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Species diversity and efficacy of different food baits for management of *Bactrocera* spp. under Terai region of West Bengal

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Abstract
An experiment was conducted to evaluate the efficacy of different food bait prepared from ripened fruit pulps for attraction of *Bactrocera* species at Pundibari, cochlear, West Bengal during the year 2017 and 2018 at farmer field. Self-made transparent rectangular PET plastic jars around 1 liter capacity and having four circular holes of 1 cm in diameter on four sides of the jar just below the shoulder of the bottle (i.e. 1/ 3rd from top) openings for the entry of flies. The mean values of fly capture of two years pooled data (2017 and 2018) has revealed that statistically highest efficacy of mean number (7.88 flies/trap/day) of flies was captured in T_2 (Grape pulp+ 0.5 ml Spinosad 45% SC) and lowest mean number of flies was captured in T_5 (Papaya pulp + 0.5 ml Spinosad 45% SC) trap (2.75 flies/trap/day) at 1st DAI. When overall mean values of trap-catch were considered, highest efficacy was noted by using T_2 (Grape pulp+ 0.5 ml Spinosad 45% SC) (3.00 flies/trap/day) as bait material followed by T_1 (Banana pulp+ 0.5 ml Spinosad 45% SC) (2.47 flies/trap/day), however, two bait material had statistically superior among all the treatments. On the contrary, T_5 (Papaya pulp + 0.5 ml Spinosad 45% SC) trap (0.91 flies/trap/day) followed by T_6 (Pineapple pulp + 0.5 ml Spinosad 45% SC) trap (1.38 flies/trap/day) recorded the lowest number of flies trapped. These results showed that the efficacy of all the bait materials gradually decreased over time, i.e. at days after preparation and placement of baits. This gradual decrease in the efficacy of the baits may be due to evaporation, drying and other environmental factors. Among the species diversity, only three species were identified *B. cucurbitae, B. dorsalis* and *B. correcta.* The dominant species was noted *B. cucurbitae* range from (48.28%-52.08%) followed by *B. dorsalis* (40.91%- 44.62%) and *B. correcta* (4.62%- 11.46%).

Keywords: *Bactrocera,* species diversity, fruit pulp, pet plastic jars, spinosad and attraction

1. Introduction
Growing of vegetables is a remunerative venture in Indian agriculture. It provides nutrition to the human beings; strengthen the rural economy as well as livelihood. India is the world's largest producer of tropical and subtropical fruits and vegetables. In the year 2015-16 total area under production of fruit and vegetables was 6.301 and 10.106 million ha, respectively while their production was 90.183 and 169.064 million tonnes, respectively (Horticultural Statistics at a Glance, 2017) [1]. The agro-ecological situation of terai region of West Bengal favours cultivation of diverse categories of vegetables. Cucurbit is one of them that constitute a large group of important vegetables. Terai region of West Bengal experienced a typical sub-tropical per humid climate with high rainfall, high relative humidity and moderate temperature coupled with prolong winter and high residual soil moisture which befit the zone for cultivation of a number of seasonal vegetables including cucurbits. According to Jana, 2007, both production and productivity of cucurbits in this zone is rising in such a quantum that after being self-sufficient, it also become able to supply large quantity to neighboring states and countries as well [2]. But the crops suffer intense insect-pests attack due to favourable conditions available for their multiplication.

A large number of insect-pests start attacking the crop right from seedling stage and continued till harvesting of the fruit and the most devastating melon fruit fly, *Bactrocera (Dacus) cucurbitae* (Coq.) resulting in both qualitative and quantitative loss of the produce. Melon fruit fly (Diptera: Tephritidae: Dacinae) is the key pest of cucurbits and is geographically distributed throughout the tropics and subtropics of the world (Drew, 1992 [3]. and Chinajariyawong *et al.*, 2003 [4], especially in most of the countries of South East Asia (All wood *et al.*, 1999) [5]. The fruit fly, *B. cucurbitae* (Coq.) (Diptera: Tephritidae)

which attacks the ultimate economic part, i.e. fruits of the crop, is one of the most important biotic limiting factors and alone can inflict yield loss in different cucurbitaceous vegetables ranging from 30-100% depending upon cucurbit species and the season (Dhillon et el., 2005a, Shooker *et al*., 2006) [6, 7]. The melon fruit fly also poses major threat to global trade, since many countries have invoked restrictions to minimize the risk of establishment of exotic species and identified as one of the five most important pests of agriculture in South East Asia (Waterhouse, 1993). Therefore, successive cultivation and export is highly dependent upon sound pest management system (Puri and Mote, 2003) [8, 9]. Considering the peculiarity in life history of this dreaded pest, most of the efforts in fruit fly management have focused on mature adult through the use of bait traps (McQuate *et el.*, 2005) [10], Cuelure traps (Inayatullah *et al.*, 1991) [11] and sterile insect technique (Hendrichs *et el.*, 2002) [12]. The maggots after getting matured within the infested fruit come out of it and spend a brief dispersal period. Then the mature third instar maggot burrows into soil and pupate therein. Thus, there remain immense scope of fly management targeting the late instar maggot and pupae. Exposing them to unfavourable environmental conditions during pupation is known to have a negative impact on survival of the fly (Jackson *et el.*, 1998) [13].

Attractive food materials can be promising alternatives to synthetic sex pheromones, especially in the emerging scenario of organic farming. Several food substances such as molasses, wheat bran, sucrose, yeast, protein hydrolysates and fishmeal waste have earlier been tested as *B. curcubitae* attractants (Chambers, 1977; Pawer *et al.*, 1984; Metcalf, 1990; Soundar Rajan *et al.*, 1996) [14-17]. We report the results of a series of field experiments conducted during 2000–2001 at the Agricultural College and Research Institute (AC and RI), Killikulam, and also in a privately owned farm, to study the attraction of *B. cucurbitae* towards some easily available food-based attractants.

2. Materials and methods

The base baits has been prepared by using different ripen fruit pulp *viz* banana, grape, guava, mango, papaya, jackfruit and pineapple. With the help of juicer mixer, semi-solid fruit pulp was prepared. The food baits consist of 40 g base bait mix with 0.5 ml of poison 5% (Spinosad 45% SC). Self-made transparent rectangular PET plastic jars around 1 liter capacity were used and having four circular holes of 2 cm in diameter on four sides of the jar just below the shoulder of the bottle (i.e. 1/ 3rd from top) openings for entry of flies. A warm pen knife or soft drill facilitated the slitting/drilling of a hole. In addition, four random holes of 2-3 mm diameter punched at the bottom with warm needles to allow drainage of water that may get collected in the bottle due to rain. The food baits was placed at base of traps. The trap was hanged from the grid support for the cucurbits vines at 1 m above the ground level in the field. The experiment was laid out in a randomized block design (RDB) with six treatments replicated four times. The traps in a replication were randomly set at 10m spacing in a row and each replication was 20 m away from the next. Comparative efficacy and attract abilitys of these food baits were evaluated in terms of annihilation of adult flies from the environment. The details of the treatments were as T_1- 40 g Banana pulp + 0.5 ml Spinosad 45% SC, T_2- 40 g Grape pulp + 0.5 ml Spinosad 45% SC, T_3- 40 g Guava pulp + 0.5 ml Spinosad 45% SC, T_4- 40 g Mango pulp + 0.5 ml Spinosad 45% SC, T_5- 40 g Papaya pulp + 0.5 ml Spinosad 45% SC and T_6- 40 g Pinapple pulp + 0.5 ml Spinosad 45% SC. Daily observations on the total number of fruit flies trapped in each treatment, till zero catch in the individual trap was recorded.

2.1 Species diversity determination: The adult flies collected by using sex attractants were critically examined under stereo-binocular microscope for their characteristic morphological features and identified by following the appropriate taxonomic keys of tephritids (R.A.I Drew 1989[18], V.C. Kapoor 1970) [19].

After proper identification, percentages of each category of species were determined as follows:

$$\% \text{ of a species} = \frac{\text{Number of individual of that particular species}}{\text{Total number individual}} \text{x100.}$$

3. Results and Discussion

Efficacy of different food bait prepared from ripened fruit pulps for attraction of *Bactrocera* spp. in different treatments during the first year of experimentation (2017-18) from Days After Installation (DAI) is depicted (Table-1, Fig.1) that the efficacy of treatment T_2 (7.25 flies/ trap/ day) in which grape pulp was used as food bait captured maximum mean number of flies followed by T_1 (6.00 flies/ trap/ day) and minimum in T_5 (2.25 flies/ trap/ day) at 1st days after installation. Significantly highest number of flies/trap/day was captured in T_2 (Grape pulp+ 0.5 ml Spinosad 45% SC) and significantly lowest number of flies was captured in T_5 (Papaya pulp + 0.5 ml Spinosad 45% SC) trap throughout the period. Highest trap-catch was noticed on the very first day followed by 2nd and 3rd day in all the treatments. After 3rd day of installation it became zero in all the treatments. These results showed that the efficacy of all the food bait materials gradually decreased over time, i.e. at days after installation. This gradual decrease in the efficacy of the baits may be due to evaporation, drying and other environmental factors. The relative efficacy of food baits in different treatments to attract flies was in order of $T_1 > T_2 > T_4 > T_3 > T_6 > T_5$. Since these treatments had differences in food bait constituents only it could be predicated that food baits had a pronounced influence on the efficacy of attraction of *Bactrocera* spp.

A perusal of 2018-19 data given in (Table 1, Fig. 2) depicted that maximum efficacy of mean number of flies captured was recorded in treatment T_2 (8.50 flies/ trap/ day) and minimum in T_5 (3.25 flies/ trap/ day) at 1st DAI and then a decreasing trend was recorded almost similar to that of the previous year. The relative efficacy of different treatments followed the same trend as in previous year. Overall trapping of flies in second year in different treatments was more as compared with the previous year.

However, the mean values of fly capture of two years pooled data (2017 and 2018) has been depicted in (Table-1 and Fig-3) reveals that the statistically highest efficacy of mean number (7.88 flies/trap/day) of flies was captured in T_2 (Grape pulp+ 0.5 ml Spinosad 45% SC) and lowest mean number of flies was captured in T_5 (Papaya pulp + 0.5 ml Spinosad 45% SC) trap (2.75 flies/trap/day) at 1st DAI. When overall mean values of trap-catch were considered, highest efficacy was noted by using T_2 (Grape pulp+ 0.5 ml Spinosad 45% SC) (3.00 flies/trap/day) as bait material followed by T_1 (Banana pulp+ 0.5 ml Spinosad 45% SC) (2.47 flies/trap/day), however, two bait material had statistically superior among all the treatments. On the contrary, T_5 (Papaya pulp + 0.5 ml

Spinosad 45% SC) trap (0.91 flies/trap/day) followed by T_6 (Pineapple pulp + 0.5 ml Spinosad 45% SC) trap (1.38 flies/trap/day) recorded the lowest number of flies trapped. These results showed that the efficacy of all the bait materials gradually decreased over time, i.e. at days after preparation and placement of baits. This gradual decrease in efficacy of the baits may be due to evaporation, drying and other environmental factors. Means of all days of flies trapped in different food bait prepared from ripened fruit pulps has been shown in fig.4. Food baits containing Grapes and Banana showed maximum efficacy in attracting *Bactrocera* spp. Vis-à-vis other fruits namely mango, guava, papaya and pineapple pulp. The efficacy of attraction of banana was at par with grapes perhaps because of high sugar content in its pulp (Bose and Mitra, 1990) [20], since fermentation of sugar attracts fruit flies (McPhail, 1937) [21]. Grapes showed better efficacy in attracting fruit flies as compared to other fruits pulp food baits. The presence of large amount of D-glucose in grape pulp is cited as the reason for this efficacy in attraction of Fruit flies as compared to other fruit pulp comprising disaccharides. Protein source is previtial to ensure fecundity in Fruit flies (Christenson and Foote, 1960) [22]. The efficacy of attraction for both male and female fruit flies was highest in case of fruit baits comprising banana pulp in it (Satpathy and Rai, 2002; Jiji *et al*., 2003; Bharathi *et al.*, 2004; Rajitha and Viraktamath, 2005) [23-26]. Bharathi *et al*., (2004) [] supplement with their findings that among Fruit pulps, grapes and banana showed maximum efficacy in attraction as compared to pineapple. Present study and results are well in tune with and conform to these quoted results.

Table 1: Evaluation of different food bait prepared from ripened fruit pulps for attraction of *Bactrocera* under terai region of West Bengal

Food Baits	Mean number of flies trapped/trap/day at DAI*												Pooled Mean
	1st			2nd			3rd			4th			
	2017-18	2018-19	Pooled Mean	2017-18	2018-19	Pooled Mean	2017-18	2018-19	Pooled Mean	2017-18	2018-19	Pooled Mean	
T_1- Banana pulp+ 0.5 ml Spinosad 45% SC	6.00 (2.55)^{ab}	7.25 (2.78)^{b}	6.63 (2.67)^{b}	2.25 (1.65)^{ab}	2.75 (1.80)^{ab}	2.50 (1.73)^{ab}	0.75 (1.10)^{ab}	0.75 (1.10)^{ab}	0.75 (1.10)^{ab}	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	2.47^{b}
T_2- Grape pulp+ 0.5 ml Spinosad 45% SC	7.25 (2.78)^{a}	8.50 (2.99)^{a}	7.88 (2.89)^{a}	2.75 (1.80)^{a}	3.25 (1.93)^{a}	3.00 (1.87)^{a}	1.00 (1.22)^{a}	1.25 (1.31)^{a}	1.13 (1.27)^{a}	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	3.00^{a}
T_3- Guava pulp + 0.5 ml Spinosad 45% SC	4.75 (2.29)^{b}	5.25 (2.40)^{c}	5.00 (2.35)^{c}	1.50 (1.40)^{bc}	1.75 (1.44)^{bc}	1.63 (1.45)^{bc}	0.25 (0.84)^{bc}	0.25 (0.84)^{c}	0.25 (0.85)^{bc}	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	1.72^{cd}
T_4- Mango pulp+ 0.5 ml Spinosad 45% SC	5.25 (2.39)^{b}	6.00 (2.55)^{c}	5.63 (2.47)^{c}	1.75 (1.48)^{abc}	2.25 (1.64)^{ab}	2.00 (1.56)b^{c}	0.50 (0.97)^{abc}	0.50 (0.97)^{ab}	0.50 (0.97)^{abc}	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	2.03^{bc}
T_5-Papaya pulp + 0.5 ml Spinosad 45% SC	2.25 (1.64)^{d}	3.25 (1.93)^{e}	2.75 (1.80)^{e}	1.00 (1.18)^{c}	0.75 (1.10)^{c}	0.88 (1.14)^{d}	0.00 (0.71)^{c}	0.00 (0.71)^{c}	0.00 (0.71)^{c}	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.91^{e}
T_6 -Pineapple pulp + 0.5 ml Spinosad 45% SC	3.50 (2.00)^{c}	4.25 (2.18)^{d}	3.88 (2.09)^{d}	1.25 (1.31)^{bc}	1.50 (1.36)^{bc}	1.38 (1.35)^{cd}	0.25 (0.84)^{bc}	0.25 (0.84)^{c}	0.25 (0.84)^{bc}	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	1.38^{d}
Pooled Mean			5.59			1.90			0.48			0.00	

* DAI-Days after Installation,
Mean of three replications
Figures in parentheses are square root transformed values
Figures following by same letters are not significantly different.

Factors	Food Baits	Days	Food Baits X Days
S. Em (±)	0.040	0.023	0.056
CD (0.05)	0.115	0.067	0.163

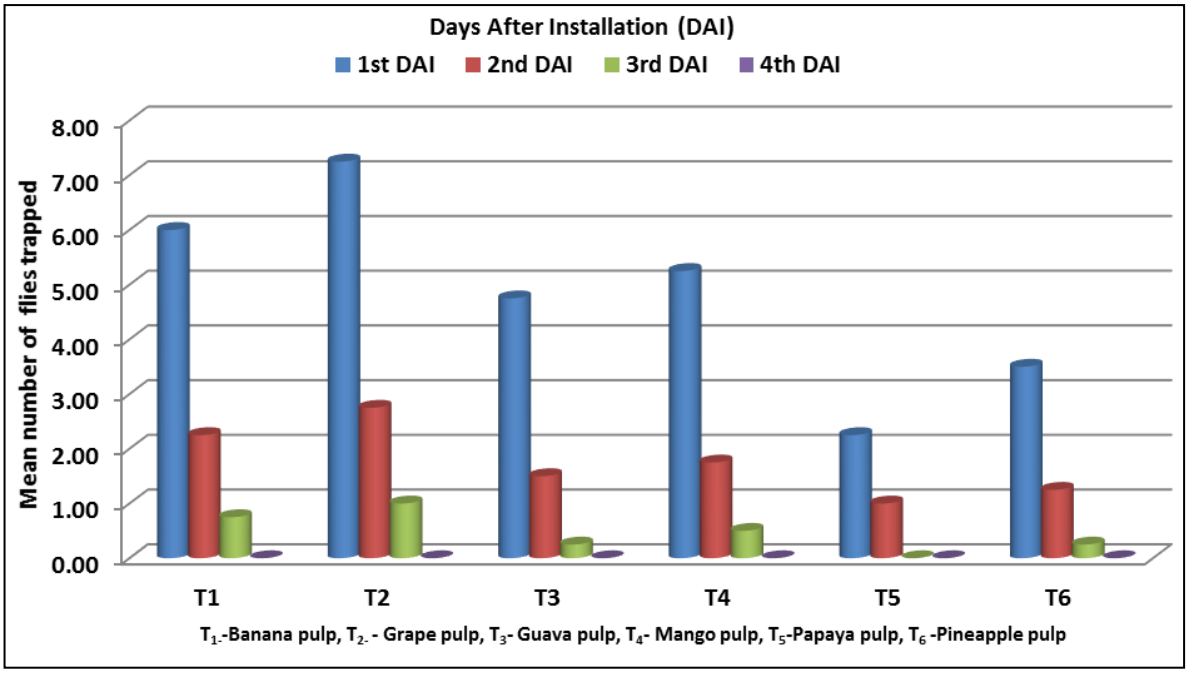


Fig 1: Mean number of flies trapped/trap/day in different food bait prepared from ripened fruit pulps during 2017-18

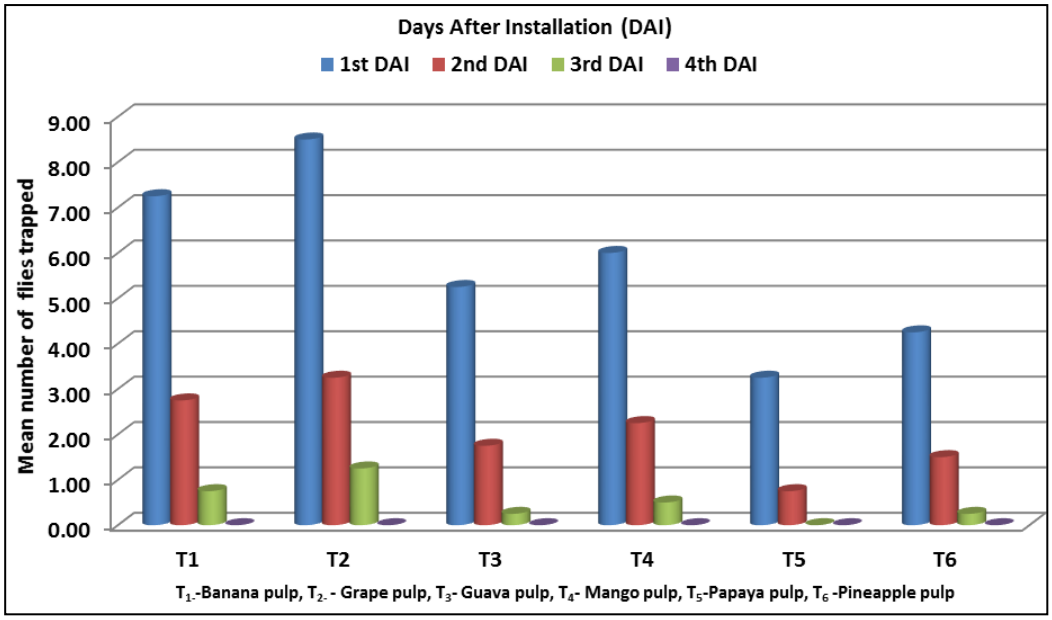


Fig 2: Mean number of flies trapped/trap/day in different food bait prepared from ripened fruit pulps during 2018-19.

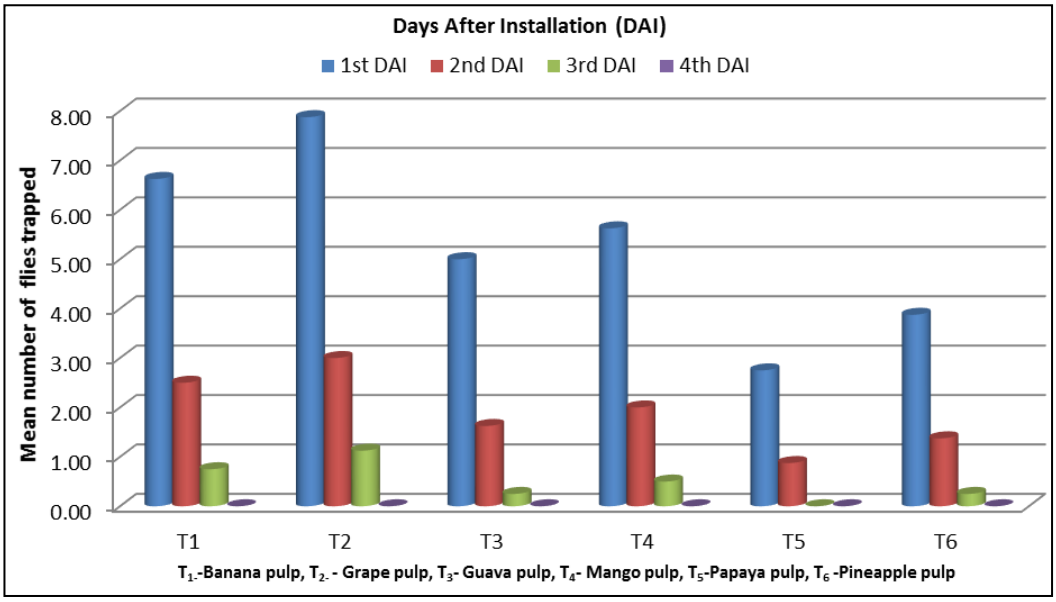


Fig 3: Mean number of flies trapped/trap/day in different food bait prepared from ripened fruit pulps (pooled over 2017-18 and 2018-19)

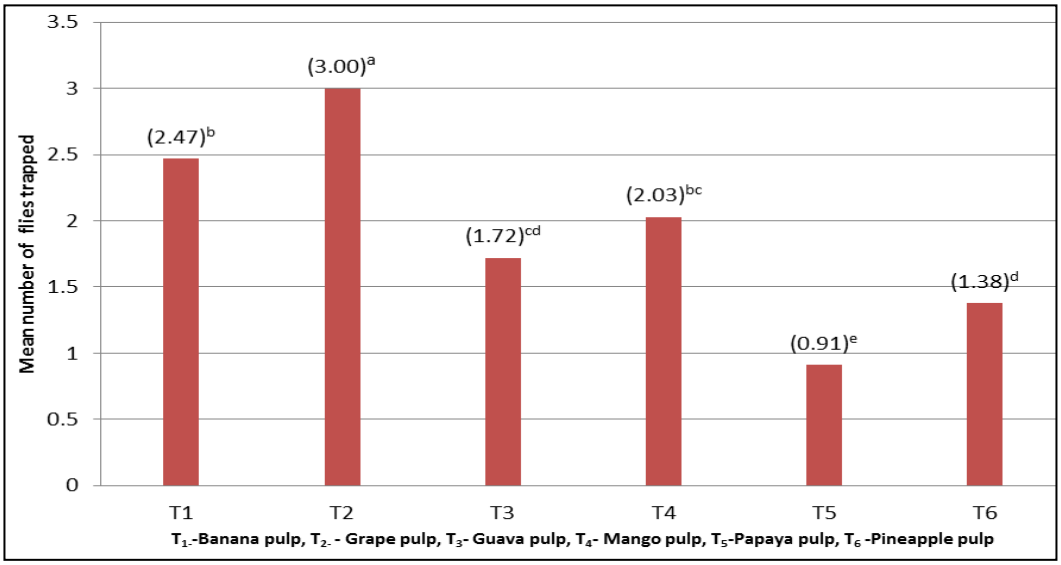


Fig 4: Pooled means number of flies trapped in different food bait prepared from ripened fruit pulps

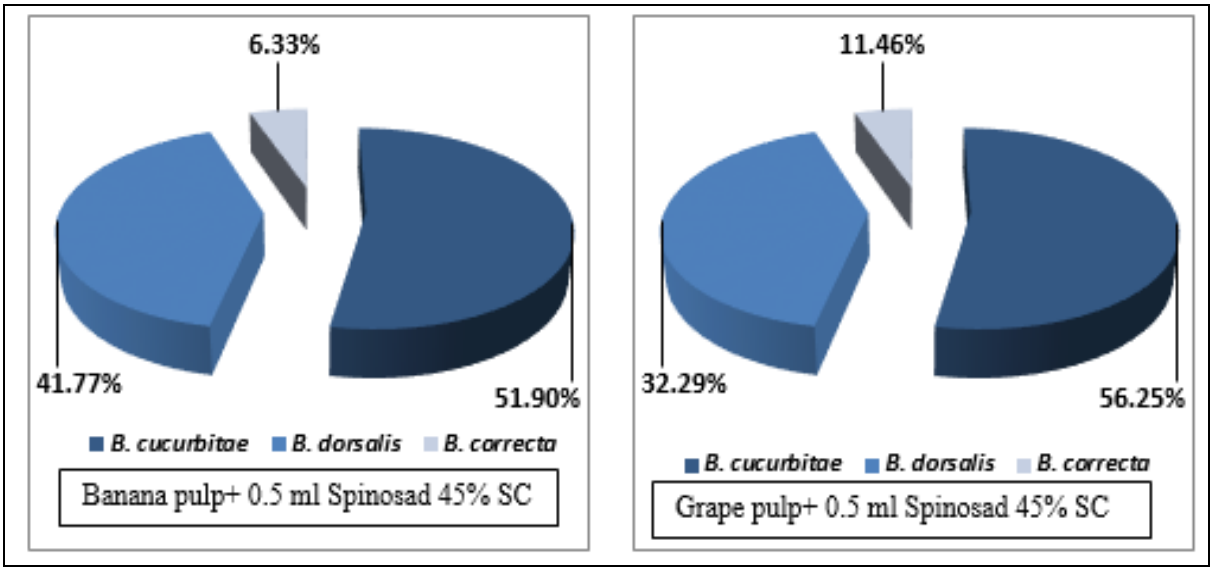
3.1 Species diversity of fruit flies trapped in different food baits: The food bait used in the present study were Banana pulp+ 0.5 ml Spinosad 45% SC, Grape pulp+ 0.5 ml Spinosad 45% SC, Guava pulp + 0.5 ml Spinosad 45% SC, Mango pulp+ 0.5 ml Spinosad 45% SC, Papaya pulp + 0.5 ml Spinosad 45% SC and Pineapple pulp + 0.5 ml Spinosad 45% SC. Number of individuals of different categories were then tabulated and presented. The findings have also been depicted in Table-1 and fig 5. From all the food bait collection, only three species identified were *B. cucurbitae, B. dorsalis* and *B. correcta.* The dominant species was noted *B. cucurbitae* range from (48.28%-52.08%) followed by *B. dorsalis* (40.91%-44.62%) and *B. correcta* (4.62%- 11.46%). Among these three species most dominant was *B. cucurbitae*. Relative abundance of the *B. cucurbitae* was noted as 52.08%, 51.90%, 50.76%, 50.00%, 49.09% and 48.28% in different food baits of grape pulp, banana pulp, mango pulp, pineapple pulp, guava pulp and papaya pulp respectively followed by *B. dorsalis* that showed 44.62%, 43.64%, 42.71%, 41.77%, 41.38% and 40.91% in different food baits of mango pulp, guava pulp, grape pulp, banana pulp, papaya pulp and pineapple pulp respectively. Least dominant species was the *B. correcta* in all the cases of recovery recorded as 10.34%, 9.094%, 7.27%, 6.33%, 5.21% and 4.62% in different food baits of papaya pulp, pineapple pulp, guava pulp banana pulp, grape pulp, and mango pulp respectively.

Ukey, *et al.* (2013) [27] found different species of fruit flies such as, *B. zonata, B. dorsalis, B. correcta* and *B. verbascifoliae* infest guava in Ahmednagar District, Maharastra, India. Among the four species, *B. dorsalis* was observed to be dominant species with highest mean number of flies 50.25 (49.95%) emerged out per cage. *B. zonata* was found next dominant species recorded 38.5 flies (31.36%) emerged out per cage. *B. correcta* recorded 24.5 flies (19.95%) emerged out per cage. Very low infestation of *B. verbascifoliae* found during that investigation which was ecorded 9.5 flies (7.73%) per cage.

Limited amount of work has been done in reference to the diversity of the species of fruit fly belonging to Tephritidaeon food baits in the agro-ecological region under study and consideration. However the findings the study have a semblance and are partially coinciding with the study of Ukey, *et al.* (2013).

Table 1: Species diversity of fruit flies trapped in different food baits

Location	Food Baits Trap	Total Number of fruit flies trapped	Species	Total number of individuals per species	Relative abundance (%)
Coochbehar (W. Bengal)	Banana pulp+ 0.5 ml Spinosad 45% SC	79	*B. cucurbitae*	41	51.90
			B. dorsalis	33	41.77
			B. correcta	5	6.33
	Grape pulp+ 0.5 ml Spinosad 45% SC	96	*B. cucurbitae*	50	52.08
			B. dorsalis	41	42.71
			B. correcta	5	5.21
	Guava pulp + 0.5 ml Spinosad 45% SC	55	*B. cucurbitae*	27	49.09
			B. dorsalis	24	43.64
			B. correcta	4	7.27
	Mango pulp+ 0.5 ml Spinosad 45% SC	65	*B. cucurbitae*	33	50.76
			B. dorsalis	29	44.62
			B. correcta	3	4.62
	Papaya pulp + 0.5 ml Spinosad 45% SC	29	*B. cucurbitae*	14	48.28
			B. dorsalis	12	41.38
			B. correcta	3	10.34
	Pineapple pulp + 0.5 ml Spinosad 45% SC	44	*B. cucurbitae*	22	50.00
			B. dorsalis	18	40.91
			B. correcta	4	9.09



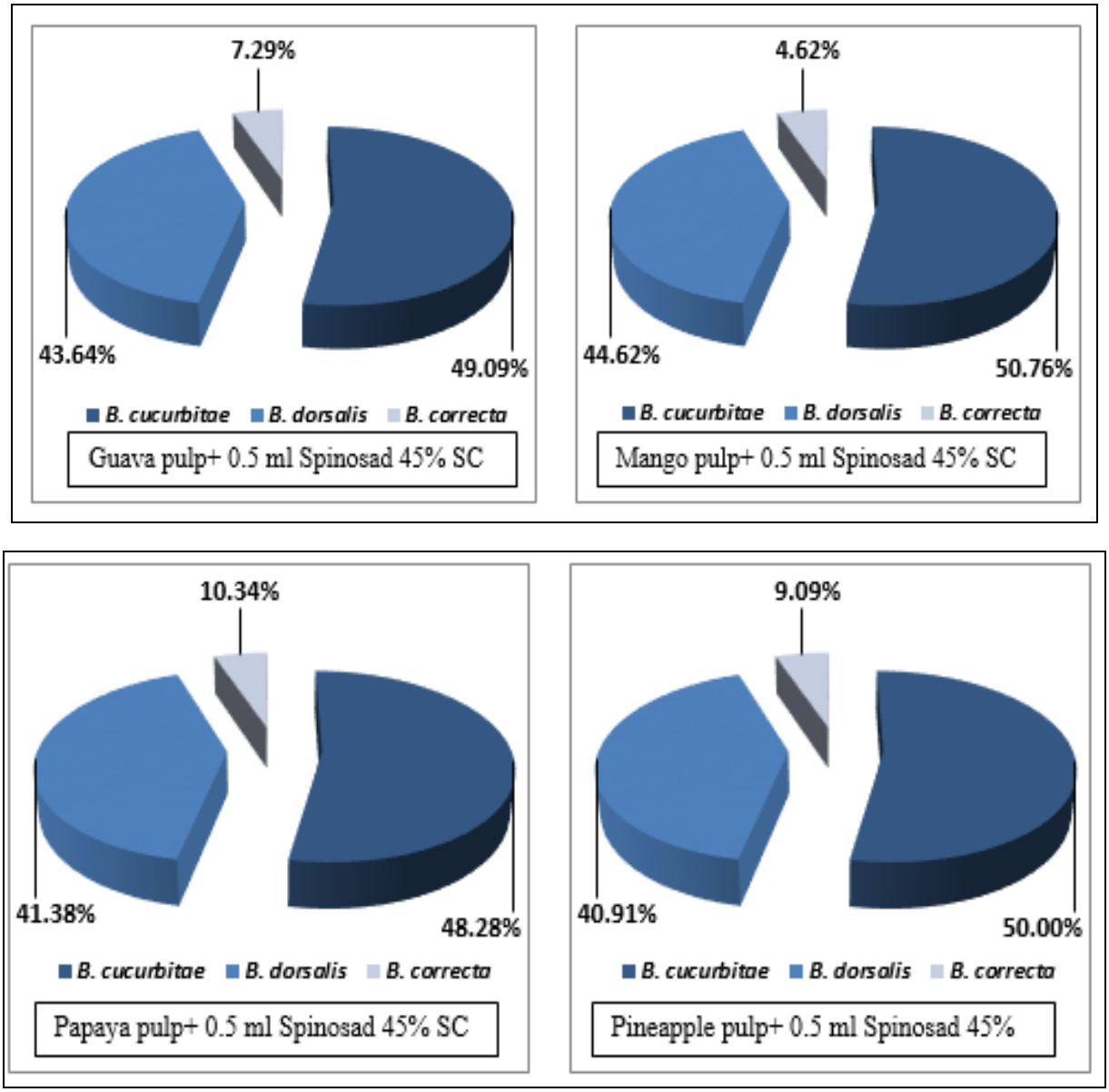


Fig 5: Species composition of fruit flies attracted in different food baits

4. Conclusion

The mean number of fly capture data in different food bait using as an attractant revealed that highest efficacy was noted by using Grape pulp (3.00 flies/trap/day) as bait material followed by Banana pulp (2.47 flies/trap/day), however, these two bait material were statistically superior among all the treatments. On the contrary, Papaya pulp (0.91 flies/trap/day) followed by Pineapple pulp (1.38 flies/trap/day) recorded the lowest number of flies trapped. Among the species diversity, only three species were identified *B. cucurbitae*, *B. dorsalis* and *B. correcta.* The dominant species was noted *B. cucurbitae* range from (48.28%-52.08%) followed by *B. dorsalis* (40.91%- 44.62%) and *B. correcta* (4.62%- 11.46%).

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