**Morphometrics of brown planthopper, *Nilaparvata lugens* (stål) populations collected from different locations of India**

**ABSTRACT**

Morphometrics -the quantitative analysis of form-serves as a powerful tool in this context. It involves precise measurements of various body parts and is widely used in systematics to study morphogenesis, population structure, and the effects of environmental stress on organisms, especially arthropods. The present study explores about morphometrics of brown planthopper, *Nilaparvata lugens* (Stål) populations collected from different locations of India. The experiment was conducted at the ICAR–Indian Institute of Rice Research, Hyderabad. Brown Planthopper (BPH) specimens were collected from farmers' fields located in BPH-prone regions across the states of Telangana, Karnataka, Chhattisgarh, Odisha, and Punjab. Following collection, the specimens were dry-mounted and carefully examined under a stereoscopic binocular microscope to study their morphological characteristics. Morphometric measurements—including total body length, body width, wing length, wing width, head length, interocular distance, and tibial spur length—were recorded for both brachypterous and macropterous forms of adult males and females. Additionally, body length and width were measured for all five nymphal instars. The study included BPH populations from different geographical locations, as well as a glasshouse-maintained BPH culture. All morphometric data were recorded in millimeters. The analysis revealed slight morphological variations among the different BPH populations. The body length of the adult macropterous female BPH from Kampasagar was more (3.448 mm) and tibial spur was longest (0.456mm) in Bargarh macropterous females compared to that from other locations. The maximum length of the head (0.777 mm) of the brachypterous male BPH was observed in Raipur population as compared to the other geographical regions.

**Key words:** Morphometric, populations, *Nilaparvata lugens,* rice

**Introduction**

“Nowadays, it is a great challenge to improve the rice field due to several pest attacks. Without precise identification, effective pest control of crop-damaging pest species is impossible. However, morphological identification of pests is sometimes challenging because of the significant physical similarities, noticeable colour variation, and smaller size variations during the nymph stage, whereas molecular techniques make the identification process very simple” (Horgan et al., 2018; Kar et al., 2024). The rice brown planthopper (BPH), Nilaparvata lugens (Stål) (Hemiptera: Delphacidae), is recognised as one of the most destructive sucking insect pests affecting rice crops across all major rice-growing regions. It feeds on the phloem sap of rice plants, leading to a condition known as “hopper burn,” which causes the plants to wilt and dry up, resulting in extensive yield losses. Outbreaks of BPH have been reported frequently in different parts of the country, posing a significant threat to food security and the livelihood of rice farmers (JhansiLakshmi et al., 2010). “Management of N. lugens is challenging, as most of the insecticides have become ineffective due to resistance development. Understanding the biochemical and genetic factors responsible for resistance is the most critical aspect of managing N. lugens. Assessing the number of biochemical constituents expressed and contributing to N. lugens resistance will help to facilitate the resistance breeding program. Knowing the biochemical/defence enzymes induced before and after a pest’s attack, and their quantity, is necessary to conclude resistance or susceptibility” (Pati et al., 2023).

In recent years, there has been a growing interest in understanding the morphological and biological diversity of BPH populations, as such variations can influence pest virulence, adaptability, and resistance to insecticides. Morphometrics -the quantitative analysis of form-serves as a powerful tool in this context. It involves precise measurements of various body parts and is widely used in systematics to study morphogenesis, population structure, and the effects of environmental stress on organisms, especially arthropods (Daly and Gregg, 1985). By applying morphometric analysis to BPH populations collected from different regions, researchers can detect subtle morphological differences that may be indicative of emerging biotypes or ecological adaptations, ultimately aiding in the development of more effective pest management strategies.

**MATERIALS AND METHODS**

Field collection of Brown Planthopper (BPH) specimens was conducted from farmers' fields located in BPH-prone areas across five states: Telangana, Karnataka, Chhattisgarh, Odisha, and Punjab. Insects were collected using aspirators (suction bulb with mouthpieces) and placed into plastic boxes (25 cm × 15 cm) with multiple perforations for ventilation. Rice stems wrapped with moistened cotton swabs were provided as food and to maintain humidity. From each location, 10–15 such boxes were collected, packed into cotton bags, and transported in the evening via buses and trains. During transit, cotton swabs were intermittently re-moistened with water to ensure the insects' survival.

Upon arrival at ICAR–Indian Institute of Rice Research, Rajendranagar, Hyderabad, the BPH specimens were transferred to an isolation chamber and gently released onto potted rice plants. Morphometric investigations were carried out at the Instrumentation Cell, College of Agriculture, PJTSAU, Rajendranagar, during 2018. Measurements recorded included body length and width, wing length and width, head length, interocular distance, and tibial spur length for both brachypterous and macropterous adult males and females. Similarly, the body length and width of all five nymphal instars were recorded. One-day-old adults and freshly moulted nymphs were used for measurement, all in millimetres.

BPH populations reared in glasshouse cages were also used. These were placed in plastic containers with rice stems and transported to the instrumentation laboratory, where they were frozen and processed. The specimens were dry-mounted and examined under a Lawrence and Mayo stereoscopic binocular microscope (Model: LM-52-3611 [ZTX-3E] with 2X zoom; Kathirithamby, 1994). From each developmental stage and region, twenty individual insects were sampled. Morphometric data were captured using T Capture Software (version 3.9 build 500). Data were subjected to appropriate transformations and analyzed using Completely Randomized Block Design (CRBD) in Statistix 8 (version 8.1), with treatment means compared using Duncan’s Multiple Range Test (DMRT).

**List 1. Details of the field collection of *N. lugens* carried out during the study period**

|  |  |  |
| --- | --- | --- |
| **Place**  | **District**  | **State**  |
| Kampasagar | Nalgonda | Telangana |
| Gangavathi | Koppal | Karnataka |
| Raipur | Raipur | Chhattisgarh |
| Bargarh | Bargarh | Odisha |
| Ludhiana | Ludhiana | Punjab |

**RESULTS AND DISCUSSIONS**

Body length of brachypterous female BPH from Kampasagar was more *.i.e.* 3.356mm and length of the head of the brachypterous female was more 0.847 mm in Raipur BPH population compared to that of other BPH populations. The body length of the adult macropterous female BPH from Kampasagar was more (3.448 mm) and tibial spur was longest (0.456mm) in Bargarh macropterous females compared to that from other locations. The maximum length of the head (0.777 mm) of the brachypterous male BPH was observed in Raipur population as compared to the other geographical regions. Interocular distance in adult macropterous male was significantly more in the Kampasagar BPH population (0.810mm). The tibial spur was the longest in the glasshouse macropterous males(0.320mm).

 The body length of the first instar BPH nymphs was more in Gangavathi BPH population (0.716 mm), the body length of second instar nymph was more in Bargarh BPH population(1.153mm). The body length and width of fourth instar BPH nymphs were more in Raipur BPH population (2.447mm and 0.988mm, respectively) and the body length of fifth instar BPH nymphs was more in Bargarh BPH (2.996mm).

“The main disadvantage of morphometrics is that the method alone cannot easily distinguish between environmental and genetic contributions to the phenotype; therefore, it cannot directly establish the biological validity of a species, *i.e.,* whether populations are reproductively isolated” (Lane, 1994)

 The present findings with regard to morphometrics of wings are in agreement with the measurements of length of macropterous male forewings 4.00 (3.80-4.20) mm and width across the compound eyes 1.02 (1.01-1.03) mm by Shashank, (2009). Measurements of length of macropterous male including forewings 3.90 (3.70-4.10) mm and width across the compound eyes 1.01 (1.01-1.02) mm by Brahma, (2010). As reported by Cook *et al.* (1987) the variation in wing length across geographical locations seems to be determined primarily by environmental dissimilarities between the locations. The adult forewing length in *N. lugens* macropterous male 3.0-3.2mm, brachyptrous male 1.0 -1.6mm, macroptereous female 3.0-3.8mm and brachypterous female 1.1- 1.6mm ([Cook](https://www.cabdirect.org/cabdirect/search/?q=au%3a%22Cook%2c+A.+G.%22) and [Perfect](https://www.cabdirect.org/cabdirect/search/?q=au%3a%22Perfect%2c+T.+J.%22),1982). Similar morphometrical studies were conducted by Bhattacharyya *et al.* (1983) on “macropterous forms of Pantnagar and Hyderabad populations. Little microtypic numerical variations recorded on some characters were unable to separate these two populations morphologically”.

 Studies on different morphological characters between rice and *Leersia*-infesting *N. lugens* from 11 locations revealed the range of length of tibial spur between 0.386 to 0.482mm (Latif *et al*. 2013) and this is in accordance with the present findings. Individuals reared on TN1 were generally somewhat larger than those on resistant varieties. The length of spur length (mm) of *N. lugens* in sequence: biotype l (B l ) on TN l; biotype 2 (B2) on Mudgo; biotype 3 (B3) on ASDT; biotype 2on TNI; biotype 3 on TNI range of 0.3-0.5, 0.3-0.4, 0.25-0.45, 0.3-0.6 and 0.35-0.50 (Claridge *et al*.1984) which was similar to the present findings, where length of spur length (mm) in *N. lugens was* recorded 0.30-0.45.

**Conclusion**

By applying morphometric analysis to BPH populations collected from different regions, researchers can detect subtle morphological differences that may be indicative of emerging biotypes or ecological adaptations, ultimately aiding in the development of more effective pest management strategies. The results help to formulate an efficient strategy for integrated pest management of *N. lugens* in rice, and the development of resistant varieties through advanced breeding programs.

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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 **Table 1. Morphometrics of brachypterous brown planthopper females from different locations**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **BPH****populations** | **Body length (mm)** | **Body** **width** **(mm)** | **Wing length (mm)** | **Wing width (mm)** | **Head length (mm)** | **Interocular distance (mm)** | **Tibial Spur****length** **(mm)** |
| **Glasshouse** | 3.314 ± 0.041 a | 1.457 ± 0.009a | 1.574 ±0.001a | 0.837 ± 0.001b | 0.842 ± 0.002a | 0.277 ± 0.003b | 0.385 ± 0.006bc |
| **Kampasagar** | 3.356 ± 0.037a | 1.249 ± 0.019b | 1.474 ± 0.003b | 0.773 ± 0.014 c | 0.781 ± 0.048c | 0.274 ± 0.005 bc | 0.434 ±0.001 a |
| **Gangavathi** | 2.920 ± 0.051b | 1.420 ± 0.015 a | 1.539 ± 0.009 ab | 0.778 ± 0.007 c | 0.816 ± 0.045 b | 0.246 ± 0.004c | 0.360 ± 0.024 d |
| **Raipur** | 3.278 ± 0.033 a | 1.410 ± 0.025 a | 1.316 ± 0.004 c | 0.758 ± 0.001 c | 0.847 ± 0.035a | 0.445 ± 0.023a | 0.372 ± 0.013cd |
| **Bargarh** | 2.988± 0.023b | 1.148 ± 0.017 c | 1.274 ± 0.017c | 0.838 ±0.005 b | 0.743 ± 0.010 d | 0.253 ± 0.004 bc | 0.416 ± 0.006ab |
| **Ludhiana** | 3.293 ± 0.028 a | 1.182 ± 0.014c | 1.565 ± 0.032 a | 0.918 ± 0.015 a | 0.788 ± 0.004c | 0.266 ± 0.002 bc | 0.350 ± 0.008 d |
| **S.E (m)** | 0.042 | 0.017 | 0.026 | 0.013 | 0.015 | 0.010 | 0.012 |
| **C.D** | 0.116 | 0.048 | 0.072 | 0.036 | 0.021 | 0.027 | 0.035 |
| **C.V** | 5.8 | 6.0 | 6.4 | 5.0 | 7.2 | 3.9 | 6.3 |

 Values in a column followed by the same letter do not differ significantly by DMRT (*P* = 0.05%)

**Table 2. Morphometrics of marcropterous brown planthopper females collected from different locations**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **BPH****Populations** | **Body length (mm)** | **Body width (mm)** | **Wing length (mm)** | **Wing width (mm)** | **Head length (mm)** | **Interocular distance (mm)** | **Tibial Spur****length (mm)** |
| **Glasshouse** | 3.336 ± 0.032b | 1.210 ± 0.20 c | 3.621 ± 0.009 ab | 1.107 ± 0.003 a | 0.786 ± 0.007a | 0.266 ± 0.003c | 0.437 ± 0.001a |
| **Kampasagar** | 3.448 ± 0.029 a | 1.415 ± 0.018a | 3.679 ± 0.033 a | 0.989 ± 0.002 c | 0.757 ± 0.004 ab | 0.281 ± 0.003b | 0.360 ± 0.002c |
| **Gangavathi** | 3.428 ± 0.009a | 1.294 ± 0.002 b | 3.566 ± 0.044c | 1.115 ± 0.001 a | 0.694 ± 0.002 c | 0.258 ± 0.002 c | 0.324 ± 0.008d |
| **Raipur** | 3.169 ± 0.035c | 1.246 ± 0.001c | 3.532 ± 0.032c | 1.083 ± 0.013 a | 0.755 ± 0.005ab | 0.366 ± 0.003a | 0.393 ± 0.007 b |
| **Bargarh** | 3.199 ±0.033 c | 1.225 ± 0.010 c | 3.553 ± 0.008bc | 1.023 ± 0.016b | 0.747 ± 0.004ab | 0.290 ± 0.004b | 0.456 ± 0.015a |
| **Ludhiana** | 3.461 ±0.040 a | 1.392 ± 0.030 a | 3.675 ± 0.003 a | 1.033 ± 0.013b | 0.725 ± 0.005 bc | 0.285 ± 0.003b | 0.373 ± 0.008bc |
| **S.E (m)** | 0.031 | 0.015 | 0.028 | 0.013 | 0.018 | 0.009 | 0.007 |
| **C.D** | 0.087 | 0.043 | 0.079 | 0.036 | 0.049 | 0.014 | 0.021 |
| **C.V** | 4.8 | 3.5 | 7.2 | 4.0 | 6.4 | 4.9 | 5.0 |

 Values in a column followed by the same letter do not differ significantly by DMRT (*P* = 0.05%)

**Table 3. Morphometrics of brachypterous brown planthopper males collected from different locations**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **BPH****populations** | **Body length (mm)** | **Body width (mm)** | **Wing length (mm)** | **Wing width (mm)** | **Head length (mm)** | **Interocular distance (mm)** | **Tibial Spur****length (mm)** |
| **Glasshouse** | 2.286 ± 0.025cd | 0.859 ± 0.007b | 1.286 ± 0.007b | 0.673 ± 0.012 b | 0.652 ± 0.006c | 0.255 ± 0.004c | 0.365 ± 0.001d |
| **Kampasagar** | 2.322 ± 0.034 c | 0.880 ± 0.008a | 1.244 ± 0.021 b | 0.616 ± 0.004d | 0.729 ±0.002 b | 0.273 ± 0.003b | 0.352 ±0.010d |
| **Gangavathi** | 2.396 ± 0.015 b | 0.852 ± 0.001bc | 0.965 ± 0.003c | 0.636 ± 0.002c | 0.668 ± 0.003c | 0.263 ± 0.001bc | 0.403 ± 0.001c |
| **Raipur** | 2.454 ±0.031 b | 0.840 ± 0.001 c | 1.250 ± 0.025b | 0.671 ± 0.001 b | 0.777 ± 0.002a | 0.262 ± 0.001bc | 0.424 ± 0.010b |
| **Bargarh** | 2.247 ± 0.022d | 0.880 ± 0.001 a | 0.993 ± 0.020c | 0.663 ± 0.004b | 0.649 ± 0.021c | 0.293 ± 0.004a | 0.448 ± 0.010a |
| **Ludhiana** | 2.504 ± 0.021a | 0.891 ±0.001a | 1.459 ± 0.033 a | 0.773 ± 0.005a | 0.663 ± 0.004c | 0.273 ± 0.002b | 0.361 ±0.001d |
| **S.E (m)** | 0.024 | 0.025 | 0.019 | 0.009 | 0.011 | 0.009 | 0.003 |
| **C.D** | 0.066 | 0.012 | 0.052 | 0.011 | 0.030 | 0.012 | 0.009 |
| **C.V** | 4.7 | 1.5 | 7.2 | 4.0 | 5.2 | 6.4 | 5.0 |

 Values in a column followed by the same letter do not differ significantly by DMRT (*P* = 0.05%)

 **Table 4. Morphometrics of macropterous brown planthopper males collected from different locations**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **BPH****Populations** | **Body length (mm)** | **Body width (mm)** | **Wing length (mm)** | **Wing width (mm)** | **Head length (mm)** | **Interocular distance (mm)** | **Tibial Spur****length (mm)** |
| **Glasshouse** | 2.521 ± 0.045bc | 1.011 ± 0.023 b | 3.064 ± 0.068 bc | 1.022 ± 0.004 a | 0.745 ± 0.007b | 0.248 ± 0.001ab | 0.320 ± 0.008a |
| **Kampasagar** | 2.397 ± 0.011d | 1.123 ± 0.041a | 3.026 ±0.043 c | 0.966 ± 0.019bc | 0.685 ± 0.032c | 0.259 ± 0.008a | 0.306 ± 0.006ab |
| **Gangavathi** | 2.481 ± 0.022c | 1.014 ± 0.007 b | 3.077 ± 0.040c | 0.963 ± 0.004 bc | 0.703 ± 0.006 c | 0.241 ± 0.010bc | 0.309 ± 0.010b |
| **Raipur** | 2.697 ± 0.001a | 1.133 ± 0.001 a | 3.149 ± 0.010 ab | 0.871 ± 0.005 d | 0.825 ± 0.017 a | 0.235 ±0.003 c | 0.304 ± 0.012ab |
| **Bargarh** | 2.551 ± 0.017b | 1.090 ± 0.019 a | 3.112 ± 0.014bc | 0.944 ± 0.005 c | 0.693 ± 0.003 c | 0.220 ±0.004 d | 0.278 ± 0.012b |
| **Ludhiana** | 2.496 ± 0.023bc | 1.019 ± 0.001 b | 3.254 ± 0.032a | 0.990 ± 0.005 ab | 0.757 ± 0.004b | 0.239 ± 0.001 bc | 0.301 ± 0.015b |
| **S.E (m)** | 0.025 | 0.018 | 0.039 | 0.012 | 0.008 | 0.007 | 0.011 |
| **C.D** | 0.069 | 0.051 | 0.110 | 0.035 | 0.024 | 0.013 | 0.031 |
| **C.V** | 4.3 | 8.0 | 5.7 | 4.2 | 7.2 | 5.7 | 6.2 |

 Values in a column followed by the same letter do not differ significantly by DMRT (*P* = 0.05%)

 **Table 5. Morphometrics of brown planthoppers nymphs collected from different locations**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **BPH****Populations** | **I instar** | **II instar** | **III instar** | **IV instar** | **V instar** |
|  | **Length** | **Width** | **Length** | **Width** | **Length** | **Width** | **Length** | **Width** | **Length** | **Width** |
| **Glasshouse** | 0.785 ± 0.016a | 0.326 ± 0.003a | 1.093 ± 0.003b | 0.461 ± 0.005 cd | 1.768 ± 0.121 ab | 0.865 ± 0.022 a | 2.411 ± 0.051 a | 0.977 ± 0.027 ab | 2.781 ± 0.040 c | 1.090 ± 0.020 b |
| **Kampasagar** | 0.767 ± 0.036 a | 0.297 ± 0.004 c | 1.098 ± 0.002 b | 0.541 ± 0.004 b | 1.809 ± 0.065 ab | 0.909 ± 0.025 a | 2.380 ± 0.042 ab | 0.935 ± 0.022 abc | 2.774 ± 0.04 c | 1.085 ± 0.054 b |
| **Gangavathi** | 0.716 ± 0.004b | 0.255 ± 0.004 d | 1.098 ± 0.024 b | 0.578 ± 0.001 a | 1.842 ±0.034 a | 0.879 ±0.026 a | 2.215 ± 0.060 b | 0.905 ± 0.031 bc | 2.867 ± 0.121 bc | 1.063 ± 0.023 bc |
| **Raipur** | 0.766 ± 0.008a | 0.290 ± 0.003 c | 1.071 ± 0.029 b | 0.451 ± 0.009 d | 1.789 ± 0.059 ab | 0.833 ± 0.041 a | 2.447 ± 0.094 a | 0.988 ± 0.036 a | 2.941 ± 0.049 ab | 1.162 ± 0.020 a |
| **Bargarh** | 0.773 ± 0.007 a | 0.310 ± 0.013 b | 1.153 ± 0.024a | 0.454 ± 0.011 cd | 1.980 ± 0.136 a | 0.829 ± 0.044 a | 2.219 ± 0.057 b | 0.902 ± 0.024 c | 2.996 ±0.090 a | 1.122 ± 0.020 ab |
| **Ludhiana** | 0.752 ± 0.017 a | 0.290 ± 0.007c | 1.090 ± 0.002 b | 0.465 ± 0.006 c |  1.595 ± 0.080 b | 0.850 ± 0.025 a | 2.333 ± 0.074 ab | 0.876 ± 0.005 c | 2.620 ± 0.073 d | 1.012 ± 0.039 c |
| **S.E (m)** | 0.013 | 0.008 | 0.013 | 0.008 | 0.084 | 0.030 | 0.065 | 0.026 | 0.038 | 0.021 |
| **C.D** | 0.036 | 0.009 | 0.036 | 0.013 | 0.237 | 0.085 | 0.184 | 0.073 | 0.107 | 0.060 |
| **C.V** | 7.3 | 7.1 | 5.4 | 4.8 | 6.1 | 3.2 | 8.8 | 3.1 | 4.7 | 8.3 |

 Values in a column followed by the same letter do not differ significantly by DMRT (*P* = 0.05%)