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Toxicity and Repellency of *Artemisia scoparia* Essential Oil and Leaf Powder Against the German Cockroach (*Blattella germanica*)

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ABSTRACT

The German cockroach, Blattella germanica, is among the most prevalent urban pests and presents considerable public health risks through food contamination and pathogen transmission. Growing resistance to synthetic insecticides and environmental safety concerns have increased interest in plant-based alternatives for cockroach management. This study assessed the insecticidal toxicity of essential oil and the repellent activity of plant powder derived from Artemisia scoparia against B. germanica under laboratory conditions. Essential oil was extracted from fresh leaves by hydro-distillation using a Clevenger apparatus, yielding 0.6 ± 0.1% (v/w). Contact toxicity was measured using the CDC bottle bioassay at concentrations of 1-10% (v/v), while repellency of plant powder (1-5% w/w) was evaluated with a three-chamber choice apparatus. Mortality increased significantly with both concentration and exposure time. Higher concentrations (7-10%) induced rapid knockdown, resulting in 100% mortality within 30-45 minutes, whereas lower concentrations required longer exposure to achieve similar outcomes. Lethal concentration analysis indicated a pronounced time-dependent increase in toxicity, with LC_{50} decreasing from 6.98% at initial exposure to 0.73% after 60 minutes. In repellency assays, A. scoparia powder demonstrated strong behavioural deterrence, with repellency ranging from 83-100% and complete avoidance observed at 4-5% concentrations within 12 hours. These results indicate that A. scoparia exhibits both rapid insecticidal and potent repellent properties against B. germanica. The findings underscore the potential of this plant as an eco-friendly and locally available botanical agent for integrated pest management programs targeting urban cockroach infestations. Further research involving chemical characterization and field evaluation is recommended to facilitate the development of practical formulations.

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INTRODUCTION

The German cockroach (*Blattella germanica*) is recognized as one of the most prevalent household pests globally (Tang et al., 2024). Adults typically range from 1.3 to 1.6 cm in length (Schal et al., 2011). This species is extensively distributed in urban environments and frequently inhabits homes, offices, restaurants, food processing facilities, hotels, and healthcare institutions (Fan et al., 2022). Infestations present significant public health risks due to food contamination, transmission of pathogenic microorganisms, and the induction of allergic reactions in humans (Ma et al., 2024).

The German cockroach demonstrates considerable adaptability and is primarily nocturnal, though it may be observed during daylight hours when populations are dense or disturbed (DeMark & Bennett, 1994). These omnivorous scavengers are attracted to foods

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high in fats, sugars, and proteins (Cooper & Schal, 2019). In the absence of preferred food sources, they may consume non-food household materials such as soap, toothpaste, and glue (Tang et al., 2024). Beyond food contamination, cockroaches can transmit bacteria responsible for diseases including typhoid fever and diarrhoea (Geng et al., 2025).

Traditional cockroach control methods depend largely on synthetic insecticides. The extensive application of these chemicals has led to environmental contamination, health risks, and the emergence of insecticide resistance (Geng et al., 2025). As a result, there is growing interest in plant-based insecticides as safer and more environmentally sustainable alternatives (Manzanares-Sierra et al., 2025).

Botanical insecticides, which are derived from plant materials, are biodegradable, locally accessible, and generally cost-effective (Mukhtiar et al., 2025). Numerous plant species produce secondary metabolites that possess insecticidal, repellent, and antifeedant properties (Pavela et al., 2025). Plant families including Rutaceae, Asteraceae, Lamiaceae, Meliaceae, and Annonaceae have been identified as sources of compounds with potent insecticidal activity (Pavela et al., 2025).

Artemisia scoparia, commonly referred to as red-stem wormwood, is a herbaceous plant in the family Asteraceae. This species is widely distributed across Asia and other temperate regions and has a longstanding history of use in herbal medicine (Ding et al., 2021). Phytochemical analyses indicate that *Artemisia* species contain diverse biologically active compounds, such as essential oils, flavonoids, terpenoids, and phenolic acids. These compounds have demonstrated antimicrobial, antifungal, insecticidal, and repellent properties, positioning this genus as a promising source for botanical pesticide development (Diab et al., 2025).

Species within the genus *Artemisia* are recognized for producing multiple bioactive compounds with both medicinal and pesticidal properties. For instance, *Artemisia annua* has demonstrated antibacterial, anti-inflammatory, antimalarial, and insecticidal activities (Sangeetha & Padmavathi, 2025). Additionally, research indicates that plant extracts from *Artemisia* species exhibit antifeedant and repellent effects against a range of insect pests (Yang et al., 2024).

Several studies have demonstrated the efficacy of plant-derived extracts and essential oils against a range of cockroach species, with certain botanical formulations significantly surpassing synthetic repellents such as DEET in performance (Passara et al., 2025). Oils extracted from *Azadirachta indica*, *Ocimum basilicum*, and *Cymbopogon citratus* have exhibited toxic, repellent, and growth-inhibiting effects on cockroach populations (Manzanares-Sierra et al., 2025). These botanical products typically contain bioactive compounds, including terpenoids, phenolics, and alkaloids, which disrupt insect physiology, behaviour, or feeding activity (Diab et al., 2025).

Due to their biodegradability and relatively low toxicity to humans, plant-based insecticides are increasingly regarded as viable alternatives to synthetic chemicals. Integrated Pest Management (IPM) strategies now prioritize these biological tools to address global demands for residue-free food production and improved environmental safety (Marrone, 2025). Although *Artemisia annua* and related species have been investigated for their effects on various pests, no published research has specifically assessed the efficacy of *A. scoparia* essential oil or powder against *Blattella germanica*. Consequently, the objective of this study is to evaluate the toxicity of *A. scoparia* essential oil and the repellent properties of its plant powder against *Blattella germanica* under laboratory conditions.

MATERIALS AND METHODS

Collection and Rearing of Insects

Blattella germanica nymphs and adults were collected from dark home storage areas and identified using morphological characteristics. Twenty pairs were placed in 40 L plastic bins containing 500 g of breadcrumbs and biscuits as food. Cellulose materials such as paper, cardboard, and human hair were supplied as harbourage to replicate preferred environmental conditions. Water was supplied in cotton-plugged

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vials. Containers were maintained at 28 ± 2°C, 65 ± 5% relative humidity, and a 12:12 hour light to dark photoperiod. Females deposited oothecae within 5 days, and eggs hatched after approximately 50 days. Nymphs were collected at three weeks of age for experiments, while adults were discarded.

Collection and Preparation of Plant Material

Fresh leaves of *Artemisia scoparia* were collected from a home garden in Katsina, Nigeria. Species identification was confirmed by a botanist in the Department of Biology, Umaru Musa Yar'adua University.

Plant powder preparation: Fresh leaves were thoroughly washed with distilled water to remove debris and shade-dried for 7 days until fully desiccated. The dried leaves were ground using a laboratory blender (Model MX-795, Kenwood, USA) and sieved through a 0.5 mm mesh to obtain a fine powder. The resulting powder was stored in airtight, labelled containers at room temperature until use.

Essential oil extraction: Essential oil from *A. scoparia* was extracted by hydro-distillation of fresh aerial parts, following standardized techniques for the *Artemisia* genus that serve as benchmarks for oil yield and quality (Azzam & Obaid, 2025). Fresh leaves were cut into pieces of approximately 2 cm², and 100 g of the material was placed in a 1000 mL round-bottom flask containing 500 mL of distilled water.

Extraction was conducted for 4 hours at 100°C using a Clevenger-type apparatus (Clevenger, 1928). The resulting water vapor containing volatile oil was condensed and collected. The oil was dried over anhydrous sodium sulfate (Na_2SO_4) to remove residual moisture and stored in airtight amber glass vials at 4°C until further use. The percentage yield was calculated using the following formula:

Percentage yield was calculated as:

$$Yield(\%) = \frac{Volume\ of\ oil\ obtained\ (mL)}{Weight\ of\ plant\ material\ (g)} \times 100$$

The mean yield was determined to be 0.6 ± 0.1% (v/w).

Toxicity Bioassay (CDC Bottle Assay)

Contact Toxicity: The contact toxicity of *A. scoparia* essential oil was assessed using the CDC bottle bioassay, a validated method for determining time-mortality relationships and evaluating insecticide resistance and toxicity in *B. germanica* (Gondhalekar et al., 2023). Stock solutions of the essential oil were prepared in absolute ethanol to obtain concentrations ranging from 1% to 10% v/v.

For each treatment, 1 mL of the prepared solution was dispensed into 250 mL glass Wheaton bottles. The bottles were capped and mechanically rotated to achieve uniform coating of the inner surfaces, then incubated at 35°C for 30 minutes to allow complete solvent evaporation. Control bottles received only absolute ethanol, while Cypermethrin (10% EC) at a 0.05% concentration was used as the positive control.

Three-week-old *B. germanica* nymphs (n = 10 per bottle) were introduced into each bottle using a hand aspirator. Each concentration and control was tested in triplicate. Mortality was assessed at predetermined intervals (0, 15, 30, 35, 40, 45, 60, 75, 90, 105, and 120 minutes). Cockroaches were classified as dead if they exhibited no response after three gentle probes with a soft brush.

Repellency Bioassay

The repellent activity of *A. scoparia* powder was assessed using a choice apparatus, following protocols established in recent cockroach behavioural studies (Elbrense and El-Aasr, 2022). The apparatus comprised three 100 mL plastic bottles connected in a linear arrangement by transparent plastic tubes measuring 15 cm in length and 1 cm in diameter. The chambers were designated as A, B, and C, with chamber B functioning as the central introduction point. Chamber A (treated) contained 5 g of biscuit bait mixed with *A. scoparia* powder at concentrations of 1%, 2%, 3%, 4%, or 5% (w/w),

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while chamber C (control) contained 5 g of untreated biscuit bait. Ten adult *B. germanica* were introduced into chamber B. The apparatus was covered with fine nylon mesh to allow ventilation and prevent escape. Each concentration was tested in triplicate.

All experiments were conducted under controlled environmental conditions of 32 ± 2 °C and 65 ± 5% relative humidity. The numbers of cockroaches present in the treated (NT) and control (NC) chambers were recorded at 12, 24, 36, and 60 hours after exposure. Percentage Repellency (PR) was calculated using the following formula:

$$PR = \left(1 - \left(\frac{NT}{NT + NC}\right)\right) \times 100$$

Where:
NT = Number of insects in treated chamber (A)
NC = Number of insects in control chamber (C)

Statistical Analysis

Probit analysis was used to estimate median lethal time (LT_{50} and LT_{90}) and median lethal concentrations (LC_{50} and LC_{90}) from mortality data (Finney, 1971). Abbott's formula was not applied because control mortality remained below 5% in all experiments. Repellency data were evaluated using one-way analysis of variance (ANOVA), followed by Tukey's Honestly Significant Difference (HSD) test for mean separation at P < 0.05. All statistical analyses were conducted using IBM SPSS Statistics version 25.0 (IBM Corp., Armonk, NY, USA).

Results

Toxicity of Artemisia scoparia Essential Oil Against Blattella germanica

The essential oil of *Artemisia scoparia* exhibited notable insecticidal activity against *Blattella germanica*. Mortality rates increased in correlation with both higher concentrations of the essential oil and extended exposure durations. At lower concentrations (1% and 2%), mortality rates increased gradually over time, with slower effects observed during initial exposure periods. In contrast, higher concentrations (7-10%) induced rapid mortality, achieving 100% within 30 to 45 minutes of exposure. For instance, at a 10% concentration, mortality reached 93.33% immediately following exposure and 100% within 15 minutes. Similarly, concentrations of 8% and 9% resulted in complete mortality within 15 minutes. Lower concentrations necessitated longer exposure times to achieve comparable mortality rates. Tables 1 and 2 presents detailed mortality percentages across various concentrations and exposure durations.

Table 1. Mortality (%) of *B. germanica* exposed to lower concentrations (1-5%) of *A. scoparia* essential oil

Time (min)	1%	2%	3%	4%	5%
0	0.0 ± 0.0	0.0 ± 0.0	13.3 ± 5.8	16.7 ± 5.8	23.3 ± 5.8
15	13.3 ± 5.8	13.3 ± 5.8	43.3 ± 5.8	40.0 ± 10.0	73.3 ± 5.8
30	26.7 ± 5.8	26.7 ± 5.8	73.3 ± 5.8	73.3 ± 5.8	90.0 ± 10.0
35	30.0 ± 0.0	30.0 ± 0.0	73.3 ± 5.8	76.7 ± 5.8	96.7 ± 5.8
40	33.3 ± 5.8	36.7 ± 5.8	76.7 ± 5.8	86.7 ± 5.8	100.0 ± 0.0
45	40.0 ± 0.0	40.0 ± 0.0	86.7 ± 5.8	100.0 ± 0.0	100.0 ± 0.0
60	56.7 ± 5.8	56.7 ± 5.8	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0
75	66.7 ± 5.8	70.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0
90	73.3 ± 5.8	76.7 ± 5.8	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0
105	80.0 ± 0.0	90.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0
120	86.7 ± 5.8	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0

Values represent mean ± standard error (SE), n = 30 per concentration (3 replicates × 10 insects).

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Table 2. Mortality (%) of *B. germanica* exposed to higher concentrations (6-10%) of *A. scoparia* essential oil and cypermethrin

Time (min)	6%	7%	8%	9%	10%	Cyper	P-value
0	26.7±5.8	36.7±5.8	56.7±5.8	73.3±5.8	93.3±5.8	10.0±10.0	<0.001
15	76.7±5.8	76.7±5.8	100.0±0.0	100.0±0.0	100.0±0.0	40.0±10.0	<0.001
30	96.7±5.8	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	63.3±5.8	<0.001
35	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	70.0±10.0	<0.001
40	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	76.7±5.8	<0.001
45	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	76.7±5.8	<0.001
60	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	80.0±10.0	<0.001
75	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	93.3±5.8	<0.001
90	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	96.7±5.8	<0.001
105	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	<0.001
120	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	<0.001

Values represent mean ± standard error (SE), n = 30 per concentration (3 replicates × 10 insects).

Lethal Concentration Analysis

The lethal concentration values provide additional evidence for the toxicity of *A. scoparia* essential oil against *B. germanica*. Both LC_{50} and LC_{90} values declined as exposure time increased, indicating that extended exposure required lower concentrations of the essential oil to achieve comparable mortality. At the initial time point, the LC_{50} value was 6.98% and the LC_{90} value was 10.70%. Following 60 minutes of exposure, the LC_{50} decreased to 0.73%, demonstrating a marked increase in toxicity over time. Table 3 provides detailed LC_{50} and LC_{90} values across different exposure durations.

Table 3. Lethal concentrations (LC_{50} and LC_{90}) of *Artemisia scoparia* essential oil against *Blattella germanica* at different exposure times.

Exposure Time (min)	LC_{50} (% v/v)	LC_{90} (% v/v)
0	6.98	10.70
15	4.33	7.75
30	2.92	6.52
35	2.72	6.34
40	2.38	6.13
45	2.14	5.81
60	0.73	5.35
75	-	4.92
90	-	4.50
105	-	3.37
120	-	1.80

LC_{50} and LC_{90} values were determined using probit analysis. At 75, 90, 105, and 120 minutes, LC_{50} could not be calculated because mortality exceeded 50% across all concentrations.

Repellent Activity of *Artemisia scoparia* Powder

Powdered leaves of *A. scoparia* demonstrated strong repellent activity against *B. germanica*. Repellency increased with higher concentrations of plant powder and longer exposure durations. After 12 hours, repellency ranged from 83.33% to 100%, depending on plant powder concentration. The highest concentration (4-5%) resulted in complete repellency, indicating strong behavioural avoidance by the insects.

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Repellency values remained high throughout the experiment, reaching 100% at several concentrations after extended exposure periods. These findings suggest that *A. scoparia* powder effectively deters cockroaches from moving toward treated areas. Table 4 presents the repellency percentages recorded during the experiment.

Table 4. Repellency (%) of *Artemisia scoparia* powder against *Blattella germanica* at different concentrations and exposure times.

Exposure Time (h)	1%	2%	3%	4%	5%
12	83.33 ±28.87	100.00 ±0.00	83.33 ±28.87	100.00 ±0.00	100.00 ±0.00
24	80.56 ±17.35	75.00 ±25.00	91.67 ±14.43	88.89 ±19.25	80.56 ±17.35
36	76.67 ±8.82	86.67 ±11.55	81.11 ±20.09	100.00 ±0.00	100.00 ±0.00
60	92.13 ±6.85	96.97 ±5.25	100.00 ±0.00	100.00 ±0.00	100.00 ±0.00

Values represent mean ± standard error (SE). n = 30 per concentration (3 replicates × 10 insects)

DISCUSSION OF FINDINGS

The insecticidal activity identified in this study is consistent with recent advancements in the use of botanical derivatives for urban pest management. Although initial investigations focused on grain beetles, subsequent research has demonstrated the high efficacy of essential oils from species such as *Artemisia scoparia. These oils* contain bioactive compounds analogous to those shown to be effective against persistent household pests, including *Blattella germanica* (Rezaei et al., 2019; Aati et al., 2020). The insecticidal activity observed in this study corroborates both historical and contemporary findings regarding *Artemisia* species.

Negahban et al. (2007) demonstrated that *A. scoparia* essential oil achieved 100% mortality in *Tribolium castaneum* within 24 hours at concentrations of 185-370 µL/L air. More recent studies have confirmed its high potency against resilient urban pests, with Parveen et al. (2024) and You et al. (2020) highlighting its effectiveness as a modern, eco-friendly alternative for controlling pests such as *B. germanica* and mosquitoes. Additional research supports the shift toward plant-based management of the German cockroach, indicating that the bioinsecticidal activity of various essential oil components (EOCs) offers an effective, low-toxicity alternative to synthetic pesticides, potentially through the induction of lethal desiccation in this persistent urban pest (Oladipupo, 2022).

The rapid knockdown effect observed at higher concentrations in the present study suggests potent neurotoxic activity, likely attributable to major essential oil components such as camphor, 1,8-cineole, and β-pinene. These compounds, identified in *A. scoparia* (Zuo et al., 2026), have demonstrated significant, dose-dependent insecticidal activity against *Blattella germanica* (Yeom et al., 2015). These monoterpenes disrupt insect octopamine receptors or GABA-gated chloride channels, resulting in hyperexcitation, paralysis, and death. Recent cheminformatics and docking analyses by Correa et al. (2023) have confirmed that these receptors serve as the primary molecular targets for various essential oil constituents, thereby providing a predictive framework for their neurotoxic mechanisms.

The rapid toxic action of *A. scoparia,* as indicated by an LC50 of 0.73% at 60 minutes, contrasts sharply with other botanical formulations. While *A. scoparia* induces significant mortality within the first hour, other plant-derived oils, including neem and linseed, typically exhibit delayed insecticidal effects and require prolonged exposure periods, often exceeding 120 minutes to 24 hours, to achieve similar mortality rates (Yeom et al., 2015).

The LC50 values declined markedly with increased exposure time, decreasing from 6.98% at 15 minutes to 0.73% at 60 minutes, at which point over 50% mortality was observed in all treatment groups. This time-dependent toxicity is typical of botanical insecticides and is attributed to the gradual cuticular penetration and internal accumulation of bioactive monoterpenes within

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insect tissues (Zuo et al., 2026). These findings indicate that even low concentrations of *A. scoparia* can be highly effective if exposure duration is sufficient to reach critical threshold levels at the target site (Devrani et al., 2024). The LC90 values exhibited a comparable temporal trend, requiring 120 minutes to decrease from 10.70% to 1.80%, which demonstrates that prolonged exposure is essential for eliminating the most resilient individuals in the population.

The repellent activity of *A. scoparia* powder observed in this study is particularly significant. Complete (100%) repellency at 4% and 5% concentrations after 12 hours surpasses the efficacy reported for many other botanicals, which often require higher concentrations or synergistic mixtures to achieve total avoidance (Passara et al., 2026). While many plant-derived repellents exhibit a rapid decline in effectiveness, the sustained 100% repellency of *A. scoparia* throughout the observation period indicates superior residual properties, likely attributable to the slow release of volatile monoterpenes from the plant matrix (MDPI Insects, 2025).

Additionally, the sustained repellency of *A. scoparia* essential oil, reported to last up to 165 minutes against mosquitoes, further supports its superior residual properties, likely due to the gradual release of volatile monoterpenes such as β-myrcene and γ-terpinene (Parveen et al., 2024). The observed repellency over 12 hours suggests that the volatile compounds in the powder provide prolonged protection. Notably, even a 1% concentration achieved greater than 90% repellency by 12 hours, indicating high efficacy at low dosages. These findings align with the potent repellent effects recently reported by Parveen et al. (2024), who demonstrated that *A. scoparia* volatiles, including β-myrcene and γ-terpinene, offer significant protection against arthropods. Although the essential oil has been noted for its 165-minute efficacy in mosquito bioassays, the present results indicate that the powdered plant matrix substantially extends this protection window to 12 hours, likely by reducing the evaporation rate of these bioactive monoterpenes.

The biphasic response observed at lower concentrations, in which some insects initially moved toward treated chambers, has been documented in previous studies. Recent research demonstrates that essential oils can produce a hormetic biphasic concentration-response effect, characterized by attraction at low concentrations and repellency at high concentrations, with half of the tested oils exhibiting both positive and negative chemotaxis depending on concentration (Bedini et al., 2024). The authors propose that olfactory stimuli may initially attract insects, after which repellent compounds deter feeding or colonization. Although this phenomenon warrants further investigation, it does not diminish the overall repellent efficacy.

The mechanisms underlying repellency most likely involve volatile compounds that interfere with insect olfactory receptors. *A. scoparia* contains several volatile terpenes, including camphor, 1,8-cineole, and limonene, which are known to activate or block odorant receptors in insects, thereby preventing the location of food sources. Recent transcriptome analyses confirm that monoterpenes such as limonene and β-pinene induce neurotoxic effects by upregulating calcium channel genes and neuroactive ligand-receptor pathways, resulting in elevated intracellular Ca^{2+}, mitochondrial dysfunction, and programmed cell death (Xie et al., 2024).

Compared to synthetic insecticides, *A. scoparia* offers several significant advantages for urban pest management. Botanical insecticides are inherently biodegradable and possess multiple modes of action, which helps mitigate the development of physiological resistance (Akbar et al., 2026). Furthermore, they pose lower risks to human health and the environment by exhibiting selective toxicity that minimises harm to non-target organisms, such as predators and pollinators (Costa et al., 2025). The local availability of *A. scoparia* in Nigeria and other tropical regions makes it a low-cost, accessible alternative for Integrated Pest Management (IPM) programs. This aligns with the growing global recognition that plant-derived products offer affordable, sustainable solutions for pest management in developing regions (Chhunla et al., 2026).

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Limitations and Future Directions

Although the results of this study are promising, several limitations should be considered. First, the chemical composition of the specific *A. scoparia* population was not analysed using gas chromatography-mass spectrometry (GC-MS), so the precise chemical profile of this local variety remains unconfirmed, despite the likelihood that activity is attributable to known monoterpenes. Second, the bioassays were performed under controlled laboratory conditions, which may not fully represent environmental variables such as temperature fluctuations, humidity, or differences in surface textures commonly encountered in residential settings. Third, although botanical products are generally regarded as safer, toxicity to non-target organisms was not directly evaluated in this study. Finally, the physiological mechanisms of action were inferred from existing literature rather than examined at the biochemical or molecular level in this specific trial. Future research should address the following areas:

1. Chemical characterisation of the local *A. scoparia* essential oil is needed to identify specific active constituents and potential chemotypes.
2. Field-scale evaluations should be conducted to determine efficacy and residual activity in real-world urban environments.
3. Safety profiling should include toxicity testing against non-target organisms, such as mammals and beneficial insects.
4. Formulation development, including approaches such as nano-encapsulation, is recommended to improve the stability and slow-release properties of the volatile compounds.
5. Synergy studies should investigate the potential for combining *A. scoparia* with other botanicals or low-dose synthetic insecticides to minimise the development of resistance.

CONCLUSION

In summary, the present study establishes *Artemisia scoparia* as a potent biorational agent for controlling the German cockroach (*Blattella germanica*). Both the essential oil and leaf powder demonstrated substantial bioactivity, with the essential oil inducing rapid mortality, achieving 100% knockdown within 30-45 minutes at higher concentrations. Additionally, the plant powder exhibited strong behavioural deterrence, maintaining 100% repellency at 4-5% concentration for 12 hours. These results indicate that *A. scoparia* represents an effective and environmentally friendly alternative to synthetic neurotoxins, providing a sustainable option for integrated pest management in regions where the plant is locally available. Although the laboratory findings are promising, further chemical characterisation and field-scale evaluations are necessary to develop this botanical resource into a commercially viable insecticide.

REFERENCES

Aati, H.Y., Perveen, S., Orfali, R., Al-Taweel, A.M., Aati, S., Wanner, J., Khan, A. and Mehmood, R., 2020. Chemical composition and antimicrobial activity of the essential oils of *Artemisia absinthium*, *Artemisia scoparia*, and *Artemisia sieberi* grown in Saudi Arabia. *Arabian Journal of Chemistry*, 13(11), pp.8209-8217.

Akbar, R., Bari, H., Fatima, T., Tahani, I. and Anjum, N.A., 2026. Botanical Insecticides: Major Sources, and Chemical and Mechanistic Insights. In: *New Horizons in Insecticides Research*. IntechOpen.

Azzam, M.O.J. and Obaid, L.M.A., 2025. Extraction of Essential Oils from *Artemisia jordanica* by Vacuum Distillation, Steam Distillation and Hydro-Distillation Using Solar Energy. *Arabian Journal for Science and Engineering*, 50(24), pp.20497-20512.

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Bedini, S., Djebbi, T., Ascrizzi, R., Farina, P., Pieracci, Y., Echeverria, M.C., Flamini, G., Trusendi, F., Ortega, S., Chiliquinga, A. and Conti, B., 2024. Repellence and attractiveness: The hormetic effect of aromatic plant essential oils on insect behavior. *Industrial Crops and Products*, 210, p.118122.

Chhunla, C., Sarun, H., Channy, L. and Nara, I., 2026. Botanical Pesticides as Sustainable Alternatives for Insect Pest Management in Vegetable Crops: A Narrative Review. *Journal of Agriculture and Environment*, 3(1), pp.87-95.

Corrêa, E.J.A., Carvalho, F.C., de Castro Oliveira, J.A., Bertolucci, S.K.V., Scotti, M.T., Silveira, C.H., Guedes, F.C., Melo, J.O.F., de Melo-Minardi, R.C. and de Lima, L.H.F., 2023. Elucidating the molecular mechanisms of essential oils' insecticidal action using a novel cheminformatics protocol. *Scientific Reports*, 13(1), p.4598.

Costa, L.T., Smagghe, G., Jumbo, L.O.V., Santos, G.R., Aguiar, R.W. and Oliveira, E.E., 2025. Selective actions of plant-based biorational insecticides: Molecular mechanisms and reduced risks to non-target organisms. *Current Opinion in Environmental Science & Health*, 44, p.100601.

Demark, J.J. and Bennett, G.W., 1994. Diel activity cycles in nymphal stadia of the German cockroach (Dictyoptera: Blattellidae). *Journal of Economic Entomology*, 87(4), pp.941-950.

Devrani, A., Kumar, R., Bargali, P., Karakoti, H., Mahawer, S.K., Prakash, O., Kumar, S., Rawat, D.S. and Srivastava, R.M., 2024. Nematicidal and insecticidal activity of essential oils from *Artemisia scoparia* and *Centratherum punctatum* and their mixtures. *Biochemical Systematics and Ecology*, 116, p.104859.

Diab, M.K., Abu-Elsaoud, A.M., Salama, M.G. and Ghareeb, E.M., 2025. Phytochemical treasure troves—insights into bioactivities, phytochemistry, and uses of *Artemisia* species. *Phytochemistry Reviews*, pp.1-38.

Ding, J., Wang, L., He, C., Zhao, J., Si, L. and Huang, H., 2021. *Artemisia scoparia*: Traditional uses, active constituents and pharmacological effects. *Journal of Ethnopharmacology*, 273, p.113960.

Elbrense, H. and El-Aasr, M., 2022. Insecticidal activity of four essential oils against the German, *Blattella germanica* (L.) and the American, *Periplaneta americana* (L.) cockroaches. *Egyptian Journal of Experimental Biology (Zoology)*, 18(1).

Fan, X., Wang, C. and Bunker, D.E., 2022. Population structure of German cockroaches (Blattodea: Ectobiidae) in an urban environment based on single nucleotide polymorphisms. *Journal of Medical Entomology*, 59(4), pp.1319-1327.

Geng, D., Yu, H., Zhao, T. and Li, C., 2025. The medical importance of cockroaches as vectors of pathogens: Implications for public health. *Zoonoses*, 5(1), p.982.

Gits, M.P., Gondhalekar, A.D. and Scharf, M.E., 2023. Impacts of bioassay type on insecticide resistance assessment in the German cockroach (Blattodea: Ectobiidae). *Journal of Medical Entomology*, 60(2), pp.356-363.

Ko, A.E., Jensen, K., Schal, C. and Silverman, J., 2017. Effects of foraging distance on macronutrient balancing and performance in the German cockroach *Blattella germanica*. *Journal of Experimental Biology*, 220(2), pp.304-311.

Ma, J., Wang, M., Sun, Y., Zheng, Y., Lai, S., Zhang, Y., Wu, Y., Jiang, C. and Shen, F., 2024. Cockroach microbiome disrupts indoor environmental microbial ecology with potential public health

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implications. *Environment & Health*, 3(4), pp.380-391.

Manzanares-Sierra, A., Monsonís-Güell, E., Gómez, C., Abril, S. and Moreno-Gómez, M., 2025. Essential oils as bioinsecticides against *Blattella germanica* (Linnaeus, 1767): Evaluating its efficacy under a practical framework. *Insects*, 16(1), p.98. *(Note: This appears twice in your list; one instance is a duplicate.)*

Marrone, P.G., 2025. Increasing the use of biological pesticides in integrated pest management programs. *Frontiers in Insect Science*, 5, p.1552361.

Mukhtiar, A., Khan, Y., Sarfraz, H., Usman, A., Kouki, M. and Mukhtiar, U., 2025. *Moringa oleifera*: a multifunctional botanical resource for sustainable agriculture, nutrition, and therapeutic applications, a review. *Zeitschrift für Naturforschung C*, (0).

Negahban, M., Moharramipour, S. and Sefidkon, F., 2006. Chemical composition and insecticidal activity of *Artemisia scoparia* essential oil against three coleopteran stored-product insects. *Journal of Asia-Pacific Entomology*, 9(4), pp.381-388.

Oladipupo, S.O., 2022. Toxicity and physiological effects of essential oil components against the German Cockroach, *Blattella germanica* (L.) (Ectobiidae) (Doctoral dissertation, Auburn University).

Parveen, A., Abbas, M.G., Keefover-Ring, K., Binyameen, M., Mozūraitis, R. and Azeem, M., 2024. Chemical composition of essential oils from natural populations of *Artemisia scoparia* collected at different altitudes: antibacterial, mosquito repellent, and larvicidal effects. *Molecules*, 29(6), p.1359.

Passara, H., Moungthipmalai, T., Laosinwattana, C., Sittichok, S., Murata, K. and Soonwera, M., 2026. Terpenoid Mixtures as Repellents Against the American Cockroach: Their Synergy and Low Toxicity Against Non-Target Species. *Insects*, 17(1), p.65.

Passara, H., Soonwera, M., Arhamad-Armeen, N., Sittichok, S. and Jintanasirinurak, S., 2025. Efficacy of plant essential oils for repelling against American cockroach adults (*Periplaneta americana* L.). *International Journal of Agricultural Technology*, 21(1), pp.153-162.

Pavela, R., Kovaříková, K. and Novák, M., 2025. Botanical antifeedants: an alternative approach to pest control. *Insects*, 16(2), p.136.

Rezaei, M., Khaghani, R. and Moharramipour, S., 2019. Insecticidal activity of *Artemisia sieberi*, *Eucalyptus camaldulensis*, *Thymus persicus* and *Eruca sativa* oils against German cockroach, *Blattella germanica* (L.). *Journal of Asia-Pacific Entomology*, 22(4), pp.1090-1097.

Sangeetha, V.S. and Padmavathi, Y.S., 2025. *Artemisia annua*: Illuminating the spectrum of pharmacological wonders. *Food and Drug Safety*, 2(1), pp.40-53.

Schal, C., Hedges, S. and Moreland, D., 2011. *Handbook of Pest Control*. GIE Media, p.150.

Souto, A.L., Sylvestre, M., Tölke, E.D., Tavares, J.F., Barbosa-Filho, J.M. and Cebrián-Torrejón, G., 2021. Plant-derived pesticides as an alternative to pest management and sustainable agricultural production: Prospects, applications and challenges. *Molecules*, 26(16), p.4835.

Tang, Q., Vargo, E.L., Ahmad, I., Jiang, H., Varadínová, Z.K., Dovih, P., Kim, D., Bourguignon, T., Booth, W., Schal, C. and Mukha, D.V., 2024. Solving the 250-year-old mystery of the origin and global spread of the German cockroach, *Blattella germanica*. *Proceedings of the National*

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Academy of Sciences, 121(22), p.e2401185121.

Xie, Y., Chen, Y., Wu, Z., Gong, X., Zhang, Z., Yang, S. and Zhang, D., 2024. Transcriptome analysis of *Reticulitermes flaviceps* exposed to *Mentha spicata* essential oil and carvone indicates a potential neurotoxic mechanism of action characterized by intracellular calcium influx mediated by dopamine receptors. *Pesticide Biochemistry and Physiology*, 204, p.106045.

Yang, M., Li, M., Chen, F. and Chen, S., 2024. Bioactive components and antimicrobial potential of extracts from *Artemisia* species and their repellent activities against Aphid (*Macrosiphoniella sanborni*). *Ornamental Plant Research*, 4(1).

Yeom, H.J., Jung, C.S., Kang, J., Kim, J., Lee, J.H., Kim, D.S., Kim, H.S., Park, P.S., Kang, K.S. and Park, I.K., 2015. Insecticidal and acetylcholine esterase inhibition activity of Asteraceae plant essential oils and their constituents against adults of the German cockroach (*Blattella germanica*). *Journal of Agricultural and Food Chemistry*, 63(8), pp.2241-2248.

You, P., Jia, J.Q. and Li, Z.Q., 2020. Sublethal Doses of Essential Oils Impact Growth and Esterase Levels in German Cockroach (Blattodea: Ectobiidae) with and without Symbiotic Bacteria. *Journal of Entomological Science*, 55(2), pp.273-285.

Zuo, S., Zhang, R., Yan, B., Zhang, Y., Duan, Z., Sun, J., Yuan, H. and Huang, X., 2026. Insecticidal and Sublethal Effects of *Artemisia scoparia* Essential Oil on *Liriomyza sativae*. *Insects*, 17(2), p.170.

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