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Research Article

RESPONSES OF GROUND-DWELLING ANT BEHAVIOR AND NESTING PATTERNS IN PREDICTION OF MONSOON SEASON IN AND AROUND NAGPUR CITY, MAHARASHTRA, INDIA

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ABSTRACT

Ants play a crucial role in the ecosystem, showing species-specific variations in their behavioral responses according to climatic conditions. This study focused on ground-dwelling ant species behaviors and the building of nests before monsoon rains in Nagpur City, Maharashtra, India. The study was carried out from March 2025 to June 2026 during the pre-monsoon and monsoon seasons across various habitats of ant species such as gardens, farmland, open areas, and residential neighborhoods. The recorded eight ant species, including *Camponotus compressus*, were the most abundant (25.6%), followed by *Solenopsis geminata* (18.5%), *Paratrechina longicornis* (16.2%), and *Monomorium pharaonis* (12.6%).and *Tapinoma melanocephalum* (12.2%). The species-specific behaviors of ants studied during the dry days under nest modification, transporting brood, relocating colonies, increased foraging, and reproductive flights before monsoon rainfall. Also, the ant nest mound height increased from April to May, and brood transport occurred in 72% of the monitored colonies before the pre-monsoon season. There was a strong positive link between ant activity and relative humidity, even in and around Nagpur city. The behavioral responses of ants observed before the heaviest rainfall suggest that ants may act as biological indicators for the arrival of the monsoon season and forecasting of whether, as per the traditional knowledge. These findings indicated that ground-dwelling ants could be valuable for ecological forecasting and monitoring environmental changes.

Keywords: Ant behavior, Monsoon prediction, Ground-dwelling ants, Bioindicators, Monsoon.

INTRODUCTION

The Indian monsoon is a major climatic phenomenon influencing agriculture, biodiversity, ecosystem productivity, and human livelihoods. Reliable prediction of rainfall remains essential for sustainable agricultural planning and ecological management. In addition to meteorological methods, biological indicators have long been used by local communities to anticipate seasonal weather changes. Ants are highly organized social insects whose activities are strongly influenced by environmental conditions such as temperature, humidity, soil moisture, and rainfall. Variations in these factors often trigger changes in foraging, nesting, brood care, and reproductive behavior. Because ants respond rapidly to environmental fluctuations, they are considered valuable bioindicators of ecosystem conditions and climatic variability. Ants are among the most abundant and ecologically significant groups of terrestrial insects and play important roles in nutrient cycling, soil modification, seed dispersal, and ecosystem functioning. Due to their sensitivity to environmental conditions, ants have been widely recognized as useful bioindicators of habitat quality, ecological disturbance, and climatic variation (Andersen, 1997; Andersen and Majer, 2004). Recent studies have further emphasized the value of ant communities for environmental monitoring, demonstrating that ant behavior and community composition respond rapidly to changes in temperature, humidity, land-use patterns, and habitat disturbance (Andersen, 2021; Akhila and Keshamma, 2023). Environmental factors associated with monsoon systems, particularly humidity and soil moisture, can strongly influence ant activity. Changes in foraging

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intensity, nest architecture, brood care, and reproductive behavior have been reported in response to climatic variability and environmental stress (Bishop *et al*., 2021; Chen and Neoh, 2023). Ant nest-building activities may also modify soil properties and contribute to ecosystem processes, highlighting the ecological importance of behavior adaptations in response to changing environmental conditions (Phillips and Slocum, 2021; Shi *et al*., 2023). Although traditional communities in India have long considered ant behavior as a predictor of rainfall, scientific investigations examining the relationship between ant activity and monsoon forecasting remain limited (Rohiwal *et al*., 2025). Previous studies have demonstrated that ant communities respond to changes in habitat quality, moisture availability, and environmental disturbance (Andersen, 1997; Andersen and Majer, 2004). However, limited information is available regarding the role of ground-dwelling ants as indicators of approaching monsoon conditions in central India. Therefore, the present study was undertaken to investigate behavioral and nesting responses of ground-dwelling ants before monsoon rainfall in and around Nagpur City to evaluate their potential as biological predictors of monsoon onset.

MATERIALS AND METHODS

Study Area

The present study was conducted in and around Nagpur City, Maharashtra, India, located in central India. The central area shows tropical climatic conditions characterized by hot summer from the month of March to May and seasonal monsoon rainfall from June to September. All the observations were noted from April to July, encircling the pre-monsoon and early monsoon periods.

Sampling Sites

The field study and observations of ground-dwelling ants at selected study areas represented different habitat types, including urban gardens, agricultural fields, residential areas, and in open grasslands. The selected ant colonies were identified and monitored throughout the study period before the pre-monsoon. All the Ground-dwelling ants were observed and identified at regular intervals using a Stereo Zoom Microscope, using standard taxonomy keys with field characteristics. Particular attention was given to behavior activities occurring before rainfall events. The parameters such as Nest mound height, Number of active nest openings, Soil deposition around nest entrances, brood transportation, foraging activity, colony relocation, reproductive activity, relative humidity and rainfall occurrence were studied in and around Nagpur City (Figure 1).

Data Analysis

Descriptive statistics were used to summarize behavior observations. Correlation analysis was employed to examine the relationship between ant activity and environmental variables. Rainfall prediction success was calculated based on the occurrence of behavioral indicators before monitored rainfall events.

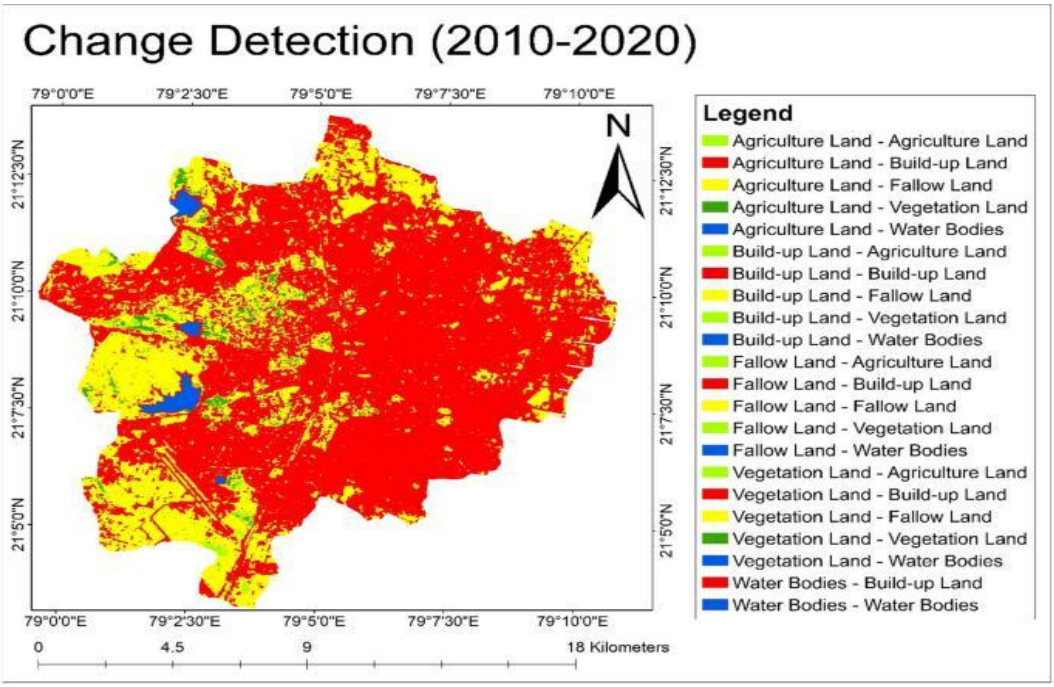

Figure 1. Geo map study of Nagpur city and surrounded vegetation.

RESULTS AND DISCUSSION

In the present study, five ground-dwelling species of ants were recorded during the study period. *Camponotus compressus* was the most abundant species (25.6%), followed by *Solenopsis geminata* (18.5%), *Paratrechina longicornis* (16.2%), *Monomorium pharaonis* (12.6%).and *Tapinoma melanocephalum* (12.2%) (Table-1). In the present study, significant modifications in nest architecture were observed before rainfall (Figure photos from 1-5). The ground-dwelling ants show the following changes before the pre-monsoon, causing certain changes in nesting and behavior patterns. Nesting Pattern: Nest entrances became narrower, and fresh soil accumulation increased considerably. Mean nest mound height increases less in comparison during the dry summer condition before the pre-monsoon period (Table-2). The higher of the ant nest heights indicated greater nest-modification activity before monsoon rainfall. C*amponotus compressus* and *Solenopsis geminata* exhibited the greatest increases in mound height, suggesting stronger adaptation to anticipated flooding. *Monomorium pharaonis* and *Tapinoma melanocephalum* showed comparatively smaller increases in nest elevation. Increased nest height is associated with flood prevention, brood protection, maintenance of nest humidity, and improved colony survival during the rainy season. Brood Transportation: The colony workers of several species are transporting larvae and pupae from lower chambers to elevated nest sections. Brood relocation occurred in approximately 72% of monitored colonies and was particularly evident in *Camponotus compressus* and *Solenopsis geminate* Foraging Behavior: Foraging activity increased substantially before rainfall events. Ants collected larger quantities of food resources and extended foraging trails. Worker movement increased by approximately 42% during the week preceding rainfall. Reproductive Activity: Winged reproductive individuals were observed during humid conditions associated with monsoon onset. Nuptial flights occurred shortly after the first substantial rainfall events, indicating favorable environmental conditions for colony establishment. Relationship with Environmental Factors: Monsoon Prediction characteristic behavioral responses were observed before 17 of 20 monitored rainfall events, resulting in a prediction accuracy of approximately 85% (Table 2).

Table 1. Shows the scientific names, appearance, and size of the ant types commonly observed in and around Nagpur before the pre-monsoon season.

S. No	Subfamily	Common Name	Scientific Name	Appearance	Queen size (mm)	Male size (mm)	Worker /Female size (mm)
1	Formicinae	Black Carpenter Ant	*Camponotus compressus*	Large black ant (8–15 mm)	16–17	10–13	5–15
2	Myrmicinae	Fire Ant	*Solenopsis geminata*	Red ant from soil mound, painful sting	7.5–8.5	5–6	3–8
3	Formicinae	Crazy Ant	*Paratrechina longicornis*	Fast erratic runner	4–5	2.5–3	2.3–3
4	Myrmicinae	Pharaoh Ant	*Monomorium pharaonis*	Tiny yellow-brown indoor urban ant	4–5	2.8–3.2	2–2.5
5	Dolichoderinae	Ghost Ant	*Tapinoma melanocephalum*	Tiny pale ant indoors in an urban area	3.5–5	2–3	1.3–1.8

Black Carpenter Ant; *Camponotus compressus* (one of the most common carpenter ants in India)

Tropical Fire Ant: *Solenopsis geminata*

Crazy Ant: *Paratrechina longicornis*

Pharaoh Ant: Monomorium pharaonis

Ghost Ant: *Tapinoma melanocephalum*

Figure 1-5. Study on Ground-dwelling Ants Nest variations before pre-monsoon season in and around Nagpur city.

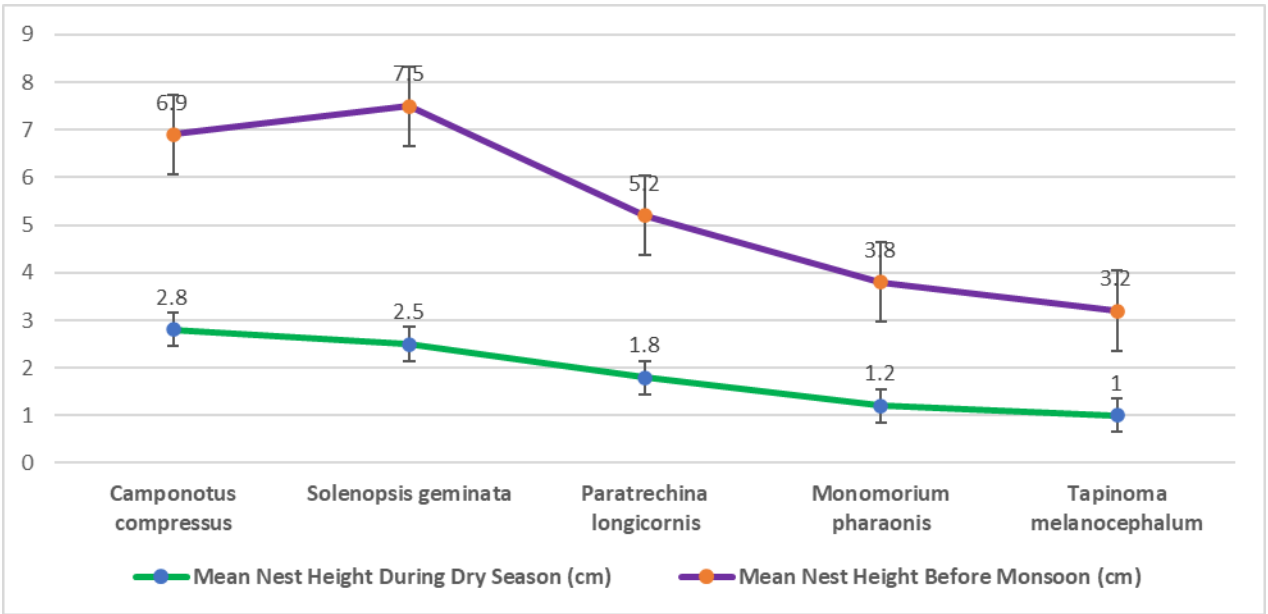

Figure 6. Study on Seasonal Species-wise Variations in the relative height of ground-dwelling ant nests in and Around Nagpur city.

Table 2. Study on Relative behavioral responses of selected Ant species to pre-monsoon environmental conditions.

S. No	Scientific Name	Nesting Responses	Brood Transportation & Relocation	Foraging Behavior	Reproductive Activity	Monsoon Bio-Indicator	Relative Humidity Response
1	*Camponotus compressus*	+++++	++++	+++++	+++	+++++	+++++
2	*Solenopsis geminata*	+++++	++++	++++	+++++	++++	++++
3	*Paratrechina longicornis*	+++++	+++	++++	+++	++++	+++
4	*Monomorium pharaonis*	+++	+++	+++++	+++++	+++	+++
5	*Tapinoma melanocephalum*	+++	+++	++	++	+++	+++

(Abb + = Low, ++ = Fair, +++ = Moderate, ++++ = High, +++++ = Very High)

The present study demonstrated that ground-dwelling ants exhibit predictable behavioral responses before monsoon rainfall. Nest modification, brood transport, relocation behavior, and increased foraging activity appear to be adaptive strategies that improve colony survival under changing environmental conditions. The Indian monsoon is a dominant climatic phenomenon that regulates environmental conditions across much of the Indian subcontinent. The seasonal rainfall associated with the monsoon influences temperature, humidity, soil moisture, and vegetation growth, thereby affecting the distribution and behavior of many terrestrial organisms (Gadgil, 2018). Ants possess a high degree of behavioural

flexibility, allowing colonies to modify foraging schedules, nesting patterns, and resource allocation strategies under changing climatic conditions (Bishop *et al*., 2021). Such responses may be particularly important in regions influenced by seasonal monsoon systems, where sudden changes in humidity and soil moisture can affect colony survival. The increase in nest mound height and soil deposition around nest entrances likely serves to reduce the risk of flooding and maintain suitable microclimatic conditions within the nest. Similar adaptive nest-building responses have been reported in tropical ant species exposed to seasonal rainfall (Hölldobler and Wilson, 1990). Nest modification and soil accumulation around nest entrances were among the most prominent responses recorded during the study. Ant nest construction is known to influence soil structure, aeration, and nutrient distribution, and recent studies have demonstrated that nest-building activities can significantly alter soil properties and associated microbial communities (Phillips and Slocum, 2021; Shi *et al*., 2023). Therefore, behaviour responses associated with monsoon preparation may have ecological consequences extending beyond colony protection. Brood transportation was frequently observed before rainfall events and represents an important protective mechanism against excessive moisture and nest inundation. Such behavior reflects the ability of ant colonies to respond proactively to environmental changes and safeguard vulnerable developmental stages (Wilson, 1971). The increased foraging activity observed before rainfall events may reflect a colony-level adaptation to anticipated reductions in food availability during prolonged wet conditions. Similar changes in foraging behaviour have been reported in urban and natural habitats where environmental conditions influence resource acquisition and worker activity (Chen and Neoh, 2023). The accumulation of food reserves before adverse weather conditions likely enhances colony resilience and contributes to long-term survival.

The strong relationship between ant activity and humidity suggests that atmospheric moisture acts as an important environmental cue. Increased foraging activity before rainfall may allow colonies to accumulate food reserves before adverse weather conditions limit external activities. Similar patterns have been documented in social insects inhabiting moisture-sensitive environments (Kaspari and Weiser, 2000). The observation that behavioral responses preceded 85% of rainfall events supports the hypothesis that ants can function as biological indicators of impending monsoon conditions. Although these indicators should not replace meteorological forecasting systems, they may act as a traditional complement to conventional approaches by providing locally relevant ecological information. The high prediction success rate observed in this study supports the growing recognition of ants as valuable ecological indicators. Recent reviews have highlighted the usefulness of insects, particularly ants, in environmental monitoring and ecosystem assessment because of their rapid responses to environmental change (Akhila and Keshamma, 2023). Furthermore, investigations conducted in diverse ecosystems have demonstrated that ant communities respond predictably to climatic disturbances and habitat alterations, reinforcing their suitability for biomonitoring applications (Andersen, 2021; Fernando *et al*., 2025). The present findings, provide additional evidence that behaviour observations of ground-dwelling ants may serve as practical and cost-effective tools for monitoring environmental conditions associated with monsoon development. So the present study, incorporating climatic data and species-specific behaviour analyses, will help improve the reliability of biological forecasting methods and contribute to a better understanding of insect responses to climate variability.

CONCLUSION

Ground-dwelling ants in and around Nagpur City displayed consistent behavioral and nesting responses before

monsoon rainfall. Nest modification, brood transportation, relocation behavior, increased foraging activity, and reproductive flights were among the most prominent responses observed. These activities showed strong associations with increasing humidity and approaching rainfall events. The high frequency with which behavior changes preceded rainfall suggests that ant colonies may serve as reliable biological indicators of monsoon onset. Further long-term investigations across diverse habitats and climatic regions are recommended to validate the use of ant behavior in ecological forecasting and environmental monitoring programs.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

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AI TOOL DECLARATION

The authors declares that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

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