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Subrat Kumar Panigrahi

Department of Zoology,
Maa Manikeshwari University,
Bhawanipatna, Kalahandi,
Odisha, India

Smruti Ranjan Parida

Department of Zoology,
Maa Manikeshwari University,
Bhawanipatna, Kalahandi,
Odisha, India

Shib Sagar Barik

Department of Zoology,
Maa Manikeshwari University,
Bhawanipatna, Kalahandi,
Odisha, India

Tapaswini Naik

Department of Zoology,
Maa Manikeshwari University,
Bhawanipatna, Kalahandi,
Odisha, India

Saswati Sahu

Department of Zoology,
Maa Manikeshwari University,
Bhawanipatna, Kalahandi,
Odisha, India

Corresponding Author:**Subrat Kumar Panigrahi**

Department of Zoology,
Maa Manikeshwari University,
Bhawanipatna, Kalahandi,
Odisha, India

Study on morphological traits of *Aedes* mosquitoes in Bhawanipatna: Implications for vector surveillance

Subrat Kumar Panigrahi, Smruti Ranjan Parida, Shib Sagar Barik, Tapaswini Naik and Saswati Sahu

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Abstract

This study was conducted in Bhawanipatna, during the rainy season from June 2024 to September 2024. A total of 173 *Aedes* mosquitoes were collected throughout the study period. The highest number of mosquitoes (54) was recorded in August, followed closely by 49 in September, 41 in July, and the lowest count of 29 in June. Among the collected *Aedes* mosquitoes, 73 female *Aedes albopictus* were identified, followed by 34 *Aedes vittatus*, 21 *Aedes aegypti*, and 8 *Aedes lineatopennis*. A Wilcoxon signed-rank and Paired t-test was calculated. The paired t-test indicated statistically significant differences in female vs. male counts for *Ae. albopictus*, *Ae. vittatus*, and *Ae. aegypti*, with females generally more abundant. *Ae. lineatopennis* poses a particular challenge for humans, as our current knowledge about this species remains limited, underscoring the need for further research to better understand its behavior and role in disease transmission.

Keywords: *Aedes*, *Ae. lineatopennis*, MHD, Kalahandi, morphological traits

1. Introduction

Mosquitoes belong to the Culicidae family in the class Insecta, phylum Arthropoda, and are responsible for transmitting many arboviral diseases. Different mosquito genera serve as vectors for different diseases: *Aedes* mosquitoes transmit dengue, chikungunya, and yellow fever ^[1]; *Anopheles* mosquitoes are vectors of malaria ^[2]; *Culex* mosquitoes spread filariasis ^[3]; and *Armigeres* mosquitoes are associated with the Zika virus ^[4]. Among these mosquito-borne diseases, dengue is particularly significant due to its severe impact on human health and the economy ^[5].

Effective surveillance and control of mosquito-borne diseases rely heavily on accurate vector identification. While many experts can identify mosquitoes at the genus level using morphological traits, species-level identification remains challenging. In India, the genus *Anopheles* contains over 60 species ^[6], *Culex* has about 100 species ^[7], *Armigeres* includes 15 species ^[8], and 25 species belong to *Aedes* ^[8]. Identification of *Anopheles* mosquitoes based on morphology is especially difficult due to the diverse patterns observed on their bodies and wings, and only highly skilled experts can identify them to the species level. Morphometric analysis is sometimes used as an additional tool for identification. Another challenge in morphological identification is that some color patterns or bands may vary due to habitat or climatic conditions, causing ambiguity ^[9]. To overcome these limitations, molecular identification techniques—such as sequencing the mitochondrial COI gene or the ITS gene—are widely used, providing more reliable and accurate identification ^[10]. However, these molecular methods are not yet affordable or accessible for every laboratory.

This study aims to compare the morphology of *Aedes* mosquitoes from Bhawanipatna in order to develop user-friendly identification keys. This does not rely on morphometric or molecular techniques. Additionally, a survey was carried out to evaluate the man-hour density of *Aedes* mosquito populations in the urban area of Bhawanipatna during the rainy season, providing valuable insights to enhance vector surveillance efforts.

2. Materials and Methods

2.1 Study Area

This study was conducted in Bhawanipatna, Kalahandi, Odisha, an eastern state of India, during the rainy season from June 2024 to September 2024. Bhawanipatna, located at approximately 19.9074° N, 83.1642° E, experiences extreme climatic conditions with both hot and cold temperatures, and receives an average annual rainfall of approximately 1,378.2 mm. The district's topography is characterized hilly tracts in the southeast and south and undulating plains and agricultural land in the west and north. Over the past two decades, Bhawanipatna has undergone significant urban expansion with the construction of numerous buildings, leading to increased urbanization. This growth has contributed to the proliferation of potential *Aedes* mosquito breeding sites, such as artificial containers. Therefore, this municipality was selected as the study area to assess the local *Aedes* mosquito population.

2.3 Methods

Adult *Aedes* mosquitoes were collected using manual aspirators from various breeding sites as well as open fields where human dwellings were prevalent. During collection, the man-hour density (MHD) was calculated, representing the number of mosquitoes captured by a single person per hour. Only outdoor collections were conducted; no indoor collections were performed. The mosquito sampling took place during the rainy season of 2024, over a period of four months. Collections were carried out bimonthly during peak mosquito activity periods, specifically twice daily from 6:00 AM to 9:00 AM and again from 4:00 PM to 7:00 PM. All

authors participated in the collection process, and collection sites varied throughout the study.

After collection, 2 to 5 adult mosquitoes were transferred into test tubes fitted with cotton plugs for aeration. The test tubes were then brought to the Department of Zoology at Maa Manikeshwari University for further entomological analysis. To immobilize the mosquitoes, they were exposed to refrigeration for 2 to 3 minutes. In this semi-conscious state, the mosquitoes were identified under an Olympus stereomicroscope using pictorial keys specific to *Aedes* mosquitoes^[11, 12, 13]. All observations were recorded for subsequent data analysis.

Photographs were taken by mounting a digital camera on the Olympus stereomicroscope. Using the identification key, a comparative analysis of morphological traits was conducted, as illustrated in figure 1. A Wilcoxon signed-rank test and Paired t-test were calculated to compare monthly female and male counts for each species by using of Statistical SSP software.

3. Results

Three common *Aedes* species were captured during the study: *Ae. albopictus*, *Ae. vittatus*, and *Ae. aegypti*. Additionally, an uncommon *Aedes* species was collected near human dwellings, which initially caused identification challenges. This species was subsequently confirmed as *Ae. lineatopennis* through molecular sequencing of the mitochondrial COI gene. The sequence data were submitted to GenBank, and are publicly available under the accession number PQ788195 on December 25, 2024.

Table 1: Man per hour density (MHD) of four *Aedes* mosquito species, collected from Bhawanipatna during rainy season, 2024.

Months	<i>Ae. albopictus</i>		<i>Ae. vittatus</i>		<i>Ae. aegypti</i>		<i>Ae. lineatopennis</i>		Total
	♀	♂	♀	♂	♀	♂	♀	♂	
June	11	03	07	02	05	01	00	00	29
July	16	02	09	03	07	03	01	00	41
August	22	05	11	04	06	04	02	00	54
September	24	04	07	01	03	02	05	03	49
Total	73	14	34	10	21	10	08	03	173

The man per hour density (MHD) of four *Aedes* mosquito species is presented in Table 1. A total of 173 *Aedes* mosquitoes were collected throughout the study period. The highest number of mosquitoes (54) was recorded in August, followed closely by 49 in September, 41 in July, and the lowest count of 29 in June. Among the collected *Aedes* mosquitoes, 73 female *Ae. albopictus* were identified, followed by 34 *Ae. vittatus*, 21 *Ae. aegypti*, and 8 *Ae. lineatopennis*. The numbers of male *Aedes* mosquitoes captured were relatively similar across species, except for *Ae.*

lineatopennis, which had the lowest count with only 3 individuals captured.

A Wilcoxon signed-rank and Paired t-test was calculated and the result are given in Table 2. The paired t-test indicated statistically significant differences in female vs. male counts for *Ae. albopictus*, *Ae. vittatus*, and *Ae. aegypti*, with females generally more abundant. The Wilcoxon test p-values were above 0.05, likely due to the small sample size, but showed trends similar to the t-test. For *Ae. lineatopennis*, neither test found a statistically significant difference at the 0.05 level.

Table 2: Statistical test results comparing female versus male monthly counts for each *Aedes* mosquito species are as follows:

Species	Wilcoxon Signed-Rank Test (p-value)	Paired t-test (p-value)
<i>Ae. albopictus</i>	0.125	0.0104 (significant)
<i>Ae. vittatus</i>	0.125	0.0007 (highly significant)
<i>Ae. aegypti</i>	0.125	0.035 (significant)
<i>Ae. lineatopennis</i>	0.102	0.080 (not significant)

Morphological traits such as the overall body structure, distinctive features of the cephalothorax, patterns of the

proboscis, legs, wings, and abdomen are illustrated in Figure 1 for all four *Aedes* species.

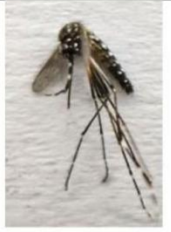
Characters	<i>Aedes albopictus</i>	<i>Aedes aegypti</i>	<i>Aedes vittatus</i>	<i>Aedes lineatopennis</i>
Whole body				
Cephalothorax				
Lateral				
Ventral				
Legs				
Wings				

Fig 1: Morphological identification traits of *Ae. albopictus*, *Ae. aegypti*, *Ae. vittatus*, and *Ae. lineatopennis* collected from Bhawanipatna, Kalahandi.

4. Discussion

Our findings show that *Aedes* mosquito species exhibit increasing abundance from June to August, which corresponds to the onset and peak of the rainy season. August recorded the highest overall mosquito numbers. This pattern supports with the earlier study by Panigrahi (2021), who reported man-hour densities alongside house and container indices for both *Ae. albopictus* and *Ae. Aegypti* [14]. However, no other studies have addressed the population density of *Aedes* mosquitoes specifically in Bhawanipatna, Kalahandi, despite very few dengue cases being reported in the past decade.

In our study, *Aedes* populations peaked in the mid to late rainy season, correlating with the increased availability of larval habitats due to rain-filled discarded artificial containers. This observation supports the findings of Petrić *et al.* (2021), a similar investigation conducted in Europe [15]. Recently,

Panigrahi *et al.* (2025) emphasized the significant influence of climatic factors directly affecting mosquito populations in this region [16]. Conversely, Alias *et al.* (2025) reported contrasting results in Johor, Malaysia, where rainfall increased *Aedes* mosquito density two fold in urban areas but decreased in rural areas [17]. This suggests that rainfall has varying effects on mosquito populations depending on geographical location and habitat type. Therefore, area-specific and species-specific studies are crucial for effective mosquito surveillance and vector-borne disease control.

Female mosquitoes are primarily responsible for biting humans and animals, making their population size a critical factor in assessing disease transmission risk and predicting future outbreaks [18]. Generally, females are more abundant than males [19] and tend to be more aggressive in seeking hosts [20]. Our results also indicate that female mosquitoes are consistently more numerous than males across most studied

species throughout the months, reflecting typical mosquito population dynamics. Although paired t-tests showed biologically meaningful differences despite a small sample size, Wilcoxon tests were not significant but still directionally supported this pattern.

Among species, *Ae. albopictus* had the highest total counts (87), peaking in September with 24 females and 4 males, surpassing other *Aedes* species. This finding contrasts with the study by Priskilla *et al.* (2025) in industrial Puducherry, India, where *Ae. aegypti* was more prevalent, followed by *Ae. Albopictus* [21]. However, our results are consistent with Sarkar *et al.* (2024) in West Bengal [22] and Mathiarasan *et al.* (2025) in Kerala [23]. Similar dominance of *Ae. albopictus* was reported by Laojun *et al.* (2024) in the border archipelagos of Thailand [24] and by López-de-Felipe Escudero *et al.* (2025) in the Mediterranean basin [25], as well as in different parts of the world [26, 27]. This widespread presence suggests that *Ae. albopictus* exhibits strong adaptability across diverse environments, climate changes, and human communities. Consequently, this species poses a significant challenge for preventing its spread between regions, necessitating regular surveillance to assess vector-borne disease risks.

Morphologically, *Ae. albopictus* can be identified by its black and white coloration, with a prominent single longitudinal white stripe on the dorsal thorax (scutum), white and black banding on the legs—especially the hind legs—and dark and silvery-white scales on the abdomen, as illustrated in Figure 1. *Ae. vittatus*, with a total of 44 specimens, maintained consistent numbers from June through August but declined slightly in September. It was the second most abundant *Aedes* species in Bhawanipatna, capable of breeding in rock holes, tree holes, artificial containers, and pools. Its ability to utilize both natural and artificial habitats poses challenges for control efforts in urban and rural settings alike. Singh *et al.* (2025) reported *Ae. albopictus* and *Ae. vittatus* as the dominant species in Haridwar city, Uttarakhand, India [28]. *Ae. vittatus* thrives in diverse environments—from urban areas to forests—and shows adaptability to various temperature ranges, indicating that control strategies must target breeding sites across these landscapes. This species is distinguishable by three pairs of small, spherical, silvery-white spots present on the scutum (Figure 1); however, it can be confused with *Ae. cogilli*, which lacks these spots.

Ae. aegypti was less abundant in our sample (31 total), but its population followed typical peak seasonality during the rainy months, peaking in July and August. This anthropophilic species prefers urban habitats [29]. Morphologically, *Ae. aegypti* can be differentiated by the presence of white/silver leg stripes and a lyre-shaped marking on the scutum, whereas *Ae. albopictus* has a single, unbroken white stripe on the dorsal thorax, which can make differentiation challenging (Figure 1).

Recently, Panigrahi *et al.* (2025) made the first record of molecular confirmation of *Ae. lineatopennis* in Kalahandi, Odisha [30], followed by confirmation from Swain *et al.* (2025) in Gopalpur, Odisha [31]. *Ae. lineatopennis* showed the lowest abundance in our study (11 total), with a notable population peak in September. Although understudied, this species appears to peak later than others. There are no records of *Ae. lineatopennis* being associated with arboviral diseases in Odisha to date, but Panigrahi *et al.* (2025) noted its recent expansion [30].

Morphologically, *Ae. lineatopennis* is characterized by a dark

brown to golden coloration throughout the body, particularly golden, curved, and narrow head scales (Figure 1). It closely resembles *Ae. mcintoshi* and *Ae. circumluteolus* but can be distinguished by wing vein scale patterns: *Ae. lineatopennis* has white scales on at least the basal half of the R vein and entirely white scales on the SC vein, whereas *Ae. mcintoshi* and *Ae. circumluteolus* have shorter white scale coverage on the R vein and some dark scales on the SC vein. This species, native primarily to Sub-Saharan Africa, has not been reported in India prior to these records.

5. Conclusion

In urban settlements, *Aedes* mosquitoes are highly adaptive, and different species exhibit varying potential for disease transmission. Therefore, accurate identification of these species is essential to implement effective vector control strategies in areas where mosquitoes are most prominent. Among them, *Ae. lineatopennis* poses a particular challenge for humans, as our current knowledge about this species remains limited, underscoring the need for further research to better understand its behavior and role in disease transmission.

6. Acknowledgement

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