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Food Preferences and Bait-Based Management of Cockroaches in Urban Households

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***Abstract*:** Cockroaches are major urban pests due to their synanthropic behavior and ability to transmit pathogenic microorganisms, posing significant public health risks. This study assessed the seasonal prevalence, habitat distribution, and feeding preferences of three dominant species *viz.,* German cockroach (*Blattella germanica*), Brown-banded cockroach (*Supella longipalpa*), and American cockroach (*Periplaneta americana*) in domestic settings at Hyderabad. Highest cockroach abundance in urban households occurs in winter, driven by cooler indoor conditions. Kitchens and storage areas show more infestation due to food and moisture availability. Laboratory based multi-choice assays showed a strong preference for carbohydrate-rich foods, particularly banana, among German and Brown-banded cockroaches, likely reflecting their nocturnal foraging activity and high energy demands. In contrast, American cockroaches exhibited opportunistic omnivory, favoring bread, likely due to their larger body size and adaptability to varied, often moist, microhabitats. A banana-based gel bait containing 0.05% fipronil recorded 88% population reduction in five weeks, with efficacy comparable to commercial gel baits. These findings highlight the potential of food preference based bait formulations as effective tools in integrated cockroach management.

Keywords: Urban pest management, *Blattella germanica, Supella longipalpa, Periplaneta americana*, Feeding preferences, Fipronil

Cockroaches are among the most ubiquitous and resilient urban pests globally, with approximately 30 species closely associated with human habitats out of over 4,600 known species (Bell et al., 2007). These insects pose significant public health risks due to their ability to mechanically transmit a wide range of pathogenic microorganisms, contaminate food, and elicit allergic reactions. In India, urban cockroach fauna is dominated by the German cockroach (*B. germanica*), Brown-banded cockroach (*S. longipalpa)* and American cockroach (*P. americana*), each occupying distinct ecological niches with specific biological and physiological adaptations (Prabakaran 2010, Luz et al., 2011). German cockroach populations in particular display high infestation rates, reaching up to 70% in residential settings, reflecting their remarkable adaptability and close synanthropic association (Yuan Pan et al., 2020).

Effective cockroach management requires a comprehensive understanding of species-specific seasonal dynamics, microhabitat preferences, and feeding ecology. Such knowledge is essential for developing optimized bait formulations with enhanced attractiveness and efficacy. Fipronil-based gel baits are widely recognized as highly effective against cockroaches due to their cascading effect, whereby the toxicants are disseminated among individuals through contact, necrophagy, and coprophagy, leading to a rapid and substantial colony-wide reduction in the population (Metha et al., 2020, Rahayu1 et al., 2021). Beyond biological factors, socio-economic and regulatory frameworks significantly influence pest control outcomes, highlighting the need for coordinated efforts between public health authorities and private pest management services to implement sustainable urban cockroach control strategies (Li et al., 2023). This study was undertaken to address gaps in understanding cockroach species distribution in urban Indian households, particularly kitchens, to assess species-specific food preferences through controlled laboratory bioassays, and to evaluate the field efficacy of banana based fipronil gel bait compared to commercially available preparations.

MATERIAL AND METHODS

Survey of cockroach incidence: A household survey on cockroach incidence was conducted among 120 urban households from residential apartments located in Kukatpally ($17^0$29' 29.9724" N and $78^0$23'31.1388"E) Hyderabad during 2020. To ensure accurate identification of cockroach species by respondents, colored photographs alongside mounted specimens of the common cockroach species were shown, reducing errors due to lack of awareness. This questionnaire-based approach assessed seasonal prevalence, species occurrence and preferred habitat sites.

Collection and maintenance of cockroaches: Adult German, Brown-banded, and American cockroach specimens were collected from infested apartments in an urban residential setting. Each cockroach species was housed individually @10 individuals in a plastic box measuring 40x10x10 cm provided with folded cardboard pieces as shelter. Cockroaches were provided with

carbohydrate-rich foods such as bread, biscuit pieces, and banana slices to meet nutritional requirements. Water was supplied using containers fitted with sponges to prevent drowning while ensuring constant moisture availability. The insect were reared at 25 ± 2 °and 70 ± 5% RH with a 12h light and 12hr dark cycle, replicating natural circadian rhythms. This standardized setup provided stable conditions for further experimental observations and behavioral assessments.

Laboratory food preference assays: Multi-choice feeding assays were conducted to quantitatively assess dietary preferences of three cockroach species under controlled laboratory conditions. Each test consisted of 0.2 g portions of representative food items *viz.,* bread (plain, with butter, or jam), boiled potato (with or without sugar or butter), banana (alone or combined with butter or prawn), cornflakes, and prawns offered simultaneously to cohorts of ten adult cockroaches per species housed in individual plastic chambers (40 cm × 10 cm × 10 cm). The environmental parameters were meticulously maintained at 25 ± 2 °C, RH 70±5% with a 12:12 h photo period, to simulate natural diurnal rhythms, factors known to influence cockroach behavior and feeding activity. Prior to feeding assays, cockroaches were starved for 24 h to standardize hunger levels. Food consumption was recorded daily for 5 consecutive days, with three independent replicates per species.

Preparation of banana based fipronil gel bait: Ripe banana pulp (100 g) was used as the bait base. Technical-grade fipronil (98%) obtained from Bhagiradha Chemicals& Industries Ltd., was incorporated to achieve a 0.05% (w/w) concentration. Sodium benzoate (e.g., 0.1% w/w) was added as a preservative. The mixture was thoroughly homogenized to form a uniform gel bait. The bait was stored in airtight containers in the dark until use.

Field evaluation of gel baits: Nine kitchens with medium-to-high cockroach infestation (≥50 individuals per night as determined by pre-survey visual counts and sticky traps) were selected for field evaluation. The randomized design was used. Three kitchens received banana-based 0.05% fipronil gel bait, three received a commercial fipronil gel, and three served as untreated controls without any bait application. Gel baits were uniformly applied at 3 drops per linear meter along cracks and crevices, based on consistent infestation levels. Cockroach populations were systematically monitored through weekly visual counts complemented by sticky traps placed near baited sites over five consecutive weeks post-application to accurately assess bait efficacy

Statistical analysis: Food preference data were analyzed using SPSS-22.0 software for Tukey HSD pairwise comparisons ($p < 0.05$). Field efficacy data comparing commercial and banana-based gel baits were analyzed using independent samples t-tests at each time point to evaluate differences in control performance.

RESULTS AND DISCUSSION

Survey data from 120 respondents showed highest cockroach problems in winter (39%) and in many cases, persisted across all seasons (35%). German cockroach predominated (68%), with infestations concentrated behind stoves, drains, and sinks (Fig. 1). Respondents acknowledged cockroach-related health risks and reported a preference for chemical sprays as their primary control method. These findings corroborate earlier reports on the persistence of *B. germanica* in diverse indoor habitats and their role as mechanical vectors of multiple pathogens including bacteria, fungi, and viruses (Yuan Pan et al., 2020). Food preference assays revealed distinct variations among the three cockroach species (Table 1). All species showed significant preference for carbohydrate and starch rich foods such as banana, boiled potato, and bread, recording the highest mean consumption values. German and Brown-banded cockroaches exhibited strong preferences for these three foods particularly banana, which was the most preferred item by *B. germanica* (31.8 mg) and *S. longipalpa* (30.2 mg) which is consistent with earlier observations that carbohydrate-rich foods with suitable texture enhance bait palatability (El-Sharabasy et al., 2014). In contrast, the American cockroach (*P. americana*) displayed broader feeding preferences, with bread (32.3 mg) followed banana, boiled potato and cornflakes forming the top-ranked group,

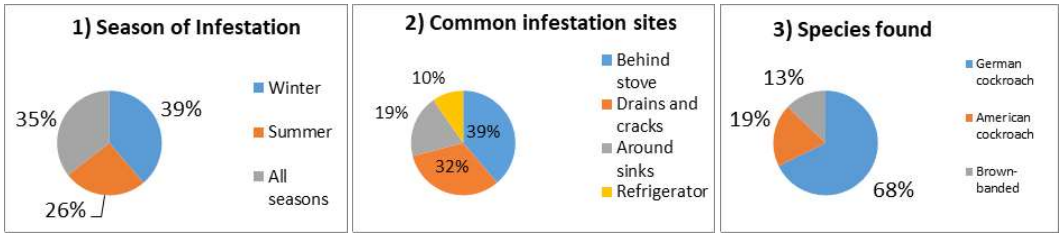

Fig. 1. Cockroach seasonal infestation, habitat and species present in urban dwellings

reflecting its omnivorous feeding habits and opportunistic feeding behavior (Anil 2022).

Additives such as butter, jam, or sugar generally reduced food consumption across species, indicating possible deterrent effects or reduced palatability. The combination of bread + butter recorded the lowest feeding response in *B. germanica* (1.3 g), while *P. americana* exhibited minimal interest in potato + sugar (2.8 mg) and bread + jam (2.4 mg). Among proteinaceous foods, prawn alone elicited moderate feeding (8.2–9.4 mg), whereas banana + prawn mixtures improved consumption slightly in *P. americana* (14.1 mg). The results indicate that banana and boiled potato serve as highly attractive and consistently preferred food substrates across species, suggesting their potential as effective phagostimulant bases for developing gel bait formulations for domestic cockroach management.

Table 1. Food preference of cockroach species (mg) (Mean ± SD)

Treatment	German cockroach	Brown-banded cockroach	American cockroach
Bread	24.7 ± 13.3[a]	19.9 ± 4.8[a]	32.3 ± 13.1[a]
Bread + Butter	1.3 ± 0.8[b]	11.6 ± 4.1[b]	3.0 ± 1.4[c]
Bread + Jam	8.0 ± 3.9[b]	5.4 ± 2.6[b]	2.4 ± 0.9[c]
Boiled Potato	31.0 ± 13.8[a]	26.6 ± 15.9[a]	22.9 ± 13.8[a]
Potato + Sugar	15.4 ± 5.5[b]	3.9 ± 2.3[b]	2.8 ± 1.0[c]
Potato + Butter	4.3 ± 3.1[b]	8.7 ± 2.7[b]	6.9 ± 3.5[c]
Banana	31.8 ± 13.1[a]	30.2 ± 15.0[a]	30.5 ± 11.9[a]
Banana + Butter	9.5 ± 4.4[b]	9.7 ± 4.0[b]	12.8 ± 4.4[b]
Banana + Prawn	8.6 ± 2.8	6.1 ± 1.4[b]	14.1 ± 3.3[b]
Cornflakes	4.5 ± 1.7[b]	1.6 ± 0.6[b]	18.6 ± 2.5[a]
Prawn	8.2 ± 2.9[b]	6.5 ± 3.5[b]	9.4 ± 4.0[b]

Figures with same letter in column do not differ significantly ($p<0.05$)

The efficacy of commercial and banana-based fipronil gel baits was assessed against cockroach infestations over a five-week period, combining both population counts and percentage control data to provide a comprehensive evaluation. Initial cockroach densities in treated kitchens ranged from 55 to 58 individuals, while control kitchens averaged approximately 52 individuals (Fig. 2). Field evaluation demonstrated significant and sustained reductions in cockroach populations with both gel baits, as evident from the progressive decline in counts to approximately 5–15 individuals by the end of the treatment period. In contrast, populations in untreated control kitchens progressively increased, surpassing 70 cockroaches by week five.

The commercial fipronil gel bait consistently achieved high control percentages with an overall mean reduction of 92.17%.The banana-based gel bait also demonstrated robust efficacy, with mean reduction of 88.69%. Independent samples t-tests revealed statistically significant differences favoring the commercial gel bait at day 1 followed by week 1, 3 and 4. However, weeks 2 and 5 showed no significant differences. Overall, commercial gel bait demonstrated marginally greater efficacy than the banana-based formulation, though both maintained effective control exceeding 85% (Table 2)

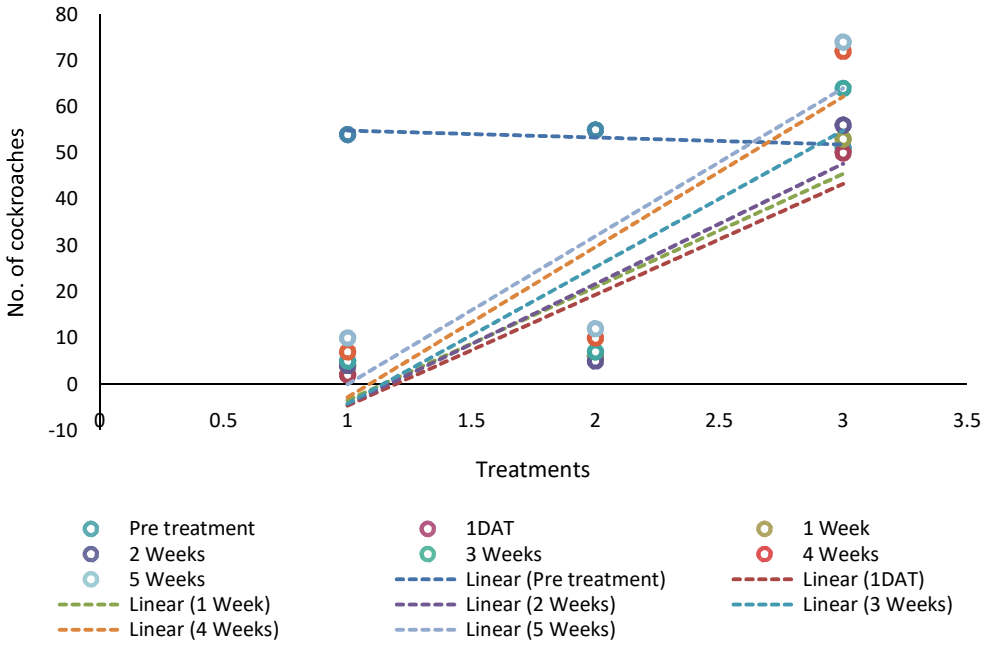

Fig. 2. Efficacy of treatments agaisnt cockroaches

Table 2. Field efficacy of commercial and banana based fipronil gel baits against cockroaches (Percent reduction) (Mean ± SD)

Time point	Commercial gel bait	Banana-based gel	t-value	p-value
Day 1	96.2 ±1.5	88.9 ±1.4	5.12	<0.01
Week 1	92.9 ±1.2	89.5 ± 1.3	3.67	0.01
Week 2	93.3 ± 1.3	91.7 ± 1.1	1.82	0.10
Week 3	92.6 ± 1.5	89.9 ± 1.2	3.12	0.02
Week 4	90.8 ± 1.4	87.1 ± 1.3	4.07	<0.01
Week 5	87.2 ± 1.7	85.0 ± 1.5	1.90	0.09
Overall mean	92.1 ±1.43	88.6 ± 1.31	4.21	<0.01

These results suggest that banana-based gel bait prepared with locally available materials can serve as a cost-effective alternative to commercial products within integrated urban pest management programs. This aligns with IPM strategies that emphasize minimizing insecticide resistance and environmental impact through innovative, eco-friendly bait matrices. Importantly, the survey revealed that most households relied on chemical sprays for cockroach control, indicating a need for greater awareness and education on the advantages of gel baits, including their safety, ease of use, and long-term efficacy. Promoting such awareness could significantly enhance community adoption and implementation of gel bait–based approaches within urban pest management frameworks (Yuan Pan et al., 2020, Li et al., 2023).

CONCLUSION

This study highlights species-specific distributions and feeding preferences of cockroaches in urban households, emphasizing the dominance of German cockroach in kitchens and exhibiting distinct seasonal infestation trends. The laboratory and field evaluations demonstrated that the banana-based fipronil gel bait formulated using locally available materials was highly effective and comparable to commercial products in suppressing cockroach populations. Integrating such cost-effective baits with improved sanitation, habitat management and public awareness initiatives can improve efficacy of urban pest control thereby reducing associated health risks.

AUTHORS CONTRIBUTION

N.Srinivasa Rao conceptualized, planned, and supervised the study. P. Saktivel conducted the experiments and prepared the manuscript. K. Praveen Kumar provided critical comments and suggestions for improvement during the study. A. Padmavathi assisted in data compilation and statistical analysis. All authors have read and approved the final version of the manuscript.

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