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**J Manikantha**  
Department of Entomology,  
Agricultural College and  
Research Institute, Madurai,  
Tamil Nadu, India

**Zadda Kavitha**  
Department of Agricultural  
Entomology, Agricultural  
College and Research Institute,  
Madurai, Tamil Nadu, India

**M Shanthi**  
Centre for Plant Protection  
Studies, TNAU, Coimbatore,  
Tamil Nadu, India

**K Subaharan**  
National Bureau of Agricultural  
Insect Resources, Bengaluru,  
Karnataka, India

**Corresponding Author**  
**J Manikantha**  
Department of Entomology,  
Agricultural College and  
Research Institute, Madurai,  
Tamil Nadu, India

## Field evaluation of attractiveness of protein and food baits to the cucurbit fruit fly, *Zeugodacus cucurbitae* Coquilett

**J Manikantha, Zadda Kavitha, M Shanthi and K Subaharan**

### Abstract

Field tests were carried out in snake gourd and bitter gourd fields located at Peraiyur, Madurai district, Tamil Nadu to determine the effectiveness of protein baits i.e., protineX®, & soybean bait and natural food baits i.e., tomato & banana bait in capturing melon fruit fly, *Zeugodacus cucurbitae*. The results indicated that protineX® bait attracted more adult flies than all other baits. Soybean bait ranked next to protineX® which was followed by tomato and banana pulp bait. The majority of the fruit flies collected in the traps were females, revealing that females were drawn to protein sources more than males for their relative higher protein requirements for female growth and sexual maturation.

**Keywords:** *Zeugodacus cucurbitae*, ProtineX® bait, Soybean bait, Tomato bait, Banana bait, Male to female ratio

### Introduction

Vegetables are one of the most essential components of Indian horticulture and India is the second largest producer of vegetables across the world next to China (Panday *et al.*, 2009) [1]. Among the vegetable crops, cucurbits are the most important ones due to rich in ascorbic acid, iron and dietary fibre and also in Vit A, Vit C, Vit B6, manganese, potassium, magnesium etc. It also boosts up the immune power and has high antibiotic quality. Cucurbits are the members of the Cucurbitaceae family comprising of 118 genera and 825 species across the world (Jeffrey 1990). A variety of major (Cucumber, melon, pumpkin, squash and gourd, and watermelon) and minor cucurbits (Bitter gourd, bottle gourd, wax gourd, sponge and ridge gourd, and snake gourd) are grown in India, accounting for around 5.6 per cent of total vegetable production. Cucurbit fruits are consumed in various forms like salads (cucumber, gherkins and long melon), sweet (ash gourd, pointed gourd), pickles (gherkins) and desserts (melons). Consuming cucurbit fruits aids in blood purification, improved digestion, increased energy levels and constipation relief in the human body. Melon fruit fly, *Zeugodacus cucurbitae* Coquilett (Tephritidae: Diptera) is the most devastating pest of cucurbits causing direct yield losses. Bitter gourd, melon, sponge gourd and ash gourd are the most preferred hosts of this fruit fly. The fruit flies are polyphagous pests that damage a variety of horticulture crops. Most commonly fruit flies attack the soft bodied vegetables and fruits such as pumpkin, bitter gourd, snake gourd, ridge gourd, water melon, muskmelon, mango, guava, orange etc. The melon fruit fly, *Z. cucurbitae* infests over a hundred different fruits and vegetables (Dhillon *et al.*, 2005) [2]. Based on the cucurbit species and season, losses due to *Z. cucurbitae* ranges from 30 to 100 per cent (Dhillon *et al.*, 2005; Shooker *et al.*, 2006) [2, 14]. According to Jakhar *et al.*, 2020 [7], melon fruit fly causes 40 to 60 per cent damage in vegetable crops in India. Cucurbit fruit fly preferred immature and young fruits and also resulted in the loss of female flowers to the extent of 9.7 per cent. More than a quarter (26%) of total fruits set, were dropped or damaged shortly after setting and another 14.04 per cent were destroyed during the harvesting stage, leaving only 38.8% of marketable fruits (Sapkota *et al.*, 2010) [13]. Spraying of insecticides is ineffective for the management of fruit flies because their damaging stage i.e., maggots remain inside the fruit and are not directly exposed to the sprayed insecticides. Moreover, insecticide sprays leave the vegetables with insecticide residues. Continuous use of insecticides has resulted in unforeseen consequences on human health and has contaminated the environment (Khan, 2019) [8]. So, exploring alternate ways of management of fruit flies is most important among which employing attract and kill strategy has derived much attention by the researchers.

Hence, the present study was conducted to evaluate different protein and food baits in attracting melon fruit flies in bitter gourd and snake gourd fields.

### Materials and Methods

The present study was conducted to evaluate the trapping efficiency of protein (ProtineX and Soybean) and food (Tomato and Banana) baits in attracting melon fruit flies in bitter gourd (9.7321° N, 77.6668° E) and snake gourd (9.7514° N, 77.7789° E) fields at Peraiyur village, Sedapatti block, Madurai, Tamil Nadu. ProtineX and Soybean baits were prepared by adding 100 g of Protienex powder and 100 g of soybean powder respectively to 1000 ml of water containing 100 g of jaggery, 50 g of ammonium acetate, 20 g of borax and 0.001% malathion. Tomato and Banana baits were prepared by adding 100 ml of tomato pulp and 100 ml of banana pulp respectively to 1000 ml of water containing 100 g of jaggery, 50 g of ammonium acetate, 20 g of borax and 0.001% malathion. Jaggery was used to increase the attractiveness of bait (Thomas and Mangan, 2005) [16]. Borax was added to all the treatments to prevent the decomposition of trapped flies (Ekesi *et al.*, 2014) [4] and to boost the alkalinity of the bait (Heath *et al.*, 1994) [6]. Plastic containers of 10 cm diameter and 20 cm height of 1 litre capacity were modified as fruit fly traps. Four square shaped holes of 20 mm<sup>2</sup> size were made in the middle in all the four sides of the container with a heated blade to allow the entry of attracted fruit flies inside the trap. The prepared baits were allowed for fermentation for 36 hours and poured in the traps @ 200 ml/trap. Negative control of protein bait, negative control of food bait and untreated control in which traps alone were placed. Traps were tied at a height of 1.5 to 2 meters to the iron wires of pandal with the help of jute coir under shade. Three replications were maintained. An isolation distance of 50 meters was maintained between the treatments and replications. Adult flies trapped in all the treatments and replications were recorded daily up to 15 days continuously. As evaporation of water content in the baits occurred, water was added in the traps to maintain 200 ml of bait in the traps. Number of males and females trapped in the different baits were recorded separately and arrived male to female ratio.

### Result

#### Snake gourd

#### Evaluation of attractiveness of the protein and food baits to the melon fruit flies

In snake gourd, in ProtineX® and soybean bait traps, trap catch was increased gradually from I day after placement of traps (DAPT) to V DAPT. In ProtineX® bait traps, the trap catch was 1.67 fruit flies / trap on I DAPT and it was 5.67 on V DAPT. In soybean bait traps on I DAPT, 1 fruit fly per trap was recorded which was gradually increased to 3.67 at V DAPT. In both these protein bait traps, on VI DAPT, a sudden increase in the number of fruit flies trapped was observed (11.33 and 6.67/trap in ProtineX® and soybean traps respectively). From VI DAPT, trap catch was increased and reached its peak on X DAPT i.e., 19.00 and 15.67/trap in ProtineX® and soybean traps respectively. From XI DAPT, number of fruit flies trapped in the protein baits decreased and on XV DAPT, trap catch in both the protein traps was 1.67/trap. ProtineX® bait attracted more number of fruit flies on X DAPT (19.00/trap) and it was significantly more when compared to the other days. It was followed by IX DAPT (17.00/trap) and VIII DAPT (16.33/trap) and both were on par

with each other (Table 1). In soybean bait, maximum trap catch recorded was 15.67 on X DAPT followed by IX DAPT (11.00/trap) and VIII DAPT (9.33/trap).

With regard to the food baits, from I DAPT to VII DAPT, gradual increase in the number of fruit flies trapped was noted. On VIII DAPT, a sudden increase in trap catch was observed. In tomato and banana bait traps number of attracted fruit flies on I DAPT and VII DAPT were 1.00 & 4.67 and 1.00 & 4.00 respectively. However, from X DAPT, trap catch started to decline and on the XV DAPT, it was 1.00 and 0.67 in tomato and banana bait traps respectively. The attraction of tomato pulp bait to fruit flies was more on IX DAPT with 9.33 fruit flies/trap followed by IX DAPT (8.67/trap) and VIII DAPT (4.67/trap). The same trend was noticed with the banana bait trap also. Maximum number of fruit flies attracted was 6.33/banana bait trap on VIII DAPT followed by IX DAPT (5.33/trap) and VII DAPT (4.00/trap). Among the baits evaluated, ProtineX® bait was ranked first with the total number of 120.67 fruit flies/trap/15 days and next to this was soybean bait with 75.00 fruit flies /trap/15 days. Food baits were found to be comparatively less attractive than the protein baits as tomato and banana pulp baits recoded a total trap catch of 51.00 and 36.67 fruit flies /trap/15 days respectively.

#### Male to female ratio of fruit flies

Male to female ratio of fruit flies trapped in the ProtineX® bait and soybean bait was in the range of 0.38:1 to 0.67:1 and 0.27:1 to 0.75:1 respectively (Table 2). In ProtineX® bait traps, more number of female flies were observed from VIII DAPT to XII DAPT and in soybean bait traps, it was from VIII DAPT to XI DAPT (Fig 1). This clearly indicated that the protein baits attracted more number of female fruit flies than the males. Male to female ratio of fruit flies in the food baits i.e., tomato bait and banana bait, ranged from 0.33:1 to 0.83:1 and 0.20:1 to 1.00:1 respectively (Table 2). The number of female flies attracted was more from the V DAPT to IX DAPT in tomato pulp bait traps and from the VI DAPT to XI DAPT in banana bait traps (Fig 2). The above ratios indicated that the food bait traps have attracted more females than the male fruit flies.

#### Evaluation of attractiveness of the protein and food baits to the adult melon fly in bitter gourd ecosystem.

In bitter gourd, in protinex bait traps, number of fruit flies attracted was gradually increased from I day after placement of traps (DAPT) to VI DAPT from 1.67 to 6.67 fruit flies/trap. In soybean bait traps, gradual increase in trap catch was observed from I DAPT (1 fruit fly/trap) to VII DAPT (6.67 fruit fly/trap). In protinex and soybean bait traps, a sudden increase in the number of fruit flies trapped was recorded on VII DAPT (11.33 FF/trap) and VIII DAPT (10.33 FF/trap) respectively. The number of fruit flies attracted has reached its peak on IX DAPT (15.33 FF/trap) and on VIII DAPT (10.33 FF/trap) in ProtineX® and soybean traps respectively. Decline in the number of fruit flies trapped was noted from IX DAPT and VIII DAPT in the protinex and soybean baits respectively. On XV DAPT, trap catch in protinex was 2.00 FF/trap and in soybean it was 1.67 FF/trap.

In the food baits, gradual increase in the number of fruit flies attracted was observed from I DAPT (0.67 FF/trap) to VIII DAPT (5.67 FF/trap) in tomato bait and from I DAPT (0.67 FF/trap) to VII DAPT (4.33 FF/trap) in banana bait. Trap catch was increased suddenly on IX DAPT (8.00 FF/trap) and VIII DAPT (7.00 FF/trap) in tomato and banana bait traps

respectively. The trap catch has started to reduce in tomato from X DAPT and banana bait from VIII DAPT and on the XV DAPT, it was 1.67 and 1.00 in tomato and banana bait traps respectively. Among the baits evaluated, ProtineX® bait was ranked first with the total trap catch of 97.33 fruit flies/trap/15 days and next to this was soybean bait with 64.33 fruit flies /trap/15 days. Comparatively less number of fruit flies were attracted in the food bait traps than the protein bait traps as tomato and banana pulp bait traps have recorded a total trap catch of 47.00 and 41.33 fruit flies /trap/15 days respectively.

**Male to female ratio of fruit flies**

In the ProtineX® bait and soybean baits, male to female ratio

of fruit flies trapped ranged from 0.41:1 to 0.75:1 and 0.33:1 to 0.80:1 respectively (Table 4) showing that the protein baits attracted more number of female fruit flies than the males. In ProtineX® bait traps, more number of female flies were observed from VII DAPT to X DAPT and in soybean bait traps, it was from VIII DAPT to X DAPT (Fig 3). Male to female ratio of fruit flies was in the range from 0.33:1 to 1.00:1 and 0.25:1 to 1.00:1 in tomato bait and banana bait respectively (Table 4). Attraction of baits to female fruit flies was more from VII DAPT to IX DAPT in tomato pulp bait traps and from VII DAPT to IX DAPT in banana bait traps (Fig 4). The food baits also were found to be more attractive to females than the male fruit flies.

**Table 1:** Evaluation of protein and food baits to attract melon fruit flies – Snake gourd

Days after placement of the trap	Total number of fruit flies attracted/trap – Snake gourd			
	ProtineX® bait	Soybean bait	Tomato bait	Banana bait
I	1.67 (1.29) <sup>g</sup>	1.00 (0.80) <sup>e</sup>	1.00 (0.80) <sup>fg</sup>	1.00 (0.80) <sup>cd</sup>
II	2.33 (1.52) <sup>fg</sup>	1.33 (1.14) <sup>de</sup>	1.67 (1.28) <sup>cdef</sup>	2.00 (1.38) <sup>abcd</sup>
III	2.67 (1.63) <sup>fg</sup>	2.33 (1.52) <sup>de</sup>	1.67 (1.28) <sup>cdef</sup>	2.00 (1.41) <sup>abcd</sup>
IV	4.67 (2.16) <sup>de</sup>	2.67 (1.63) <sup>de</sup>	2.67 (1.63) <sup>cde</sup>	1.67 (1.28) <sup>bcd</sup>
V	5.67 (2.38) <sup>de</sup>	3.67 (1.90) <sup>cd</sup>	3.00 (1.72) <sup>cde</sup>	2.67 (1.61) <sup>abcd</sup>
VI	11.33 (3.37) <sup>c</sup>	6.67 (2.58) <sup>bc</sup>	4.33 (2.08) <sup>bcd</sup>	3.33 (1.82) <sup>abcd</sup>
VII	14.00 (3.74) <sup>bc</sup>	7.67 (2.77) <sup>bc</sup>	4.67 (2.16) <sup>abc</sup>	4.00 (1.99) <sup>abc</sup>
VIII	16.33 (4.04) <sup>ab</sup>	9.33 (3.05) <sup>b</sup>	8.67 (2.94) <sup>ab</sup>	6.33 (2.51) <sup>a</sup>
IX	17.00 (4.12) <sup>ab</sup>	11.00 (3.31) <sup>ab</sup>	9.33 (3.05) <sup>a</sup>	5.33 (2.30) <sup>ab</sup>
X	19.00 (4.36) <sup>a</sup>	15.67 (3.96) <sup>a</sup>	4.67 (2.16) <sup>abc</sup>	2.00 (1.38) <sup>abcd</sup>
XI	11.67 (3.41) <sup>c</sup>	6.33 (2.51) <sup>bc</sup>	3.67 (1.91) <sup>de</sup>	2.33 (1.52) <sup>abcd</sup>
XII	6.67 (2.58) <sup>d</sup>	2.33 (1.52) <sup>de</sup>	1.33 (1.14) <sup>efg</sup>	1.67 (1.28) <sup>bcd</sup>
XIII	3.67 (1.91) <sup>ef</sup>	2.00 (1.38) <sup>de</sup>	2.00 (1.38) <sup>cdef</sup>	1.00 (0.80) <sup>cd</sup>
XIV	2.67 (1.63) <sup>fg</sup>	1.33 (1.14) <sup>de</sup>	1.67 (1.28) <sup>cdef</sup>	0.67 (0.67) <sup>d</sup>
XV	1.67 (1.28) <sup>g</sup>	1.67 (1.24) <sup>de</sup>	1.00 (0.80) <sup>fg</sup>	0.67 (0.67) <sup>d</sup>
S.Ed	0.13239	0.24187	0.25753	0.32789
P value	0.000	0.000	0.000	0.000

Mean of three replications

Figures in parentheses are square root transformed values

Means followed by the same letter in a column are not significantly different by Tukey’s HSD test. (P=0.05)

**Table 2:** Male to female ratio of melon fruit flies trapped in protein and food baits – Snake gourd

Days after placement of the trap	Male to female ratio			
	ProtineX® bait	Soybean bait	Tomato bait	Banana bait
I	0.67:1	0.50:1	0.50:1	0.50:1
II	0.40:1	0.33:1	0.67:1	0.50:1
III	0.60:1	0.40:1	0.67:1	0.50:1
IV	0.56:1	0.60:1	0.60:1	0.67:1
V	0.42:1	0.57:1	0.50:1	0.60:1
VI	0.62:1	0.54:1	0.44:1	0.43:1
VII	0.62:1	0.64:1	0.40:1	0.33:1
VIII	0.45:1	0.40:1	0.44:1	0.46:1
IX	0.38:1	0.27:1	0.47:1	0.33:1
X	0.46:1	0.38:1	0.75:1	0.20:1

XI	0.46:1	0.46:1	0.83:1	0.40:1
XII	0.43:1	0.75:1	0.33:1	0.67:1
XIII	0.57:1	0.50:1	0.50:1	0.50:1
XIV	0.60:1	0.33:1	0.67:1	1.00:1
XV	0.67:1	0.67:1	0.50:1	1.00:1

**Table 3:** Evaluation of protein and food baits to attract melon fruit flies – Bitter gourd

Days after placement of the trap	Total number of fruit flies attracted – Bitter gourd			
	ProtineX® bait	Soybean bait	Tomato bait	Banana bait
I	1.67 (1.28) <sup>h</sup>	1.00 (1.00) <sup>f</sup>	0.67 (0.67) <sup>e</sup>	0.67 (0.67) <sup>c</sup>
II	2.00 (1.38) <sup>gh</sup>	1.33 (1.14) <sup>ef</sup>	1.00 (0.80) <sup>de</sup>	0.67 (0.67) <sup>c</sup>
III	2.33 (1.52) <sup>gh</sup>	2.33 (1.52) <sup>ef</sup>	1.67 (1.28) <sup>cdef</sup>	1.00 (0.80) <sup>c</sup>
IV	4.33 (2.07) <sup>ef</sup>	3.00 (1.72) <sup>de</sup>	2.33 (1.52) <sup>bcdef</sup>	1.67 (1.28) <sup>bc</sup>
V	5.33 (2.29) <sup>ef</sup>	3.00 (1.72) <sup>de</sup>	2.00 (1.38) <sup>abcdef</sup>	2.00 (1.38) <sup>abc</sup>
VI	6.67 (2.58) <sup>de</sup>	5.33 (2.31) <sup>cd</sup>	4.33 (2.06) <sup>abc</sup>	2.33 (1.52) <sup>abc</sup>
VII	11.33 (3.36) <sup>bc</sup>	6.67 (2.58) <sup>abc</sup>	4.67 (2.16) <sup>abc</sup>	4.33 (2.08) <sup>ab</sup>
VIII	13.67 (3.70) <sup>ab</sup>	10.33 (3.21) <sup>a</sup>	5.67 (2.38) <sup>ab</sup>	7.00 (2.64) <sup>a</sup>
IX	15.33 (3.91) <sup>a</sup>	9.33 (3.05) <sup>ab</sup>	8.00 (2.82) <sup>a</sup>	6.67 (2.58) <sup>a</sup>
X	12.00 (3.46) <sup>ab</sup>	8.33 (2.87) <sup>abc</sup>	5.33 (2.31) <sup>ab</sup>	5.00 (2.23) <sup>ab</sup>
XI	8.33 (2.89) <sup>cd</sup>	5.67 (2.37) <sup>bcd</sup>	3.67 (1.91) <sup>abcd</sup>	3.00 (1.72) <sup>abc</sup>
XII	6.33 (2.51) <sup>de</sup>	2.67 (1.63) <sup>e</sup>	2.33 (1.49) <sup>bcde</sup>	2.00 (1.38) <sup>abc</sup>
XIII	3.67 (1.91) <sup>fg</sup>	2.00 (1.41) <sup>ef</sup>	2.00 (1.38) <sup>bcde</sup>	2.33 (1.52) <sup>abc</sup>
XIV	2.33 (1.52) <sup>gh</sup>	1.67 (1.24) <sup>ef</sup>	1.67 (1.05) <sup>cde</sup>	1.67 (1.05) <sup>bc</sup>
XV	2.00 (1.41) <sup>gh</sup>	1.67 (1.14) <sup>ef</sup>	1.67 (1.28) <sup>bcde</sup>	1.00 (1.00) <sup>bc</sup>
S.Ed	0.14898	0.18526	0.33560	0.34470
P value	0.000	0.000	0.000	0.000

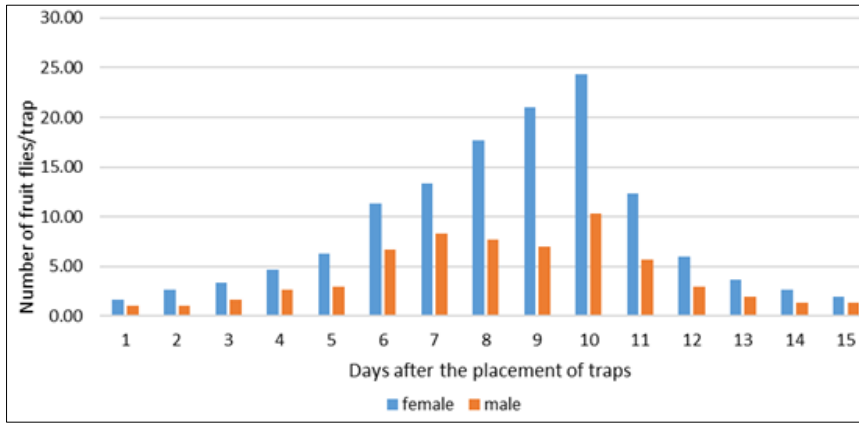
Mean of three replications

Figures in parentheses are square root transformed values

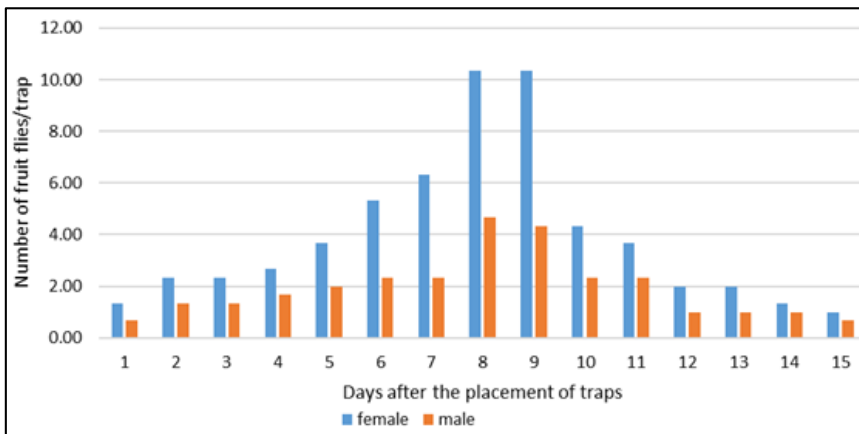
Means followed by the same letter in a column are not significantly different by Tukey's HSD test. (P=0.05)

**Table 4:** Male to female ratio of melon fruit flies trapped in protein and food baits – Bitter gourd

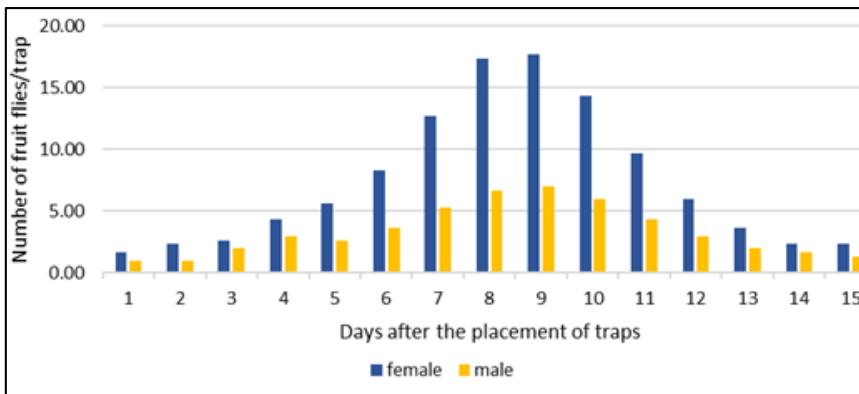
DAP	Male to female ratio			
	ProtineX® bait	Soybean bait	Tomato bait	Banana bait
I	0.67:1	0.50:1	1.00:1	1.00:1
II	0.50:1	0.33:1	0.50:1	0.00:1
III	0.75:1	0.75:1	0.67:1	0.50:1
IV	0.63:1	0.80:1	0.40:1	0.67:1
V	0.45:1	0.50:1	0.50:1	0.50:1
VI	0.43:1	0.45:1	0.44:1	0.40:1
VII	0.42:1	0.43:1	0.40:1	0.44:1
VIII	0.41:1	0.35:1	0.42:1	0.31:1
IX	0.44:1	0.33:1	0.33:1	0.25:1
X	0.44:1	0.39:1	0.45:1	0.50:1
XI	0.47:1	0.42:1	0.57:1	0.50:1
XII	0.46:1	0.60:1	0.40:1	0.50:1
XIII	0.57:1	0.50:1	0.50:1	0.75:1
XIV	0.75:1	0.67:1	0.67:1	0.67:1
XV	0.50:1	0.67:1	0.67:1	0.50:1



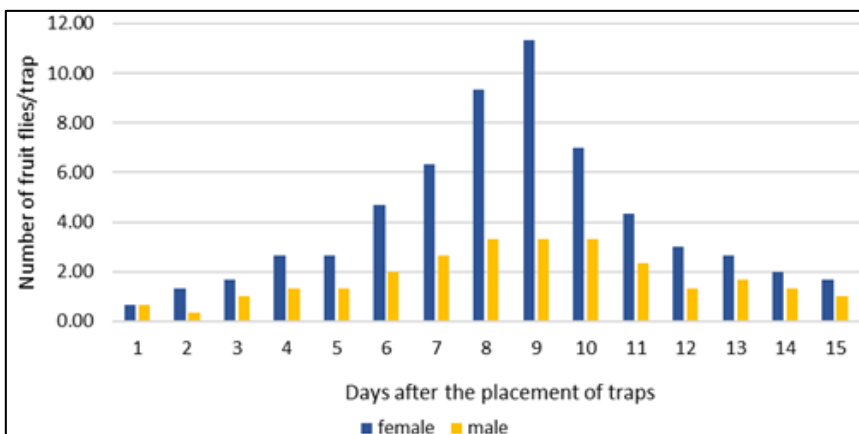
**Fig 1:** Number of males and females trapped in protein baits in snake gourd ecosystem



**Fig 2:** Number of males and females trapped in food baits in snake gourd ecosystem



**Fig 3:** Number of males and females trapped in protein baits in bitter gourd ecosystem



**Fig 4:** Number of males and females trapped in food baits in bitter gourd ecosystem

## Discussion

In the present study, both the protein (soybean and protinex®) and food baits (tomato and banana) were found to be attractive to melon fruit flies in bitter gourd and snake gourd. However, protein baits were more effective in trapping the cucurbit fruit flies. The attractiveness of protein based baits to fruit flies was also confirmed by Putruele *et al.* (1993) [12] who reported that 10% protein hydrolysate along with 1.5% mercapton was more effective in attracting mediterranean fruit fly, *Ceratitidis capitata*. Attraction of protein baits to fruit flies is due to their protein requirements for development and maturity which is in accordance with the statement of Drew and Yuval, 2000 [3] that both male and female need a protein-rich diet to thrive and reach sexual maturity immediately after emergence.

In bitter gourd ecosystem, in protein and food baits, male to female ratio of fruit flies trapped was ranged from 0.33:1 to 0.80:1 and 0.25:1 to 1:1 respectively. In snake gourd fields, in protein and food baits, male to female ratio of fruit flies trapped was ranged from 0.27:1 to 0.75:1 and 0.20:1 to 1.00:1 respectively. This proved that both protein and food baits were more attractive to female fruit flies than the males. The present study was also supported by the findings of Enkerlin and Reyes-Flores (2018) [5] that the protein-based attractants are female-biased, capturing on average 60% females and 40% males. Yugendra *et al.* (2020) [17] reported that in guava, a combination of protinex (20%), yeast (10%) and 5% ammonium acetate attracted considerably more number of female *Bactrocera dorsalis* in guava orchards in Dharwad. Abinaya *et al.* (2020) [1] evaluated that three food baits i.e., guava pulp bait, muskmelon pulp bait and guava+muskmelon bait in ridge gourd and snake gourd fields in Coimbatore and Tiruppur of Tamil Nadu and reported that among the total trapped fruit flies of melon fruit fly, *Z. cucurbitae*, 70% are females and 30% are males. AB Sruthi *et al.* (2021) [15] reported that among the fruit flies caught in the protein and food bait, majority were females proving the fact that females were attracted more towards the protein sources than males because females need comparatively more protein for their development and sexual maturation. Reduction in the attractiveness of all the tested baits was recorded after the VIII to IX DAPT due to the drying of baits and loss of volatiles. This was in close agreement with the findings of Lucci Freitas *et al.* (2014) [9] who reported that exposure of baits in field conditions made the baits dry and decreases its attractiveness.

## Conclusion

The present study concluded that protein and food based baits were proved to be attractive to the melon fruit flies, *Z. cucurbitae* in snake gourd and bitter gourd. Food baits were found to be less attractive as they have trapped less number of flies compared to protein baits. More number of female fruit flies were trapped in protein and food baits than males which is a positive factor in reducing the population in the fields as females are the key factor for multiplication.

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