmit arboviral diseases more efficiently than other subpopulations[14]. Thus, the study warrants more rigorous control measures, specifically targeting *Ae. albopictus* mosquitoes, mainly in coastal plains of Odisha to check the spread of arboviral diseases.

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