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RESEARCH COMMUNICATION

Evaluation of different types of attractants for *Bactrocera correcta* (Bezzi, 1916) in the Ber (*Ziziphus mauritiana* Lamk.) ecosystem

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Abstract

Fruit flies pose a significant threat to ber (*Ziziphus mauritiana* Lamk.) cultivation, necessitating effective monitoring and management strategies. This study evaluated the efficacy of various attractants in trapping *Carpomya vesuviana* and *Bactrocera correcta*. Various baits were tested, including ripe pulp of ber, guava and banana; fish meal; jaggery solution; honey solution; ammonium acetate; proteinex and commercial lures (methyl eugenol and cue lure). However, no adults of *C. vesuviana* were captured. But *B. correcta* was effectively trapped, with methyl eugenol (T9) and cue lure (T10) consistently demonstrating superior efficacy across all standard weeks. These traps captured the highest mean number of fruit flies (54.6 and 49.5 flies/trap respectively), followed by proteinex (T8) (13.3 flies/trap) and guava pulp (T3) (7.4 flies/trap). Banana pulp (T2), fish meal trap (T4) and ammonium acetate (T7) showed moderate attraction, with mean trap catches of 6.2, 5.1 and 5.4 flies/trap respectively. In contrast, ripened ber fruit pulp (T1) showed limited effectiveness, with a mean trap catch of 4.8 fruit flies/ trap. Honey solution (T6) and jaggery (T5) recorded the lowest trap catches, with mean values of 1.4 and 1.1 fruit flies/trap respectively, indicating minimal attractiveness. The findings confirm the efficacy of methyl eugenol and cue lure traps in attracting *B. correcta*, reinforcing their role in integrated pest management strategies. However, the failure to trap *C. vesuviana* highlights the need for alternative attractants tailored to its behavioural ecology. Future research should focus on developing more efficient trapping methods for *C. vesuviana* to enhance pest control in ber orchards.

Keywords: attractants; *Bactrocera correcta*; *Carpomya vesuviana*; ber; cue lure; methyl eugenol

Introduction

The Indian jujube (*Ziziphus mauritiana* Lamk.), also known as Indian ber, is an ancient and widely cultivated fruit in India. Recently, there has been a surge in interest in cultivating jujube orchards in the arid regions of Andhra Pradesh, Gujarat and Rajasthan. India is the second largest producer of jujube in the world after China. The major states for jujube cultivation in India include Maharashtra, Gujarat, Uttar Pradesh, Tamil Nadu, Jammu and Kashmir, West Bengal, Haryana, Rajasthan, Madhya Pradesh, Punjab, Karnataka, Bihar, Chhattisgarh and Andhra Pradesh (1). A total of 22 insect and non-insect species infest ber in Karnataka State (2). In Andhra Pradesh, 23 pest species that infest ber were recorded (3). In Punjab, 37 insect pests were reported to attack ber (4). Among these fruit fly *Carpomyia vesuviana* (Costa), *Bactrocera dorsalis* (Hendel) and *B. zonata* (Saunders); the ber butterfly *Tarcus theophrastus* (Fabricius); the fruit borer *Cadra cautella* (Walker); the bark-eating caterpillar *Indarbela tetraonis* (Moore); the white grub *Holotrichia consanguinea* (Blanch); and the stone weevil *Aubeus himalayanus* (Voss) are the major pests (4-10). However, ber cultivation is severely threatened by the fruit fly complexes which can cause yield losses up to 80 % under severe conditions affecting different species of ber (11). Infestation of ber fruits sometimes occurs together with other fruit flies such as *B. correcta* (Bezzi), *B. dorsalis* (Hendel) and *B. zonata* (Saunders) (4, 12). The most common species attacking these fruits are *Bactrocera dorsalis* (Hendel), *B. correcta* (Bezzi) and *B. zonata* (Saunders) (13, 14). Female attractant baits are essential for effective monitoring and direct control of these pests (15). Female fruit flies require a protein source to attain sexual maturity and for egg development (16).

Materials and Methods

Field experiments were conducted at Tamil Nadu Agricultural University, Regional Research Station, Aruppukottai, Tamil Nadu, during 2023-2024 to study the efficacy of different attractants for fruit flies in the ber ecosystem. The experiment was laid out in a randomised block design (RBD) with ten treatments and three replications (Table 1). Plastic containers of 1 L capacity (10 cm diameter and 20 cm height) were modified as fruit fly traps. Four 20 mm holes were made on each side of the container using a heated blade to allow fruit flies to enter the trap. Traps were suspended at a height of 1.5-2.0 m from the iron wires of the pandal using jute twine. An isolation distance of 50 m was maintained between the treatments and replications. Traps were placed at the early fruiting stage of the crop and observations were taken continuously at five-day intervals for three months. The baits were replaced every ten days. The total number of fruit flies trapped in each treatment was recorded at each five-day interval (Fig. 1).

Results

No adults of *C. vesuviana* were trapped using any of the attractants tested in this study, which included ripe pulp of ber, guava and banana; fish meal; 10 % jaggery solution; honey solution; 5 % ammonium acetate; proteinex; as well as the commercial methyl eugenol and cue lure traps. The results for *B. correcta* are discussed in detail below.

In the 1st week, the efficacy of various treatments against *B. correcta* was assessed based on the number of flies trapped. The methyl eugenol trap (T9) was the most effective, capturing 76.4 fruit flies/trap, followed by the cue lure trap (T10) with 51.1 fruit flies/trap. Proteinex (T8) recorded 17.0 fruit flies/trap. Traps baited with ripened ber pulp (T1) and guava pulp (T3) captured 6.6 and 6.0 fruit flies/trap respectively. Honey solution (T6) was the least effective, attracting only 1.4 fruit flies/trap (Table 2).

In the 2nd standard week, methyl eugenol (T9) remained the most effective treatment, which captured 69.6 fruit flies/trap, while the cue lure trap (T10) attracted 53.3 fruit flies/trap. Proteinex (T8) captured 16.8 fruit flies/trap and the treatments with the pulp of ripened ber fruits (T1) and guava (T3) captured 7.3 and 7.1 fruit flies/trap respectively and were on par with each other. Meanwhile jaggery (T5) remained less effective, capturing 1.6 fruit flies/trap.

In the 3rd week, methyl eugenol (T9) and cue lure (T10) traps captured 70.7 and 69.8 fruit flies/trap respectively and were on par with each other, maintaining their superior efficacy. Proteinex (T8) captured 16.3 fruit flies/trap, followed by guava pulp (T3), which recorded 7.9 fruit flies/trap. Jaggery (T5) remained the least effective, attracting only 1.7 fruit flies/trap (Table 2).

During the 4th week, methyl eugenol (T9) and cue lure (T10) traps captured between 67.0 and 67.9 fruit flies/trap and were on par with each other, confirming their effectiveness. This was followed by, proteinex (T8) which captured 14.9 fruit flies/trap and then by, fish meal trap (T4) with 7.7 fruit flies/trap. Ammonium acetate (5 %) (T7) and pulp of ripened ber fruits (T1) recorded 7.1 and 6.5 fruit flies/trap. Meanwhile honey solution (T6) remained least effective with 1.9 fruit flies/trap (Table 2).

Table 1. Treatment details for luring efficacy studies

Treatments	Treatment details
T_1	Pulp of ripened ber fruits
T_2	Guava pulp
T_3	Banana pulp
T_4	Fish meal trap
T_5	Jaggery (10%)
T_6	Honey solution
T_7	Ammonium acetate (5%)
T_8	Proteinex
T_9	Methyl Eugenol trap
T_{10}	Cue lure

Table 2. Treatment efficiency studies for *B. correcta* in ber ecosystem

Treatment No.	Treatment details	No. of fruit flies trapped/trap*										Mean
		I	II	III	IV	V	VI	VII	VIII	IX	X	
T1	Pulp of ripened Ber fruits	6.6 (2.6)^{e}	7.3 (2.7)^{d}	0.0 (0.7)^{h}	6.5 (2.6)^{e}	7.5 (2.8)^{e}	0.0 (0.7)^{e}	0.0 (0.7)^{g}	6.2 (2.5)^{f}	6.4 (2.6)^{f}	7.3 (2.7)^{d}	4.8 (2.1)^{d}
T2	Banana pulp	4.3 (2.1)^{g}	5.1 (2.3)^{e}	7.1 (2.7)^{d}	7.4 (2.8)^{cd}	6.9 (2.7)^{f}	6.5 (2.6)^{c}	8.6 (3.0)^{c}	6.2 (2.5)^{f}	5.2 (2.3)^{g}	4.8 (2.1)^{e}	6.2 (2.5)^{cd}
T3	Guava pulp	6.0 (2.5)^{f}	7.1 (2.7)^{d}	7.9 (2.9)^{c}	4.9 (2.3)^{f}	7.1 (2.7)^{f}	6.6 (2.6)^{c}	7.9 (2.8)^{d}	9.3 (3.1)^{c}	8.3 (2.9)^{d}	8.9 (2.9)^{c}	7.4 (2.8)^{c}
T4	Fish meal trap	7.9 (2.9)^{d}	0.0 (0.7)^{h}	7.4 (2.8)^{cd}	7.7 (2.8)^{c}	0.0 (0.7)^{g}	6.2 (2.5)^{c}	7.5 (2.8)^{b}	0.0 (0.7)^{h}	7.4 (2.8)^{e}	7.3 (2.7)^{d}	5.1 (2.1)^{cd}
T5	Jaggery (10 %)	0.0 (0.7)^{i}	1.6 (1.4)^{g}	1.7 (1.4)^{g}	0.0 (0.7)^{h}	0.0 (0.7)^{g}	0.0 (0.7)^{e}	2.6 (1.7)^{f}	2.1 (1.6)^{g}	0.0 (0.7)^{i}	2.7 (1.6)^{f}	1.1 (1.1)^{e}
T6	Honey solution	1.4 (1.3)^{h}	1.8 (1.5)^{f}	2.3 (1.6)^{f}	1.9 (1.5)^{g}	0.0 (0.7)^{g}	1.7 (1.4)^{d}	0.0 (0.7)^{g}	0.0 (0.7)^{h}	2.9 (1.8)^{h}	1.9 (1.3)^{g}	1.4 (1.3)^{e}
T7	Ammonium acetate (5 %)	5.9 (2.5)^{f}	5.1 (2.3)^{e}	6.2 (2.5)^{e}	7.1 (2.7)^{d}	8.1 (2.9)^{d}	0.0 (0.7)^{e}	6.4 (2.6)^{e}	7.4 (2.8)^{d}	0.0 (0.7)^{i}	7.4 (2.7)^{d}	5.4 (2.2)^{cd}
T8	Proteinex	17.0 (4.1)^{c}	16.8 (4.1)^{c}	16.3 (4.0)^{b}	14.9 (3.9)^{b}	11.7 (3.4)^{c}	9.4 (3.1)^{b}	11.3 (3.4)^{b}	6.8 (2.7)^{e}	13.1 (3.6)^{c}	15.3 (3.9)^{b}	13.3 (3.6)^{b}
T9	Methyl eugenol trap	76.4 (8.7)^{a}	69.6 (8.3)^{a}	70.7 (8.4)^{a}	67.0 (8.2)^{a}	65.2 (8.1)^{a}	46.7 (6.8)^{a}	42.7 (6.5)^{a}	39.9 (6.3)^{a}	36.6 (6.0)^{a}	31.2 (5.5)^{a}	54.6 (7.3)^{a}
T10	Cue lure trap	51.1 (7.1)^{b}	53.3 (7.3)^{b}	69.8 (8.3)^{a}	67.9 (8.2)^{a}	62.2 (7.9)^{b}	46.2 (6.8)^{a}	42.3 (6.5)^{a}	37.1 (6.1)^{b}	34.5 (5.9)^{b}	30.8 (5.5)^{a}	49.5 (7.0)^{a}
C.D. (0.05)		0.07	0.05	0.09	0.06	0.06	0.06	0.09	0.05	0.05	0.06	0.66
CV (%)		1.20	1.01	1.61	1.06	1.11	1.26	1.28	1.06	1.15	1.18	22.96

*Mean of three replications.

Figures in parentheses are $\sqrt{x+0.5}$ transformed values.

Mean ± SE; In a column, means followed by same letter are on par by DMRT (p = 0.05).

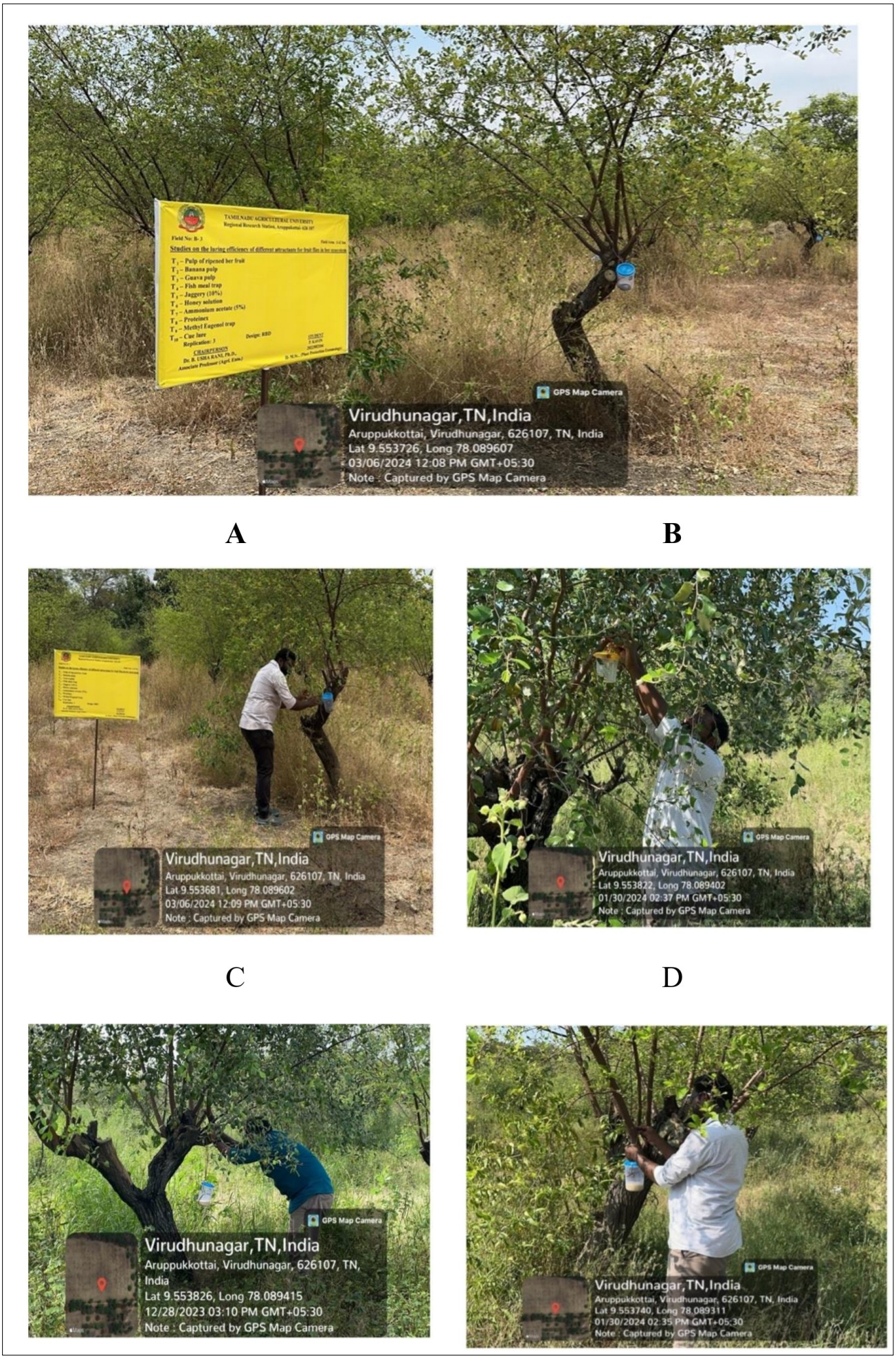

Fig. 1. Luring efficiency testing for different attractants in ber ecosystem.

In the 5th week, methyl eugenol (T9) showed highest efficacy of 65.2 fruit flies/trap, followed by cue lure (T10) traps with 62.2 fruit flies/trap. Proteinex (T8) captured 11.7 fruit flies/trap, followed by ammonium acetate (5 %) (T7) with 8.1 fruit flies/trap, while banana pulp (T2) had the lowest efficacy with 6.9 fruit flies/trap. In terms of the 6th week, methyl eugenol (T9) and cue lure (T10) traps captured 46.7 and 46.2 fruit flies/trap and were on par with each other and then they were followed by proteinex (T8) which showed 9.4 fruit flies/trap. Banana pulp (T2), guava pulp (T3) and fish meal trap (T4) recorded 6.5, 6.6 and 6.2 fruit flies/trap respectively and were on par with each other. The honey solution (T6) showed the least efficacy with a value of 1.7 fruit flies/trap.

The results from the 7th week showed that methyl eugenol (T9) and cue lure (T10) traps captured 42.7 and 42.3 fruit flies/trap respectively and were on par with each other. The treatment with proteinex (T8) and fish meal trap (T4) recorded 11.3 and 7.5 fruit flies/trap respectively and were on par with each other.

In the 8th week, methyl eugenol (T9) and cue lure (T10) traps captured 39.9 and 37.1 fruit flies/trap respectively, followed by proteinex (T8), which captured 6.8 fruit flies/trap (Table 2).

During the 9th week, the attractant methyl eugenol captured (T9) 36.6 fruit flies/trap, followed by the cue lure trap (T10) with 34.5 fruit flies/trap and then proteinex (T8) with 13.1 fruit flies/trap. The least efficacy recorded was 2.9 fruit flies/trap in honey solution (T6). The 10th week showed that methyl eugenol (T9) and cue lure (T10) traps captured 31.2 and 30.8 fruit flies/trap respectively and were on par with each other. The treatment proteinex (T8) showed 15.3 fruit flies/trap and honey solution (T6) recorded the least effective treatment with 1.9 fruit flies/trap.

On average, over the study period, the methyl eugenol trap (T9) and the cue lure trap (T10) captured a significantly higher mean of 54.6 and 49.5 fruit flies/trap and they were statistically on par with each other. The proteinex trap (T8) followed with a mean of 13.3 fruit flies/trap. Guava pulp (T3) showed moderate effectiveness, capturing an average of 7.4 fruit flies/trap. Other treatments, including fish meal trap, banana pulp and pulp of ripened ber and honey solution, exhibited lower average catches. Jaggery (T5) was consistently the least effective, with a mean of only 1.1 fruit flies/trap (Table 2).

Discussion

Methyl eugenol trap and cue lure traps consistently captured significantly the highest mean number of flies/trap (54.6 and 49.5 respectively) and they were statistically on par with each other. This was followed by the proteinex treatment, which attracted an average of 13.3 fruit flies/ trap. Guava pulp also showed moderate attraction with 7.4 fruit flies/trap. The present findings are in alignment with the previous reports, which stated that proteinaceous substrates were essential for the sexual maturation and ovary development of tephritid male and female fruit fly adults (17). The attractiveness of different protein food baits to female fruit flies concluded that the mixture of proteinex and 5 % ammonium acetate attracted more *B. correcta*, *B. dorsalis* and *B. cucurbitae* in guava (18). They also reported that a fruit fly diet and mango pulp with 5 % ammonium acetate could be used for the management of fruit flies in mango orchards.

Yeast and sucrose play a major role in the artificial diet of the fruit fly adults and the proportions of these were very crucial for the egg production of *B. dorsalis* (19). Previous trials that used only sugar as bait attracted a limited number of flies and they stated that the function of sugar was to stimulate the feeding rate, which was essential in insecticide bait sprays (20).

Protein-rich molasses and snake gourd pulp, when added to yeast and black jaggery in a 1:1:1 ratio along with acetic acid (5 %), captured fruit flies in the snake gourd ecosystem (21). Jaggery was found to be attractive to *Z. tau* (22). Proteinex + guava pulp and Proteinex + 5 % ammonium acetate are attractive to *B. correcta*, *B. dorsalis* and *Z. cucurbitae* (18). Ammonia-releasing components in food baits act as key factors in attracting female fruit flies (23). Ammonium acetate (5 %) is reported to stimulate the attractiveness of food baits to female fruit fly adults (18). The alluring capacity of food bait to the Mediterranean fruit fly, *C. capitata*, appears to increase with the release of ammonia from the bait (23). This was attributed to the fact that ammonia and its derivatives act as volatile cues for female fruit flies.

Conclusion

The study assessed the efficacy of various attractants in capturing *C. vesuviana* and *B. correcta*. Notably, no adults of *C. vesuviana* were captured using any of the tested attractants, including ripe fruit pulps, protein-based baits and commercially available lures. However, among the tested attractants for *B. correcta*, methyl eugenol (T9) and cue lure (T10) traps consistently outperformed the other treatments across all standard weeks. These traps captured the highest mean number of fruit flies per trap (54.6 and 49.5 respectively), significantly surpassing the other attractants. Proteinex (T8) showed moderate efficacy (13.3 fruit flies/trap), while guava pulp (T3) also demonstrated some effectiveness (7.4 fruit flies/trap). Other treatments, such as honey solution, fish meal, banana pulp and ripened ber pulp, had lower capture rates. Jaggery solution was the least effective attractant throughout the study. The results confirm that methyl eugenol and cue lure remain the most effective attractants for *B. correcta*, reinforcing their role in fruit fly management strategies. Future studies should explore alternative attractants for *C. vesuviana* and optimize baiting techniques to enhance trapping efficacy in ber orchards.

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Authors' contributions

KP was responsible for the planning, framework, editing and compilation of the review article and drafted the manuscript. UB contributed to editing and reviewing, while KJ participated in developing the concept, supervising the work and investigating the resources. SK, RKN and MML were responsible for editing, resource acquisition and reviewing and served as advisors. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

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