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Breeding site profiling of *Aedes* mosquitoes using breeding preference ratio in a semi-urban setting of Kesinga town, Kalahandi, Odisha

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Abstract

Dengue has emerged as a major public health concern in Odisha, with over a thousand cases reported annually and a rising incidence in recent years. The principal vectors of dengue and chikungunya in the region are *Aedes aegypti* and *Aedes albopictus*. Kesinga, a semi-urban town in the Kalahandi district, holds epidemiological importance due to its major railway station and extensive transportation network, which facilitates human movement and potential vector dispersal. Despite this, no published research has previously documented *Aedes* breeding habitats in Kesinga. The present study constitutes the first baseline survey of *Aedes* breeding sites in this area, aiming to assess larval habitat preferences and behavioural ecology to support future vector control and disease risk prediction strategies.

Sampling was conducted bimonthly, during the first and last weeks of each month. Indoor sampling targeted five habitat types: earthen pots, cement tanks, plastic containers, flower pots, and plastic buckets. Outdoor collections included nine habitat types: earthen pots, cement tanks, tree holes, coconut shells, metal drums, plant pots, plastic containers, discarded tyres, and plant axils. A total of 1,649 potential breeding habitats were surveyed, comprising 557 indoor and 1,092 outdoor sites, of which 734 were positive for *Aedes* larvae. The Breeding Preference Ratio (BPR) revealed plastic containers as the most preferred breeding site both indoors (1.57) and outdoors (1.25). Among outdoor habitats, earthen pots exhibited an identical BPR (1.25), followed by discarded tyres (0.74) and tree holes (0.69). Metal drums showed no larval positivity. Indoors, plastic containers were followed by earthen pots (0.85), cement tanks (0.78), and plastic buckets (0.62). The Container Index (CI) varied seasonally, with the highest indoor CI in August (12.93) and lower outdoor CI values throughout, peaking at 0.105 in August. This study provides the first evidence of *Aedes* breeding ecology in Kesinga, establishing essential baseline data for targeted surveillance, control measures, and early warning systems for dengue and other *Aedes*-borne diseases.

Keywords: *Aedes*, BPR, breeding habitats, ci, Kesinga, Kalahandi

1. Introduction

Mosquitoes are among the most important vectors responsible for transmitting several infectious diseases, including malaria, filariasis, Japanese encephalitis, dengue and dengue hemorrhagic fever, yellow fever, chikungunya, Ross River virus, and West Nile virus (Ganesan *et al.*, 2018) [12]. Globally, approximately 3,500 species of mosquitoes have been recorded (Singh *et al.*, 2024) [36]. In India, about 320 mosquito species belonging to the subfamilies *Anophelinae*, *Culicinae*, and *Toxorhynchitinae* under the order Diptera have been documented (Nagpal and Sharma, 1983) [22]. Dengue has emerged as a growing public health concern in Odisha, with more than 1,000 cases reported annually and a significant increase observed in recent years (Swain *et al.*, 2020) [38]. In the state, *Aedes aegypti* and *Aedes albopictus* are recognized as the principal vectors responsible for transmitting dengue and chikungunya (Das *et al.*, 2012) [8]. Among the *Aedes*-borne diseases, dengue virus infection (DENV) remains the most prevalent viral disease transmitted to humans (Gubler, 1998) [14].

Over the past few decades, mosquito-borne diseases have become a serious global concern.

Various control measures, including the use of larvicides, insecticides, and several genetically engineered vector control strategies, have been attempted. However, these approaches have often yielded only temporary or limited success and sometimes posed additional environmental and health challenges. Environmental parameters such as temperature, relative humidity, and rainfall significantly influence mosquito abundance and distribution (Gizaw *et al.*, 2024) [13]. Likewise, anthropogenic factors such as industrialisation, improper waste management, human-created breeding habitats, and sociocultural practices also contribute to increased mosquito proliferation (Derraik and Slaney, 2007) [9].

Several larval and pupal studies have been conducted across different parts of Odisha. Das and Hazra (2013) [7] investigated pupal stages along the coastal regions of the state, while Panigrahi *et al.* (2013) [30] studied *Aedes* breeding sites in and around Berhampur city. Rao and Padhy (2014) [33] carried out a comprehensive survey of *Aedes* larvae in the Angul district. However, limited research has been carried out on *Aedes* breeding habitats in Kalahandi district, despite recurring dengue outbreaks in recent years. A few studies have been undertaken in the urban areas of the district, particularly within Bhawanipatna Municipality. The first *Aedes* larval survey in Kalahandi was conducted by Panigrahi in 2021 [23]. Bhattacharya *et al.* (2023) [3] subsequently examined the resting behaviour of *Aedes* mosquitoes in Bhawanipatna. Recent investigations by Panigrahi *et al.* (2025a) [24] explored the influence of habitat chemical characteristics on *Aedes* mosquito breeding preferences and larval survivability, while another study (Panigrahi *et al.*, 2025b) [25] focused on the morphological traits of *Aedes* species in Bhawanipatna. Moreover, the genetic characterisation and molecular phylogeny of *Aedes vittatus* based on the COI gene from Bhawanipatna were reported by Panigrahi *et al.* (2024) [29]. Other related studies (Parida *et al.*, 2024; Panigrahi *et al.*, 2025c) [26] further highlight the growing understanding of mosquito ecology and behaviour in this region.

In Kalahandi district, Kesinga town holds particular importance due to its transportation network, especially its major railway station, which serves thousands of passengers daily. Despite this significance and the high potential for vector dispersal, no published research has yet documented *Aedes* breeding site surveys in Kesinga. Hence, the present study represents the first survey of *Aedes* breeding habitats in the semi-urban environment of Kesinga town. This baseline investigation aims to understand *Aedes* breeding preferences and behavioural ecology and provides a foundation for the development of effective vector control strategies and disease risk prediction models for dengue and other *Aedes*-borne diseases in the future.

2. Materials and Method

Study Area

The state of Odisha is situated on the eastern coast of India, bordered by Jharkhand to the north, Chhattisgarh to the west, West Bengal to the northeast, and Andhra Pradesh to the south, while the Bay of Bengal lies along its eastern boundary. The present study was undertaken in Kesinga town, located in the Kalahandi district of Odisha, where field surveys and data collection were carried out at multiple selected sites. Kesinga is positioned at 20 °11′ N latitude and 83 °13′ E longitude, at an elevation ranging from 186 to 350 meters above mean sea level (Fig. 1). The region experiences a tropical wet and dry climate with an annual average rainfall of approximately 1,378 mm.

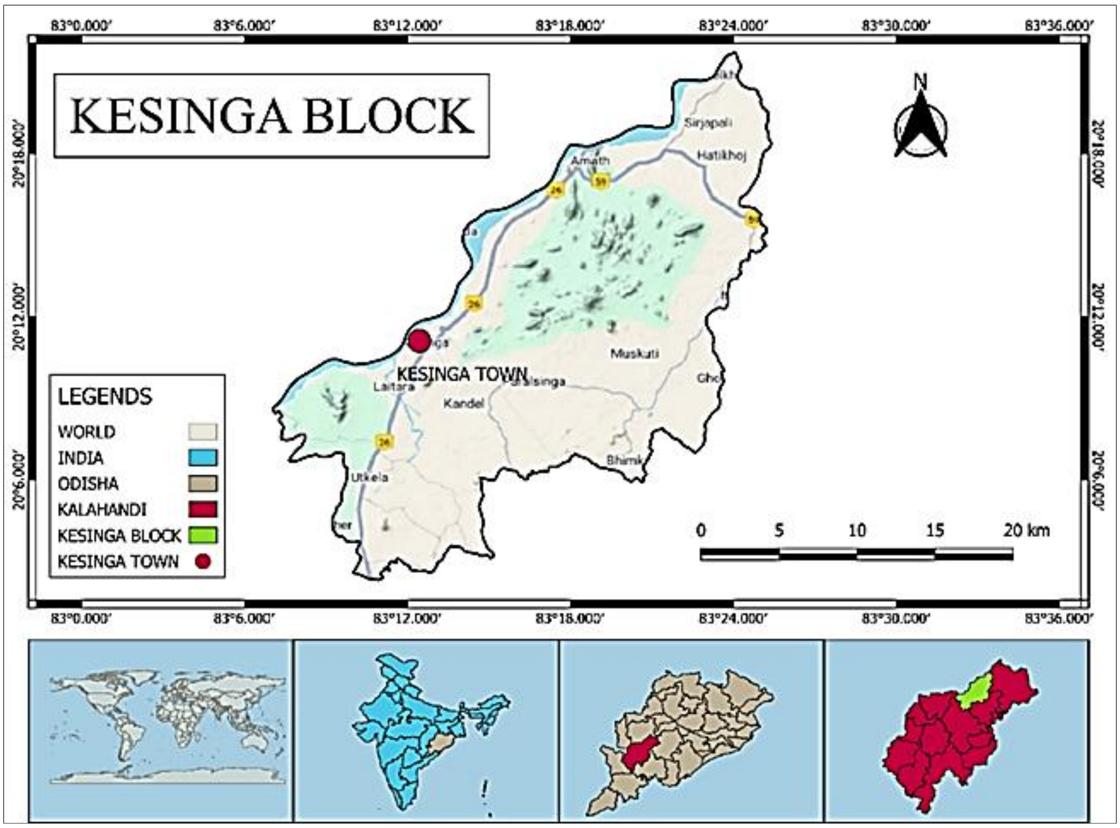

Fig 1: Showing the Study Area Kesinga Town, Kalahandi District, Odisha

Methodology

The study was conducted in the Kesinga block of Kalahandi district, Odisha, India, from February 2025 to September 2025, encompassing both the summer and rainy seasons. Sampling was carried out bimonthly during the first and last weeks of each month as per guidelines of Service (1993) [35]. Detailed field records were maintained, including date, time, georeferenced photographs, and other relevant environmental data. Indoor sampling involved the collection of larvae from five types of breeding habitats: earthen pots, cement tanks, plastic containers, flower pots, and plastic buckets. Outdoor collections were performed from nine breeding site types, including earthen pots, cement tanks, tree holes, coconut shells, metal drums, plant pots, plastic containers, discarded tyres, and plant axils. Mosquito larvae were collected using standard dipping and pipetting techniques and were transferred into labelled plastic containers for transportation. All collected specimens were brought to the laboratory for rearing to the adult stage. Identification was carried out following the morphological diagnostic characteristics provided in the pictorial keys of Rueda (2004) [34].

3. Results

A total of 1,649 potential *Aedes* mosquito breeding habitats were surveyed during the study period, comprising 557 indoor and 1,092 outdoor sites. Among these, 734 sites were found positive for *Aedes* larvae. The breeding preference ratio (BPR) indicated that plastic containers exhibited the highest preference in both indoor (1.57) and outdoor (1.25) environments (Table 1).

Table 1: Habitat-wise Breeding Preference Ratio (BPR) of *Aedes* in indoor and outdoor habitats

Survey	Breeding Sites	Positive Container (X)	Examined Container (Y)	X/ΣX	Y/ΣY	BPR= (X/ΣX)/(Y/ΣY)
Indoor	Earthen Pot	16	42	0.0218	0.0255	0.85
	Cement Tank	7	20	0.0095	0.0121	0.78
	Plastic Container	169	242	0.2303	0.1467	1.57
	Flower Pot	26	102	0.0354	0.0619	0.57
	Plastic Bucket	42	151	0.0572	0.0916	0.62
Total			**557**			**4.39**
Outdoor	Earthen Pot	9	16	0.0123	0.0097	1.25
	Cement Tank	25	87	0.034	0.0528	0.64
	Tree Holes	8	26	0.0109	0.0158	0.69
	Coconut Shell	5	35	0.0068	0.0212	0.32
	Metal Drum	0	11	0	0.0067	0
	Flower Pot	14	88	0.0191	0.0534	0.36
	Plastic Container	358	642	0.4877	0.3893	1.25
	Discarded Tyres	42	127	0.0572	0.077	0.74
	Plant Axils	13	60	0.0177	0.0364	0.49
TOTAL		**734**	**1092**			**5.74**
Grant Total=557 +1092=1659 (examined), 734 (larval positive)						

In outdoor habitats, earthen pots showed an identical BPR value (1.25) to that of plastic containers, followed by discarded tyres (0.74) and tree holes (0.69). Metal drums, however, did not show any positive breeding, indicating zero preference. In indoor habitats, the highest BPR was recorded for plastic containers (1.57), followed by cement tanks (0.78), earthen pots (0.85), and plastic buckets (0.62). Flower pots exhibited the lowest preference for breeding, with a BPR value of 0.57. These findings highlight the dominance of artificial water-holding containers, particularly plastic containers, as preferred breeding habitats for *Aedes* mosquitoes in both indoor and outdoor environments.

Table 2: Monthly Container Index expressed as a percentage for both indoor and outdoor habitats

Month	Total indoor Positive Containers (M) out of 557(N)	Indoor Container Index (M/N)	Total outdoor Positive Containers (M') out of 1092 (N')	Outdoor Container Index (M'/N')
February	8	1.44	28	0.026
March	8	1.44	37	0.034
April	9	1.62	17	0.015
May	18	3.23	14	0.013
June	33	5.92	83	0.076
July	66	11.85	95	0.086
August	72	12.93	115	0.105
September	46	8.26	85	0.0779

Table 2 presents the month-wise variation in the Container Index (CI) for both indoor and outdoor habitats. The highest indoor CI value (12.93) was recorded during August, followed by July (11.85), September (8.26), and June (5.92). In contrast, the outdoor CI values remained comparatively low throughout the study period, with a maximum of 0.105 observed in August.

4. Discussion

Adult mosquito species were observed to oviposit in both indoor and outdoor breeding habitats. The survey revealed the presence of breeding sites in both environments, with a Breeding Preference Ratio (BPR) of 4.35 indoors and 5.74 outdoors. The higher outdoor BPR was attributed to the greater availability and diversity of potential containers, with nine types of breeding sites recorded outdoors compared to five indoors. This variation appears closely linked to anthropogenic and cultural practices within the local population. A study on the breeding habitat preferences of *Aedes* mosquitoes in urban, semi-urban, and rural areas of the Kurunegala District, Sri Lanka, conducted by Herath *et al.* (2024) [16], highlighted the relationship between BPR, container types, and water quality, but did not address the distinction between indoor and outdoor preferences. Their findings indicated that plastic containers and discarded tyres were the most preferred breeding sites for *Aedes*. In contrast, a recent meta-analysis by Bukhari *et al.* (2025) [4] comparing indoor and outdoor habitats of *Aedes aegypti* and *Aedes albopictus* reported that *Aedes aegypti* shows a stronger tendency to inhabit indoor environments, whereas *Aedes albopictus* exhibits more outdoor association. Several studies have also noted that *Aedes* mosquitoes prefer to feed outdoors but rest indoors (Konkone *et al.*, 2025; Guo *et al.*, 2025; Khan *et al.*, 2025) [20, 15, 19]. However, to date, no comprehensive data are available on the detailed BPR of *Aedes* for indoor and outdoor habitats, warranting further critical investigation.

In Odisha, small earthen pots are commonly used for sacred rituals. These pots are typically discarded after each ritual without being broken, leading to their accumulation in shaded or secluded areas, often under large trees or in backyards near residences. Such disposal practices create suitable conditions for *Aedes* breeding. Limited public awareness regarding the breeding ecology of *Aedes* mosquitoes further exacerbates this issue. In densely populated residential areas, earthen pots are frequently discarded in backyards, while in more isolated households, they are thrown into shaded spaces, both significantly contributing to potential breeding habitats. Earthen pots are particularly favored by *Aedes* mosquitoes during hot and dry seasons due to their water-retaining capacity and thermal stability. Consequently, outdoor earthen pots showed a higher BPR (1.25) compared to indoor ones (0.85). Among all container types surveyed, outdoor plastic containers and earthen pots were identified as the most preferred breeding habitats for *Aedes* species, corroborating the observations of Panigrahi *et al.* (2025d) [27], who reported the high breeding potential of earthen pots for *Aedes* mosquitoes.

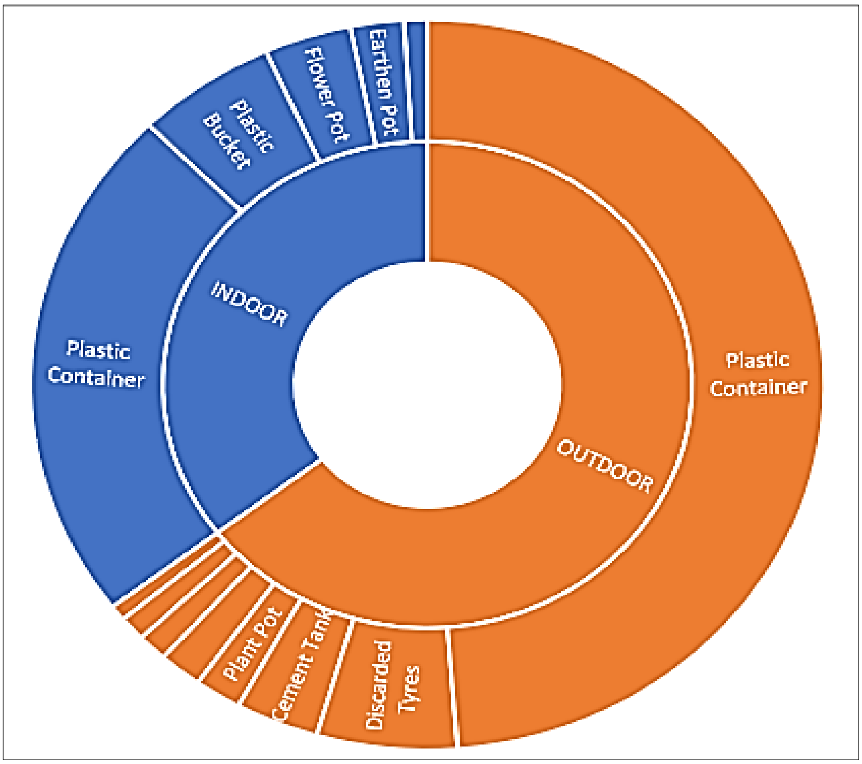

Fig 2: Sunburst chart illustrating the comparative BPR (%) of indoor versus outdoor habitats

Recent studies and field observations highlight the increasing importance of plastic containers (PCs) as preferred breeding sites for *Aedes* mosquitoes. In the present survey, the indoor Breeding Preference Ratio (BPR) was highest for plastic containers (1.57), surpassing that of plastic buckets (0.62). Outdoors, the BPR for plastic containers was 1.25, indicating substantial utilization compared to other container types. This dominance can be attributed to the widespread availability of plastic containers resulting from domestic practices, food packaging, and commercial usage, which facilitate their consistent presence as potential breeding habitats. Several studies have similarly reported plastic containers as common and productive breeding sites for *Aedes* mosquitoes (Jemberie *et al.*, 2025; Cárdenas *et al.*, 2025) [17, 5]. Frequent use, coupled with improper disposal, allows these containers to retain water for prolonged periods, enhancing their suitability for oviposition. Although plastic buckets are larger, they were slightly less preferred due to periodic disturbance by residents and less consistent water retention. The findings indicated that plastic containers were the most favored indoor breeding habitats for *Aedes*, while outdoors, both plastic containers and earthen pots exhibited comparable preferences.

Public awareness plays a crucial role in addressing the proliferation of plastic materials, as effective source reduction and proper waste management are essential to limiting *Aedes* breeding opportunities. Allen *et al.* (2025) [2] emphasized the importance of community awareness programs in minimizing breeding sites associated with plastic waste. Cement tanks and metal drums exhibited minimal breeding potential in this study, although metal drums occasionally served as resting sites due to their large size and rapid heating under sunlight. A study by Zanoni *et al.* (2025) [40] in Campo Grande, Brazil, reported water tanks as the most preferred breeding sites for *Aedes*; however, the authors did not specify the tank material, which significantly influences breeding suitability and water quality (Dalpadado *et al.*, 2022) [6]. Flower pots also exhibited breeding potential indoors but were less utilized outdoors, likely due to the greater availability of alternative sites such as plastic containers and earthen pots. These observations align with the findings of Ferdousi *et al.* (2015) [11] in Dhaka, Bangladesh.

Natural habitats, including plant axils and tree holes, showed limited breeding activity in the present survey, although tree holes have been reported as significant larval habitats in other studies (Peña *et al.*, 2025) [32]. Coconut shells exhibited minimal breeding preference, contrasting with the findings of Edillo *et al.* (2012) [10], who reported metal drums and discarded coconut shells as major breeding sites. Discarded tyres represented potential breeding habitats after tree holes in the present study, though previous studies identified tyres as among the most preferred sites due to their cool, shaded, and moisture-retaining environment (Akorli *et al.*, 2025; Jemberie *et al.*, 2025) [1, 17]. Overall, the increasing proliferation of plastic containers in household and commercial settings has elevated their importance as key breeding sites for *Aedes* mosquitoes, underscoring the urgent need for strengthened public awareness campaigns and targeted source-reduction strategies to mitigate vector proliferation.

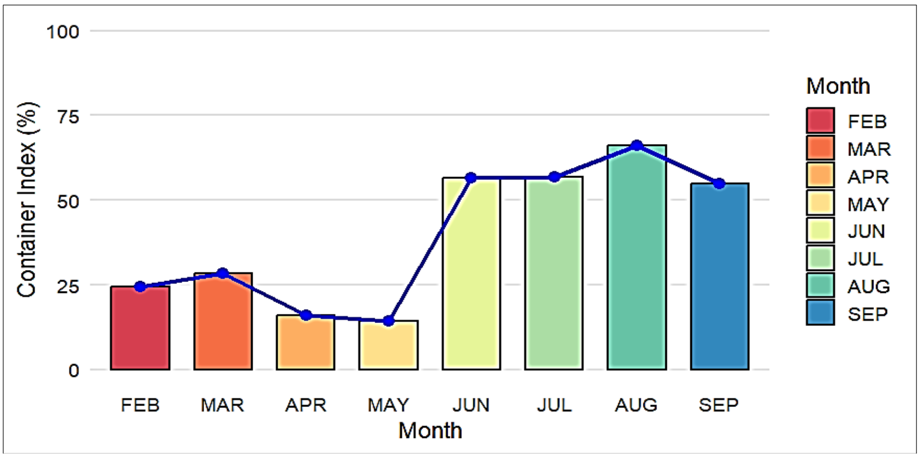

Fig 3: Monthly variation in Container Index for outdoor habitats

Figures 3 and 4 present the seasonal variation in container index (CI) for *Aedes*-positive breeding sites, contrasting indoor and outdoor environments. The monthly CI data reveal distinct seasonal dynamics, with indoor CI consistently exceeding outdoor values across most months. During the dry months of February and March, the indoor CI remained low at 1.44%, whereas the outdoor CI was substantially lower, registering 0.026% and 0.034% respectively. In April, indoor CI rose modestly to 1.62%, still surpassing outdoor CI (0.015%), with a marked indoor CI surge observed in May (3.23%) compared to outdoors (0.013%). The commencement of the rainy season triggered pronounced increases in both indices, with June showing an indoor CI of 5.92% and an outdoor CI of 0.076%. This upward trajectory persisted through July to September, peaking in August with an indoor CI of 12.93% and an outdoor CI of 0.105%. A subsequent decline was evident in September (indoor CI 8.26%, outdoor CI 0.0779%).

Comparatively, studies in Nepal have reported higher container indices during the post-monsoon period compared to the monsoon, mirroring these observed trends of heightened vector activity following increased rainfall and humidity (Sukupayo *et al.*, 2025;) [37]. Such data underscore the correlation between climatic factors and vector population dynamics, supporting the findings of Panigrahi *et al.* (2025e) [28] from Kalahandi, Odisha, where climatic elements significantly influenced perennial malaria cases and, by extension, mosquito population dynamics. These results confirm established patterns in vector ecology, demonstrating that increases in rainfall and humidity are closely tied to elevated *Aedes* breeding indices in both indoor and outdoor settings, with indoor environments often providing relatively stable and favorable conditions for sustained breeding during the wet season.

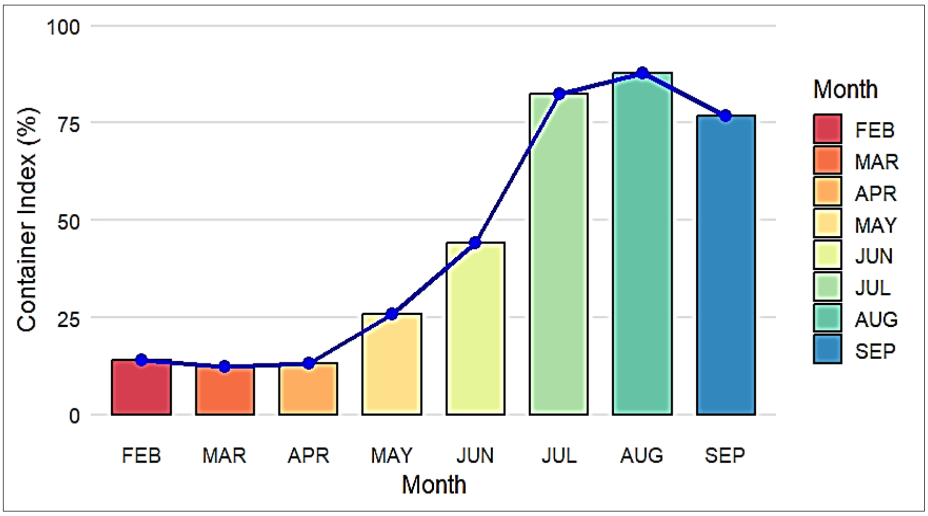

Fig 4: Monthly variation in Container Index for indoor habitats

Based on the findings, it is evident that community awareness in Kesinga town is crucial for reducing diverse *Aedes* mosquito breeding habitats. Community participation and public awareness play a vital role in the sustainable control of *Aedes* populations and the prevention of diseases such as dengue, chikungunya, etc., as previously reported by Allen *et al.* (2025) [2]. Active engagement of the community in identifying, eliminating, and managing potential breeding sites such as stagnant water in plastic containers, earthen pots, discarded tyres, and domestic receptacles significantly enhances the effectiveness of vector control programs. Tompkins (2025) [39] emphasized that public education campaigns focusing on behavioral changes, environmental sanitation, and household-level interventions can foster a sense of shared responsibility and encourage regular monitoring of mosquito breeding sites. Moreover, collaborative efforts among local health authorities, community organizations, and residents are essential to achieving long-term success in minimizing vector proliferation and reducing the risk of mosquito-borne disease transmission, as also highlighted by Lowe and Codeço (2025) [21]. Therefore, based on our observations, it is imperative to develop comprehensive community involvement strategies alongside awareness programs to effectively prevent the future spread of *Aedes*-borne diseases in Kesinga town.

5. Conclusion

The higher outdoor Breeding Preference Ratio (BPR) observed in Kesinga town. Plastic containers were the most preferred breeding sites both indoors and outdoors, while earthen pots were predominantly favoured among outdoor habitats. Additionally, our findings indicate that the Container Index (CI) was higher during the monsoon season compared to the summer, reflecting seasonal variations in breeding site availability and mosquito proliferation. Despite these observations, it is evident that community awareness in Kesinga remains insufficient to effectively reduce the diverse *Aedes* mosquito breeding habitats. Strengthened community education and engagement, particularly focusing on the elimination and management of key breeding containers such as plastic containers, earthen pots, discarded tyres, and other domestic receptacles, are essential to improve vector control outcomes and reduce disease transmission risk. These findings highlight the need for integrated control strategies combining environmental management and sustained community participation to mitigate the burden of *Aedes*-borne diseases in this region.

6. Acknowledgment

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