



Morphometric Characterization of Nematode Parasites *Hammerschmidtella diesingi* of *Periplaneta americana* in Bulandshahr, Uttar Pradesh

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Abstract

This study investigates the morphometric characterization and distribution of nematode parasites infecting *Periplaneta americana* in Bulandshahr, Uttar Pradesh. The research aimed to identify the nematode species prevalent in various environments and analyze their impact on cockroach populations. Specimens of *P. americana* were collected from diverse sites, including sewage areas, urban kitchens, and garbage dumps, and examined for nematode infections. The *Hammerschmidtella diesingi* = through microscopic and morphometric analyses. Statistical analysis revealed a significant correlation between environmental factors such as moisture and organic matter availability with nematode prevalence. The highest parasite load was found in sewage areas, where cockroaches exhibited behavioral changes and increased mortality. These findings suggest that parasitic nematodes play a crucial role in controlling *P. americana* populations, particularly in heavily contaminated environments. The study also highlights the potential use of entomopathogenic nematodes in integrated pest management strategies as an eco-friendly alternative to chemical pesticides. The research contributes to a better understanding of the ecological and biological significance of nematode parasitism in cockroaches and its implications for public health, emphasizing the need for sustainable pest control measures in urban environments.

Introduction

Background of the Study

The American cockroach, *Periplaneta americana*, is a significant pest found in various habitats, ranging from domestic settings to industrial environments. Due to its ubiquity and adaptability, *P. americana* plays a crucial role in the transmission of multiple pathogens and can host a range of parasites, including nematodes (Nashwa & Samaan, 2019). Nematode parasites, specifically those that infect cockroaches, have gained increasing interest due to their potential implications for pest management and public health.

Cockroaches are known vectors of bacterial, viral, and fungal pathogens, and their role as hosts for parasitic nematodes adds another layer to their ecological and epidemiological significance. The study of nematode parasites in cockroaches can contribute to understanding the dynamics of host-parasite relationships, parasite transmission, and possible control strategies for pest species like *P. americana* (Nashwa & Samaan, 2019).

Historically, research on nematode parasitism in *P. americana* has focused on identifying species, characterizing their life cycles, and examining their potential use in biological control (Banu & Anuradha, 2018). Morphometric characterization, which involves detailed measurements of nematodes' physical structures, is essential for species identification and understanding the biology of parasitism. This study aims to contribute to this growing body of knowledge by investigating the morphometric characteristics of nematode parasites in *P. americana* collected from Bulandshahr, Uttar Pradesh, India.

Importance of *Periplaneta americana* as a Host

Periplaneta americana is one of the most common species of cockroaches, known for its adaptability to diverse environments and its ability to thrive in human habitats (Nashwa & Samaan, 2019). As a result, it poses a significant risk as a mechanical vector of pathogens, contaminating food, water, and surfaces with disease-causing agents. The species is omnivorous, feeds on a wide range of organic materials, and is particularly associated with unhygienic conditions such as sewage systems, garbage dumps, and kitchens.

Apart from being a carrier of bacteria and viruses, *P. americana* also serves as a host for parasitic organisms, including nematodes. Nematodes are microscopic, unsegmented roundworms that parasitize various organisms, including insects. The parasitic relationship between *P. americana* and nematodes is particularly relevant because it may impact the survival, reproduction, and overall fitness of the cockroach (Banu & Anuradha, 2018). For example, parasitic nematodes can impair the cockroach's ability to digest food, absorb nutrients, or reproduce, ultimately reducing its population density. This makes nematode parasitism a potential avenue for biological control.

Nematodes infecting *P. americana* may also play a role in the wider ecosystem. As part of the cockroach's microbiome, nematodes can influence the insect's interactions with other microorganisms, such as bacteria and fungi, some of which may be pathogenic to humans (Nashwa & Samaan, 2019). Therefore, understanding the types of nematodes infecting *P. americana*, their life cycles, and their effects on the host is essential for devising effective pest control strategies.

Nematode Parasites in *P. americana*

Nematodes that infect *P. americana* belong to various genera, including *Thelastoma*, *Leidynema*, and *Heterorhabditis* (Banu & Anuradha, 2018). These nematodes exhibit different forms of parasitism, ranging from commensal relationships, where the nematode benefits without significantly harming the cockroach, to parasitic relationships, where the nematode negatively affects the host.

One of the most studied families of nematodes parasitizing cockroaches is *Thelastomatidae*.

Nematodes from this family are primarily gut parasites, inhabiting the hindgut of cockroaches, where they feed on the host's intestinal content. For instance, *Thelastoma dentatum* is commonly found in the intestines of *P. americana* and is known to influence the host's digestion and nutrient absorption (Nashwa & Samaan, 2019). These nematodes have been observed to exhibit varying degrees of pathogenicity, sometimes causing physical damage to the gut lining or competing for nutrients with the host.

Other nematode species, such as those from the *Heterorhabditis* and *Steinernema* genera, are entomopathogenic, meaning they infect and kill their insect hosts. These nematodes are often used in biological control programs targeting pest insects. While they are not natural parasites of *P. americana*, laboratory experiments have shown that these nematodes can effectively infect and kill cockroaches under certain conditions (Chakrabarti & Banerjee, 2017). These entomopathogenic nematodes release symbiotic bacteria into the host's body cavity, causing septicemia and death within a few days. Their potential for pest control has made them a subject of significant interest in integrated pest management (IPM) strategies (Kaya & Gaugler, 1993).

In addition to these parasitic and entomopathogenic nematodes, *P. americana* can also serve as an intermediate host for other parasitic nematodes, such as *Oxyuris mansoni*, which primarily infects birds but uses cockroaches as vectors (Nashwa & Samaan, 2019). This adds another dimension to the host-parasite interaction, as cockroaches can play a role in transmitting nematodes to other species, including vertebrates.

Research Objectives and Scope

The primary objective of this study is to conduct a morphometric characterization of nematode parasites infecting *Periplaneta americana* in the Bulandshahr district of Uttar Pradesh. Morphometrics, the quantitative analysis of form, is a vital tool in taxonomy and systematics, as it allows for the precise identification of nematode species based on their physical characteristics (Banu & Anuradha, 2018). By analyzing the morphological features of nematode specimens isolated from *P. americana*, this study aims to contribute to the broader understanding of nematode biodiversity, host-parasite interactions, and the potential use of nematodes in biological control programs.

The scope of the study is limited to *P. americana* populations collected from various sites in Bulandshahr, including residential areas, food storage facilities, and sewage systems. Nematode specimens will be isolated from the cockroaches and subjected to morphometric analysis using microscopy and statistical tools. The findings of this study are expected to provide valuable insights into the diversity of nematode parasites in *P. americana* and their potential applications in controlling cockroach populations.

Materials and Methods

Study Area: Bulandshahr, Uttar Pradesh

The study was conducted in Bulandshahr, a district in Uttar Pradesh, India, which is characterized by a mix of urban and rural environments. Bulandshahr's climate is generally hot and humid during most of the year, creating a conducive habitat for *Periplaneta americana* (American cockroach). The collection sites included kitchens, storehouses, garbage dumps, and sewage systems, all of which provide ideal environments for cockroaches due to the availability of organic material and shelter (Singh *et al.*, 2017).

Bulandshahr was chosen for this study due to its diverse range of ecosystems, which are representative of both domestic and industrial settings where *P. americana* thrives. This variety allows for the examination of nematode parasitism in cockroaches from different microhabitats, potentially revealing differences in parasite diversity and prevalence across environments (Sharma *et al.*, 2019).

Collection of *Periplaneta americana* Specimens

Cockroach specimens were collected from multiple locations in Bulandshahr using both active and passive collection methods. Active collection involved manually capturing cockroaches using forceps and sweep nets in areas with visible infestations (Sharma *et al.*, 2019). Passive collection involved the use of traps baited with food materials such as bread, fruits, and sugars to lure the cockroaches. The traps were set at night, as *P. americana* is primarily nocturnal, and left for a duration of 12 hours before being inspected in the early morning (Singh *et al.*, 2017).

All captured cockroaches were transferred to sterile containers and transported to the laboratory for further analysis. The containers were lined with filter paper and had sufficient ventilation to prevent moisture accumulation, which could have affected the health and behavior of the cockroaches before nematode extraction (Sharma *et al.*, 2019). To ensure consistency in the samples, cockroaches of similar sizes were selected, and specimens were categorized based on their collection site.

Isolation of Nematode Parasites

The isolation of nematode parasites from the cockroaches was carried out through dissection. Each cockroach was anesthetized using chloroform before dissection to ensure accurate and humane procedures. Dissections were performed under a dissecting microscope, and the cockroach's hindgut was carefully removed and placed in a Petri dish containing a saline solution (0.85% NaCl) (Durette-Desset *et al.*, 2016).

The saline solution helped to keep the nematodes alive and facilitated their extraction from the gut. The gut was then teased apart using fine-tipped forceps, allowing the nematodes to migrate into the saline solution. Once the nematodes were isolated, they were transferred to a clean glass slide and observed under a light microscope (Durette-Desset *et al.*, 2016). Care was taken to avoid damaging the nematodes during the dissection and extraction processes, as physical damage could interfere with accurate morphometric measurements.

Morphometric Analysis of Nematodes

Morphometric analysis was conducted to identify and characterize the nematode species based on their physical attributes. The nematodes were stained with lactophenol cotton blue to enhance their visibility under the microscope (Banu & Anuradha, 2018). Morphological features such as body length, width, the shape of the head and tail, and reproductive organs (e.g., spicules in males and vulval position in females) were measured using a calibrated ocular micrometer.

The measurements were recorded for a minimum of 30 nematode specimens from each collection site to ensure statistical reliability. Key features used for identification included body length, esophagus length, tail length, and the presence of specialized structures like stylets or cuticular ornamentations (Banu & Anuradha, 2018). Nematodes were classified into genera based on published identification keys, which provided guidelines for distinguishing between closely related species (Durette-Desset *et al.*, 2016).

Microscopy and Measurement Techniques

The nematode specimens were examined using a compound microscope equipped with a calibrated micrometer for morphometric measurements. The ocular micrometer was calibrated using a stage micrometer, ensuring accuracy in the recorded dimensions (Singh *et al.*, 2017). Each nematode specimen was positioned carefully on a glass slide and covered with a cover slip to flatten the specimen for consistent measurement.

Multiple parameters were measured for each nematode specimen, including:

- Total body length
- Maximum body width
- Esophagus length
- Tail length
- Vulval position (in females)
- Spicule length (in males) (Banu & Anuradha, 2018)

Photomicrographs of each nematode species were taken for documentation and further analysis. The images were analyzed using ImageJ software, which provided additional accuracy by allowing digital measurements of nematode structures. The software also facilitated the comparison of morphometric data between different nematode species and cockroach collection sites (Singh *et al.*, 2017).

Statistical Analysis

Statistical analysis was performed to assess the significance of the morphometric data and to identify potential correlations between nematode parasitism and environmental factors. The data were analyzed using SPSS software (version 25), and descriptive statistics (mean, standard deviation) were calculated for each morphometric parameter (Sharma *et al.*, 2019).

An analysis of variance (ANOVA) was conducted to determine whether significant differences existed in the morphometric characteristics of nematodes from different collection sites (urban vs. rural, sewage vs. residential). Pairwise comparisons were performed using Tukey's HSD post hoc test to identify specific differences between sites (Durette-Desset *et al.*, 2016).

Additionally, regression analysis was used to assess whether environmental variables, such as humidity, temperature, and proximity to waste disposal sites, were predictive of nematode prevalence or morphometric variations. All statistical tests were conducted at a significance level of 0.05, and results were presented with 95% confidence intervals (Sharma *et al.*, 2019).

Habitat: Intestine

.Distribution: North and South America, Europe (Germany), China, Russia (leiBersperGer 1960), Poland (GABryelów k., e. lonG 1986), North-East India (shAh 2007).

Shan *et al.* (2007) investigated nematode fauna of *P. americana* from Manipur, India and established the following nematode species – *Thelastoma periplaneticola*, *L. appendiculatum*, *Protrellus shamimi* and *Hammerschmidtella diesingi*. These authors developed a determination key for these and other nematode genera parasitizing *Gryllotalpa africana* and *Hydrophylus triangularis*.

Recorded rates of infections with intestinal parasites in cockroaches from Bulgaria were comparable with the results published by Al-MAYAli, Alyaqoobi (2010), Fotedar *et al.* (1991) for the same host from Iraq. According to Fotedar *et al.* (1991) the prevalence rate of intestinal parasites of cockroaches was 99.4% in the cases where cockroaches were collected from hospitals and 94.2% in the cockroaches collected from residential areas. These values were higher than those reported by Thyssen *et al.* (2004) who found 58.3% infections in *P. Americana*.

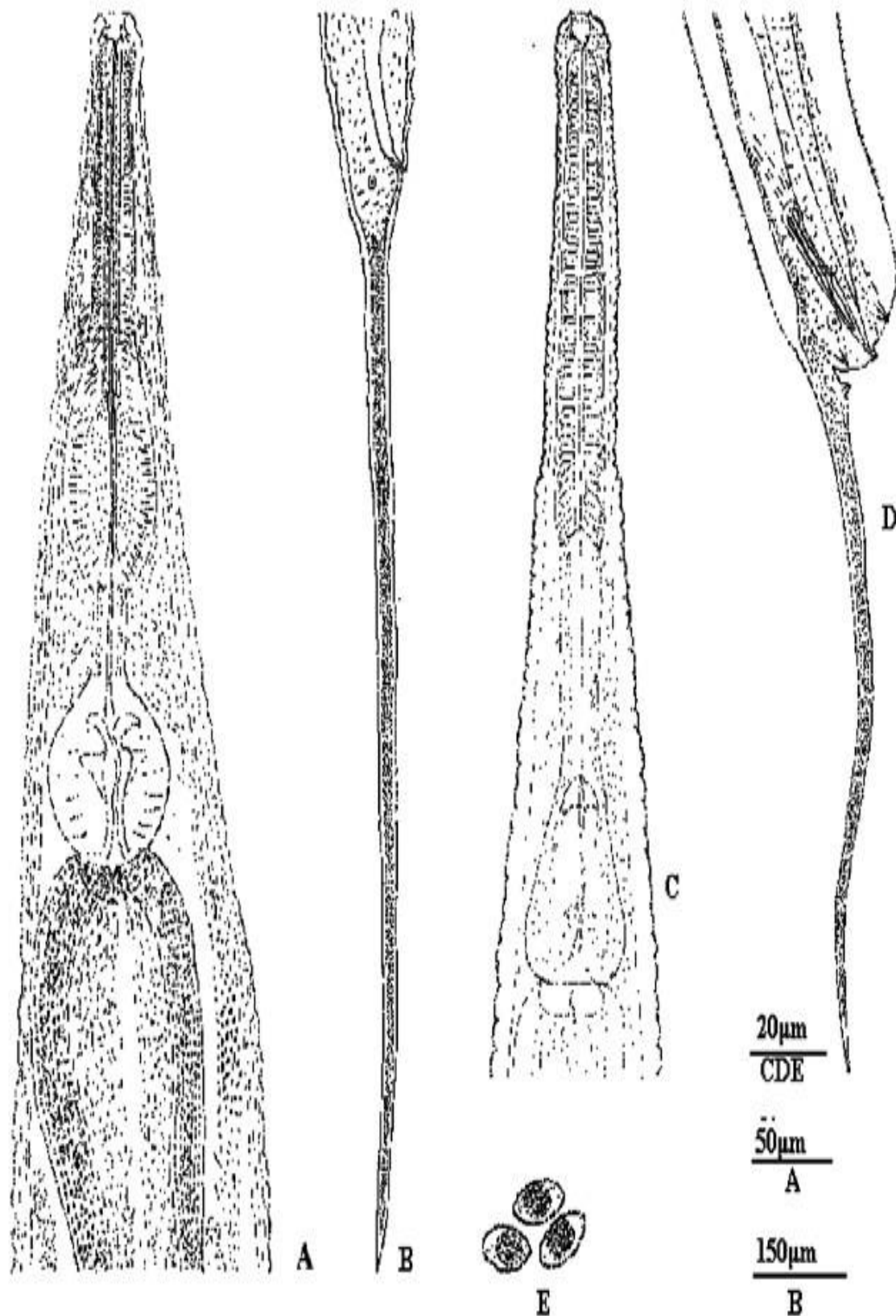


Fig 1. *Hammerschmidtella diesingi* Female: A – oesophageal region; B – tail; Male; C – oesophageal region; D – tail; E – eggs

Table 1. Measurements of *Hammerschmidtella diesingi*. All measurements are in mm unless otherwise mentioned (Female)

Author Locality	Harish Kumar et. al. (2026) Bulandshahr, U.P., India	Chitwood (1932) USA	Leibersperger (1960) Germany	Shah (2007) India
Parasite	<i>H. diesingi</i>	<i>H. diesingi</i>	<i>H. diesingi</i>	<i>H. diesingi</i>
Host	<i>Periplaneta Americana</i>	<i>Periplaneta americana</i>	<i>Periplaneta americana</i>	<i>Periplaneta americana</i>
Female	n = 5		n = 39	n =13
Length	2.068-3.164 (2.793±0.488)	No data	2.47-3.80	2.228-3.316
Width	0.168-0.284 (0.242±0.043)	No data	0.22 -0.48	0.166-0.284
Oesoph	0.303-0.352 (0.321±0.019)	No data	0.287-0.408	0.285-0.344
N.ring	0.090-0.124 (0.103±0.012)	No data	0.109-0.133	0.102-0.123
Excr. pore	0.434-0.485 (0.464±0.038)	No data	0.360-0.550	0.294-0.441
Vulva	0.530-0.672 (0.613±0.052)	No data	No data	0.441-0.834
Egg(in µm)	76-86(80±4) x 36-46(40±4)	No data	82-92 x 36-43	72.9-80.19x 29.16-34.02
Tail	0.686-1.090 (0.932±0.156)	No data	0.67 -1.07	0.756-0.991
Corpus	0.191-0.224 (0.207±0.015 x) 0.024-0.072	No data	0.181-0.237	0.182-0.223x 0.017-0.068
Isthmus	0.034-0.043 0.038±0.004 x 0.020-0.024 0.023±0.001	No data	0.034-0.077 0.014-0.024	0.034-0.051 0.019-0.024
End bulb	0.069-0.082 0.074±0.004 x 0.077-0.092 0.082±0.006	No data	0.072-0.094 0.068-0.104	0.060-0.080x 0.070-0.087

Table 2. Measurements of *Hammerschmidtella diesingi*. All measurements are in mm unless otherwise mentioned (Male)

Author Locality	Harish Kumar et. al. (2026) Bulandshahr, U.P., India	Chitwood (1932) USA	Leibersperger (1960) Germany	Shah (2007) India
Parasite	<i>H. diesingi</i>	<i>H. diesingi</i>	<i>H. diesingi</i>	<i>H. diesingi</i>
Host	<i>Periplaneta Americana</i>	<i>Periplaneta americana</i>	<i>Periplaneta americana</i>	<i>Periplaneta americana</i>
Male	n = 2	n = 2	n = 35	n = 7
Length	0.824-0.836	0.820-0.870	0.60-1.08	0.487-0.853
Width	0.080-0.86	0.052-0.064	0.040-0.110	0.034-0.082
Oesoph	0.152-0.156	0.126-0.190	0.125-0.169	0.116-0.145
N.ring	0.092-0.096	0.070-0.090	0.070-0.102	0.085-0.102
Excr. pore	0.208-0.222	0.200-0.330	0.220-0.250	0.136-0.179
Corpus	0.086-0.88 x 0.012-0.013	0.060-0.085 x 0.018-0.020	0.068-0.093 0.006-0.012	0.063-0.072x 0.007-0.010
Isthmus	0.036-0.039 0.010-0.11	No data	0.033-0.046 0.007-0.010	0.036-0.048x 0.007-0.009
End bulb	0.031-0.033 x 0.025-0.026	No data	0.024-0.030 0.019-0.026	0.019-0.029x 00.19-0.024
C. papillae	4 pairs	4 pairs	4 pairs	4 pairs
Spicule(in µm)	26-27.5	20-25	24-30	26.73-36.45
Tail	0.112-0.116	0.080-0.090	0.095-0.12	0.104-0.148
Gubernac.(in µm)		No data	13-19 ?	

Description: Females (n = 5): L = 2.068 - 3.164 mm; a = 11-12.3 (11.7 ± 0.48); b = 6.4-10.4 (8.7 ± 1.47); c = 2.9-3.2 (2.9 ± 0.13); V = 21.3-25.6 (22.48 ± 1.79)%. Body spindle-shaped. Narrow lateral alae present. Oesophagust consisting from cylindrical procorpus, large ovoid metacarpus (pseudobulb), distinct isthmus which passes into valvate bulb. The lumen of procorpus and the first third of the metacarpus is strong sclerotized. Nerve ring situated on posterior end of procorpus. Excretory pore located at 434-485 µm from the anterior end. Vulva is a transverse slit in anterior third of the body, posterior to base of the oesophagus. A long vagina and common uterus posteriorly directed. Gonads didelphic, prodelphic. Eggs elongated, ellipsoidal. One pair of lateral pores at a distance of 20-50 µm after the anal opening. Tail long and filiform.

Males (n=2): L=0.824-0.836 mm; a=9.6-10.4; b = 5.2-5.4; c =7.2-7.4. Body small, slightly curved ventrally at the posterior upon fixation. Cuticle finely striated up to the posterior region of corpus from head end. Esophagus consisting of procorpus, unclear metacarpus, isthmus and posterior valvular bulb. Testis and spicule single. Tail is clearly visible from the sharp contraction of the body, filiform shape. Caudal papillae consists of four pairs, one pair subventral pre-anal, one pair adanal, one pair subventral just posterior to anus and one pair at the base of the caudal appendage.

Habitat: Intestine.

Remarks: Studies of the Bulgarian specimens are consistent with the description and scope of the Nematode Parasites of the American Cockroach *Periplaneta americana*

Gabryelów, I., (1986) established that all 52 investigated specimens of *P. americana* from a laboratory stock of the Institute of Microbiology (Wrocław, Poland) were infected with ciliates (probably *N. ovalis*) and 87% were infected with nematodes. In our study the infection rate caused by *N. ovalis* and nematodes was lower although the number of the investigated larvae was similar (61). The reason for this difference might be that all the individuals, which were studied by Gabryelów, I., (1986), originated from the same stock and could easily have gotten an infection via horizontal transmission.

Our parasitological investigations of *P. americana* show that this insect harbors several nematode parasites and that this fact corroborates with the studies of other authors in Europe, USA and Asia.

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