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Research Article

Indoor Resting Behaviour of *Aedes* in Bhawanipatna, Kalahandi, Odisha

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ABSTRACT

Mosquitoes being one of the primary vectors for vector borne diseases (VBDs) make a significant impact on global health in terms of morbidity and mortality. Changing environmental conditions, the behavioural characteristics of dengue vectors have added to the difficulties in vector control. Indoor residual spraying (IRS) is a common method in mosquito control and economically viable than intermittent fogging; it has also recently become of interest in dengue vector control community. Therefore, the main objective of this study was to determine the most preferred indoor resting locations of *Aedes* in urban houses that can be used for developing effective vector control strategy and dengue prevention. Our work suggested that vector control using targeted IRS focusing on walls at heights below and above 1.5 m in living/bed/dining rooms of huts and lower than 1.5 m in toilet /bathroom of the concrete house and dining/living room and bedroom of multi-storey building could be part of an integrated effective strategy for *Aedes* mosquito control.

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INTRODUCTION

Mosquitoes being one of the primary vectors for vector borne diseases (VBDs) make a significant impact on global health in terms of morbidity and mortality. Such vector mosquitoes often confine to a specific and distinct geo-area to proliferate successfully. Due to tropical climatic conditions, India ranks fifth concerning mosquito faunal diversity. There are several vectors borne diseases (VBDs) out of which dengue is one of the most prevalent vector borne diseases transmitted by *Aedes* mosquitoes affecting more than 3.9 billion people over 129 countries with an estimated 96 million cases and an estimated 40,000 deaths every year [1]. Other diseases transmitted by *Aedes* mosquito include Chikungunya, Zika, Yellow fever etc. The number of dengue cases reported to the World Health Organization has increased more than eight-fold over the last two decades [2]. An estimated 50 million dengue infections occur annually and approximately 2.5 billion people live in dengue endemic countries [3]. *Aedes aegypti* (L.) is a tropical and subtropical mosquito species widely distributed around the world. It is a primary vector of dengue virus (DENV) and is well-adapted to completing its entire life cycle within urban areas and around houses, primarily feeding on humans. *Aedes albopictus* is a secondary vector of DENV and, although more rural, also exhibits peridomestic resting and biting behaviors [4].

Mosquito vector control has become less effective in recent years, due to lack of effective of alternative control strategies, lack of an epidemiological basis for interventions, inadequate resources and infrastructure, and poor management. Changing environmental conditions, the behavioural characteristics of dengue vectors have added to the difficulties in vector control. Indoor residual spraying (IRS) is a common method in mosquito control and economically viable than intermittent fogging; it has also recently become of interest in dengue vector control community [5]. The effectiveness of IRS depends on knowledge of where mosquitoes rest and therefore targeted IRS should focus on areas where adult mosquitoes are most likely to rest. Adult *Aedes* generally rest inside the houses rather than outside [6, 7]. Generally, they rest on the lower parts of walls, and can vary depending on the type of room [8, 9]. Resting preference of *Aedes* inside the room is also influenced by several factors (type of surface, density of goods present in the room) [6]. However, house structures differ worldwide, and global generalizations may not be applicable. As far as we know, there are currently no reports on the resting behaviours of adult *Aedes* in Odisha state. Therefore, the main

objective of this study was to determine the most preferred indoor resting locations of *Aedes* in urban houses that can be used for developing effective vector control strategy and dengue prevention.

MATERIALS AND METHODS

Study Areas

The collection of data was made from different locations of Bhawanipatna Municipal Corporation; headquarter of the district of Kalahandi. Bhawanipatna (Figure: I) is located at 19.9°N 83.17°E, has a tropical wet and dry climate, and the annual average rainfall is 1300 mm. The municipality has a population of 69,045 of which 35,506 are males while 33,539 are females residing in around 16,500 houses as per a report released by census India 2011.

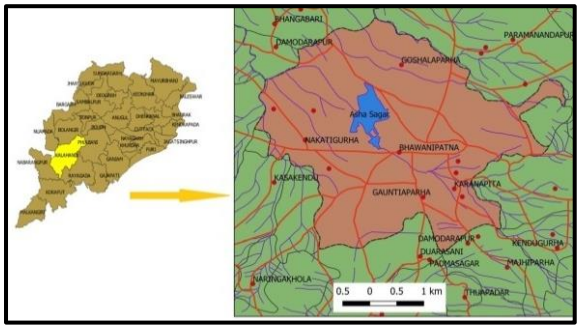

Figure: I Showing the study area, Bhawanipatna city, Kalahandi, Odisha

Methodology

The collection was carried out by authors using a manual aspirator and torch [10]. We selected a total of 45 houses, were three types i.e., huts, concrete and multi-storey buildings, 15 in each type. Usually, huts were smaller houses than concrete houses and multi-storey buildings, usually found in slum area of Bhawanipatna municipality. Separate individual rooms (Like living, kitchen, bed etc.) were hardly found in huts, because usually low-income groups were living in huts. So there was no demarcation of living room, dining room and kitchen, but we selected 15 huts from different localities of Bhawanipatna town that had separate living/dining/bedroom, kitchen and toilet/bathrooms. In Bhawanipatna most of the houses made from concrete had single-storey houses. We selected 15 concrete houses from the different localities of the city; each concrete house had 5 separate rooms (Bedroom, Kitchen room, Puja room, Tiolet/Bathroom and Dining/Living room). Multi-storey buildings were fewer in number as compared to the number of huts and concrete houses, these numbers have been increasing gradually for the last two decades in the central and peripheral regions of the city due to the expanding of urbanization. We also selected 15 multi-storey buildings from different localities of the city and had a minimum of three floors. We ignored the multi-storey buildings that had more than four floors because the number of such houses was very low in this city. The mosquito collection was made of six sites (Dining/Living room, Bedroom, Kitchen, Puja room, Toilet/Bathroom and

Balcony area of different floors) of multi-storey buildings. Mosquitoes were collected in the morning between 08:00 am and 12:00 pm in 21 (6 sites from each type) of the selected houses and in 24 (8 sites from each site) different houses between 2:00 and 6:00 p.m. for 15-20 minutes in each of the bedroom, bathroom, kitchen and living room, respectively. Indoors, collections were stratified by height [9] by having one author collecting mosquitoes from the bottom (<1.5m) walls and resting sites and another author collecting from the top wall (and any objects or spaces that may serve as resting areas) and ceiling (>1.5 m) using a telescopic aspirator handle, as previously described [8]. Before the study, the author measured the angle of their arm on a wall with a horizontally marking the 1.5 m threshold. Both authors collecting indoors worked simultaneously on each room, following each room by using different collection cups per room (i.e., living-dining room, bedrooms, kitchen, puja room and bath-toilet room). Multi-storey building collections were carried out in different floor-wise and stored on a separate cup, but not stratified by height. The balcony was also surveyed from different floors of multi-storey buildings.

Collections were made, for 3 to 5 consecutive days per month at the study houses. Overall, mosquitoes were collected during 30 sampling days. All collected mosquitoes were cold-killed, identified following available keys [11] and classified by genus, sex type of resting site and sampling origin. The samples collected were stored, managed and analyzed using SPSS statistics 29.0. Simple statistical methods were used for data analysis. Graph and chat for the paper were prepared with Excel.

RESULTS

Total 251 *Aedes* mosquitoes were collected, out of 152 from huts and 99 from concrete houses during the survey (Table: I), whereas a total 156 number of *Aedes* mosquitoes were collected from different floors of the multi-storey building (Table: II).

Total of 130 female *Aedes* mosquitoes was collected from multi-storey building followed by 124 female *Aedes* from huts and least number 80 female were collected from concrete houses. As compared to female *Aedes* mosquito maximum number 28 of male *Aedes* mosquitoes were collected from huts, followed by 26 male *Aedes* mosquitoes from storey buildings and the least number of male *Aedes* mosquitoes were found in concrete houses (Table: I & II).

Table: I Number of *Aedes* mosquitoes collected from indoor (Huts and Concrete Houses)

Heights in meter	Sites	No. of *Aedes* Mosquitoes Collected					
		Female		Male		Total	
< 1.5 m	Huts	89	(43.63)	18	(38.30)	107	(42.63)
> 1.5m	Huts	35	(17.16)	10	(21.28)	45	(17.93)
Total		**124**	**(60.78)**	**28**	**(59.57)**	**152**	(60.56)
<1.5 m	Concrete House	80	(39.22)	16	(34.04)	96	(38.25)
> 1.5m	Concrete House	0	(0.00)	3	(06.38)	3	(01.20)
Total		**80**		**19**	**(40.43)**	**99**	**(39.44)**
G.Total		**204**	(100.00)	**47**	(100.00)	**251**	(100.00)

Table: II Number of *Aedes* mosquitoes collected from indoor (Multi-Storey Bulding)

Collection Sites	Different Floors	No. of *Aedes* Mosquitoes collected					
		Female		Male		Total	
Multi Storey Building	Ground Floor	88	(67.69)	15	(57.69)	103	(66.03)
	First Floor	28	(21.54)	09	(34.62)	37	(23.72)
	Second Floor	14	(10.77)	02	(07.69)	16	(10.26)
	Third Floor	00	(0.00)	00	(00.00)	00	(00.00)

Stratified *Aedes* collection in height gave surprising results that most of the *Aedes* mosquitoes (107 in huts and 96 in concrete houses) in both sexes were collected at a height of less than an equal 1.5 meters and less number of *Aedes* mosquitoes (45 in huts and 03 in the concrete house) in both sex was caught from the height above 1.5 meters (Table: I). Total 89 number of female *Aedes* mosquitoes in huts, 80 number of female *Aedes* in a concrete house, 18 male *Aedes* mosquitoes from huts and 16 males *Aedes* from the concrete house were collected below 1.5 meters height from floor (Table: I). Total 35 female and 10 male *Aedes* mosquitoes in huts and 03 male *Aedes* mosquitoes in concrete house were collected from above the height of 1.5 meters. No female *Aedes* mosquitoes were found above 1.5 meters in concrete houses (Table: I).

A total 103 number of *Aedes* mosquitoes on the ground floor, 37 on the first floor, and 16 on the second floor in both sexes were collected from multi-storey buildings. But no *Aedes* mosquitoes were found on the third floor of a multi-storey building. A total 130 numbers of female *Aedes* were found 88 numbers in the ground floor, 28 number in the first floor, and 14 number in the second floor a total 26 number of male *Aedes* were collected 15 from the ground

floor, 09 number from the first floor and 02 number from the second floor of multi-storey buildings (Table: II).

A maximum 63 number of female *Aedes* mosquitoes were collected in the living/dining/bedroom followed by 32 number in the toilet/bathroom and 29 number in the kitchen, where a total 14 number of male *Aedes* were collected in the toilet followed by 11 number in the living/dining/bedroom and least number in the kitchen from huts (Table: III). Maximum 25 number of female *Aedes* mosquitoes was found in toilet/bathroom followed by 20 numbers in kitchen and least number 05 in puja room of concrete house. Similarly, a maximum 07 number of male *Aedes* mosquitoes were collected in the toilet/bathroom and the least number 01 in the kitchen (Table: III).

Table: III Room-wise number of *Aedes* mosquitoes collected from Huts and Concrete Houses

Site	No. of *Aedes* Mosquitoes collected			
	Types of Room	Female	Male	Total
Huts	Living/Bed/Dining	63 (30.88)	11 (23.40)	74 (29.48)
	Kitchen	29 (14.22)	03 (06.38)	32 (12.75)
	Toilet/Bathroom	32 (15.69)	14 (29.79)	46 18.33)
Total		**124**(60.78)	**28 (59.57)**	**152 (60.56)**
Concrete House	Bedroom	13 (06.37)	02 (04.26)	15 (05.98)
	Kitchen	20 (09.80)	01 (02.13)	21 (08.37)
	Puja Room	05 (02.45)	03 (06.38)	08 (03.19)
	Toilet/Bath room	25 (12.25)	07 (01.89)	32 (12.75)
	Dining/Living Room	17 (08.33)	06 (12.77)	23 (09.16)
Total		**80 (39.22)**	**19(14.43)**	**99 (39.44)**
G.Total		**204 (100.00)**	**47(100.00)**	**251(100.00)**

A maximum 51 number of female *Aedes* mosquitoes were collected in the dining/living room followed by bedroom (47), toilet/bathroom (10), kitchen (09), balcony (07) and puja room (06) whereas maximum 13 number of male *Aedes* in dining/living room followed by bedroom and toilet/bathroom (04 in each room), 03 in balcony and 02 in kitchen were collected from multi-storey building (Table: IV).

Table: IV Room-wise number of *Aedes* mosquitoes collected from Multi-Storey Building

Site	No. of *Aedes* Mosquitoes collected			
	Types of Room	**Female**	**Male**	**Total**
Multi-storey Building	Dining/Living	51 (39.23)	13 (50.00)	64 (41.03)
	Bedroom	47 (36.15)	04 (15.38)	51 (32.69)
	Kitchen	09 (06.92)	02 (07.69)	11 (07.05)
	Puja Room	06 (04.62)	00 (00.00)	6 (03.85)
	Toilet/Bathroom	10 (07.69)	04 (15.38)	14 (08.97)
	Balcony	07 (05.38)	03 (11.54)	10 (06.41)
Total		**130 (100.00)**	**26 (100.00)**	**156 (100.00)**

DISCUSSION

More *Aedes* mosquitoes were collected (42.63%) below 1.5 meters in height and 17.93% above 1.5 meters in height in huts. In a concrete house, this percentage was 38.25 and 1.20 below and above 1.5 meters in height respectively. More female *Aedes* (60.78%) were collected in huts than in concrete houses only 39.22%. But collection percentage of male mosquitoes in huts was 59.57% and in concrete houses was 40.43% (Table: I & III). A maximum of 30.88% of female *Aedes* were collected in the living/bed/dining room of huts followed by 15.69% (Toilet/Bathroom) and the lowest percentage 14.22 from the kitchen of huts. In concrete houses a maximum of 12.25 % female *Aedes* were collected followed by 9.80% (Kitchen), 8.33% (Dining Room/Living Room), 6.37% (Bedroom) and 2.45% (Puja Room) (Figure: II). But in multi-storey building a maximum number of female *Aedes* were collected from Dining/Living room followed by the bedroom (36.15%), toilet/bathroom (7.69%), kitchen (6.92%), balcony (5.38%) and puja room (4.62%) (Figure: III).

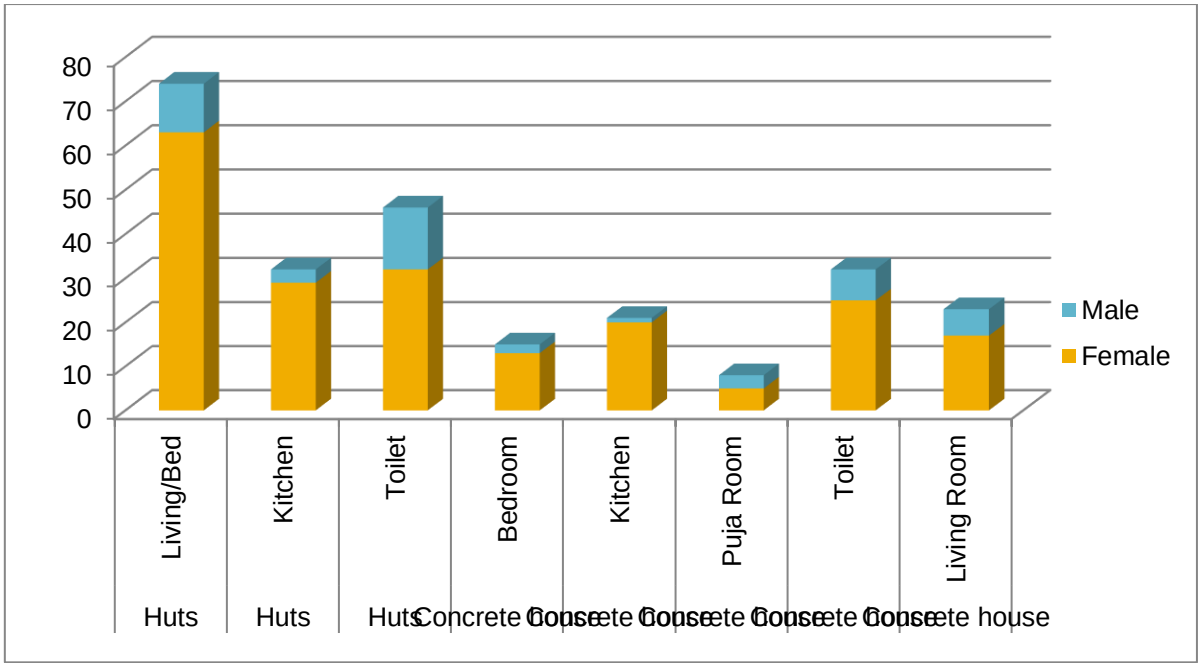

Figure: II Sex-wise *Aedes* mosquitoes collected from different rooms of different types of houses

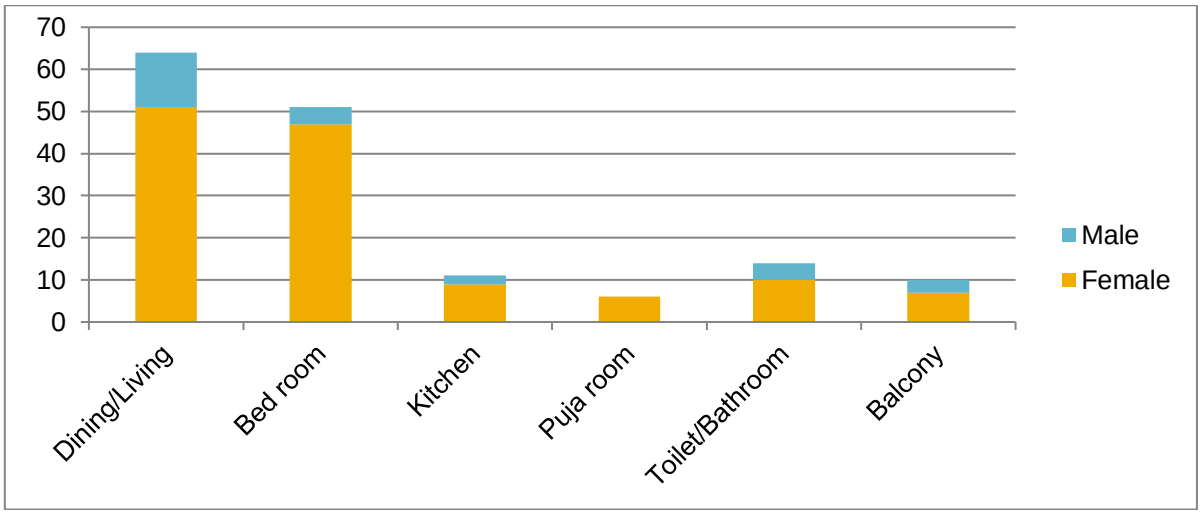

Figure: III Sex-wise *Aedes* mosquitoes collected from different rooms of multi-storey building

The tendency for resting to predominantly occur at below 1.5 meters height was observed for both sexes of *Aedes* mosquitoes. Our findings support the earlier finding of Seang-Arwut *et.al*; in northeastern Thailand and others [3, 8]. At lower heights, there is less air movement as well as less disturbed areas (corner areas of the room in particular), and it is generally darker than the wall near the ceiling and often lightened by electric bulbs. Furthermore, ceiling fans are often installed, which may interfere with mosquito resting. Finally, at lower heights, there are often hanging objects such as clothes, towels and mosquito nets as well as furniture that create sheltered dark sites, offering an ideal hiding place to rest and

digest [12]. Mosquitoes rest on hanging objects or are attracted to used clothes emitting human odors [13].

More number of *Aedes* mosquitoes was collected in huts than in both concrete houses and multi-storey buildings in account of areas wise. Generally, huts were denser with household goods and the ceiling was made of wood, paddy straw and bamboo etc. helping to lower of temperature in the room as compared to others. Less percentage of male *Aedes* also collected from several study sites as compare to female population because female *Aedes* mosquitoes prefer rest indoor rather than outdoor to collect human blood meal.

CONCLUSION

Our work suggested that vector control using targeted IRS focusing on walls at heights below and above 1.5 m in living/bed/dining rooms of huts and lower than 1.5 m in toilet /bathroom of the concrete house and dining/living room and bedroom of multi-storey building could be part of an integrated effective strategy for *Aedes* mosquito control. In multi-storey building ground floor is more important for the predominant resting of *Aedes* mosquitoes.

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