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Impact of sucrose in adult diet on survivorship of males of *Bactrocera tau* (Diptera: Tephritidae)

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Abstract
Pumpkin fruit fly, *Bactrocera tau*, is a key pest in pumpkin orchards, causing serious economic damage. Impact of sucrose and protein on survivorship of adult males of *Bactrocera tau* has been studied in the present study. Flies fed optimal diet (Sucrose and Protein in 3:1 ratio), and only sugar from the day of eclosion demonstrated mortality of only 7.33% and 1.33% respectively in 4 days. However, flies fed only protein, and starved from the day of eclosion showed mortality of 100% and 99.6% respectively in the same time period. At the same time, change of dietary habit of flies from optimal diet to protein as well as optimal diet to no food on 7th and 11th day resulted no survivorship, or 100% mortality, for both cases in 4 days. Number of adult flies died for the change of optimal diet to sugar on 7th day and 11th day in the study period was insignificant. Study demonstrated the absolute requirement of carbohydrate in the adult diet, and insignificant capability of conversion of lipids to metabolic energy.

Keywords: *Bactrocera tau*, diet, survivorship

1. Introduction

Most of the species of fruit flies are polyphagous and thus damage a wide range of fruits and vegetables [1, 2]. Upto 100% of fruits may damage by fruit fly when lift uncontrolled [3]. As such, their infestation not only decreases the yield of fruits but also affects the quality and price of the crop. They are very common insect pests of economic importance in tropical, subtropical and several temperate regions of world [4, 5]. Billions of dollars of agriculture commodity are lost due to these pests infestation every year worldwide [6]. Therefore research on fruit flies is significantly important in the sustainable fruit and vegetable production as well as trade issues.

The fruit flies of the family Tephritidae is considered the main fruit pests worldwide [7]. Out of 5000 documented species in Tephritidae family, 70 species of fruit flies are important agricultural pests on different vegetables and fruits of tropical and subtropical regions [8, 9, 10]. *Bactrocera tau* is a very harmful pest for pumpkin fruits, which has huge economical importance worldwide.

Among numerous techniques implemented worldwide to control pests, Sterile Insect Technique (SIT) has been proved so far to be an efficient, target specific and safe-for-fruits tool [11]. However, one of the main problems of this method is its big cost to rear large number of flies in the laboratory for several days to become sexually mature before they are applied in the field to meet wild female insects. Therefore SIT management protocol should be improvised minimizing cost without compromising reproduction capabilities. Before applying SIT, it is extremely necessary to develop healthy adults ensuring biological parameters. To produce such adults, it is essential to maintain the colony with a good dietary supplement where the competitive adults could bring about a successful suppression in the field population [12].

Yeast that contains appropriate concentration of protein, sterols, vitamins and minerals is considered to be major source of nutrition for fruit flies. Although, yeast is used for mass rearing of larvae and adult tephritidae flies [13, 14, 15, 16], researchers are in search of enhanced diet to develop more strong and appropriate insect for SIT. As such, we chose several artificial diets and applied on flies to check if those can be used as food supplements. Therefore biological parameters on *B. tau* fed these diets have been investigated in the experiment.

The necessity of consumption of both carbohydrate and protein for the reproduction and effective signaling has already been studied [17]. Although absolute necessities for either protein or sugar in the adult diet of *Anastrepha suspensa* [18] *and B. cucurbitae* [19] have recently been studied, no such work on *B. tau* has been performed so far, especially in our country. Therefore there was a requirement from our side for doing such experiment on *Bactrocera tau*. This study is the second experiment in our laboratory on justification of the absolute requirement of carbohydrate for survival of fruit flies.

2. Materials and Methods

The experiment on survivorship of *B. tau* were carried out at the laboratory of Radiation Entomology & Acarolgy Division, Institute of Food and Radiation Biology, Atomic Energy Research Establishment, Savar, from December 2018 to April 2019. Mortality of flies after feeding only protein or sugar or no food, or after switching from one diet to another, was studied in the present study. Flies were either provided with optimal diet (Sugar and Yeast in 3:1 ratio) or protein or sugar or no food (only water) from the day of eclosion or switched from the optimal diet to only protein or sugar, or no food on 7th and 11th day. *B. tau* flies were cultured in 12cm×10cm×8cm steel frame cages covered with nylon net and maintained at 25±3^{0} C temperature, 60-65% humidity and 12:12 L:D at the laboratory.

The experiment was conducted with randomly selected 100

adult flies emerged in the laboratory stock. A 50 ml conical beaker full of water and soaked cotton was provided to supply continuous water and to maintain moisture content inside the cages. Protein was supplied in cake form. The residual diets were replaced by fresh diets in every two days interval. The optimal diet was applied as the standard diet. Mortality rate of flies were recorded each 24 hours from where survivorship was calculated.
After emergence, a certain amount of optimal diet, sugar, and protein were served as food source for each 100 flies in separate petri dishes, and the effects of these diets on survivorship of male flies were counted. Separate experiments were also conducted in which we maintained male flies on the optimal diet after eclosion and then switched to sugar or protein or no food (only water) diets on 7th day and 11th day for several days, to know the effect on survivorship for each dietary change. In each case, survivorship of flies was counted to compare with survivorship on optimal diet. Statistical analysis of the study was performed by ANOVA.

3. Results

Impact of different diet on survivorship of males of *Bactrocera tau* has been investigated in the present study. Study showed (Table 1, Fig.1-9) mortality profile of 100 flies fed Different diet or starved, or flies whose diet has been changed from one to another or kept on starvation from diet. Flies fed only optimum diet from the day of eclosion showed survivorship of 92.67% on 4th day (Table 1) showing good agreement with survivorship of 92.4% for *Bactrocera cucurbitae* [19].

Table 1: Mean survivorship of flies after being fed optimum diet (OPD).

Days feeding only optimum diet	*B. tau*	*B. cucurbitae*
0	100	100
1	98.67	100
2	94.67	97.7
3	92.67	92.4

* Mean survivorship of *B. tau* fed only OPD is 96.5

However, the study demonstrated 0% survivorship, or 100% mortality, of *B. tau* in only 4 days when they were fed only protein from the day of eclosion (Fig. 1). It also showed same survivorship rate in the same time frame as they were switched to only protein from optimum diet on 7th day (Fig. 2) and 11th day (Fig. 3). Results are comparable with mean survivorship of 1.7%, or mortality of 98.3%, of *B. cucurbitae* fed only protein from the day of eclosion, and mean survivorship of 0% of the same flies when they were changed from optimal diet to starvation on 7th and 11th day in same duration [19].

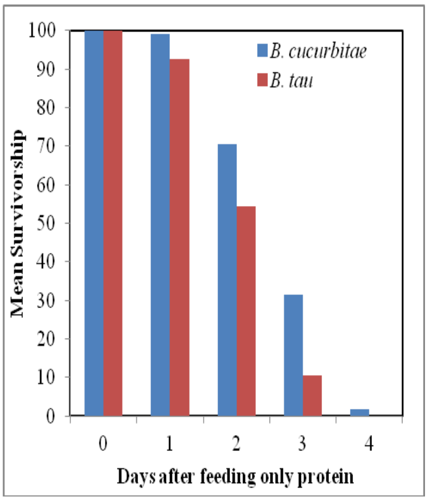

Fig 1: Mean survivorship of flies fed only protein from the day of eclosion

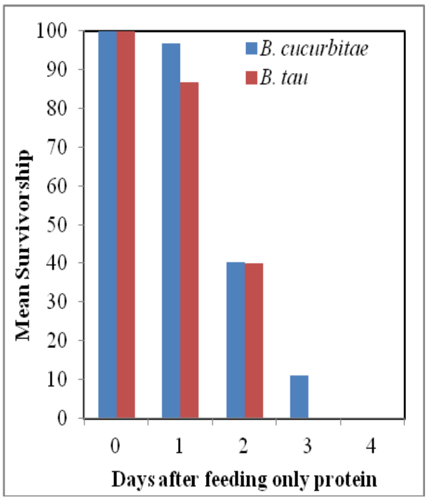

Fig 2: Mean survivorship of flies switched to protein from optimal diet on day 7

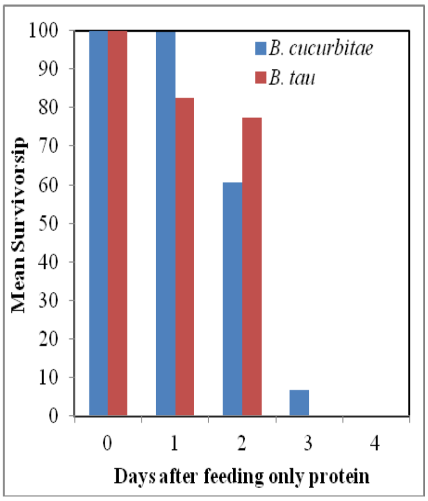

Fig 3: Mean survivorship of flies switched to protein from optimal diet on day 11

*Means are not significantly different in an ANOVA test (P=0.99>0.05, df=5, 24; F=0.05). Mean survivorship of *B. tau* flies fed protein-only for 4 days from day of eclosion was 51.5% against 60.58% for *B. cucurbitae*; 4 days from 7th day was 45.33% against 49.66% for *B. cucurbitae*; and 4 days from 11th day was 52% against 53.4% for *B. cucurbitae* [19].
In the same way, mean survivorship of starving *B. tau* declined sharply in only 4 days. Experiment resulted only 0.4% of survivorship in four days as they were fed no food (only water) from the day of eclosion (Fig. 4). Moreover, it demonstrated 0% of survivorship, or 100% of mortality, in the same study hours after switching optimal diet to no food (only water) on 7th and 11th day (Fig. 5-6) in separate experiments. Mean survivorship of *B. cucurbitae* in the previous experiment[19] of only 8.4%, 6% and 0% for the above cases showed good agreement between two experimental outcomes.

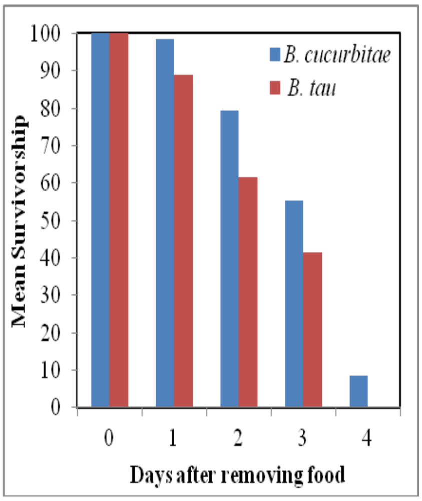

Fig 4: Mean survivorship of flies with no food (only water) from the day of eclosion

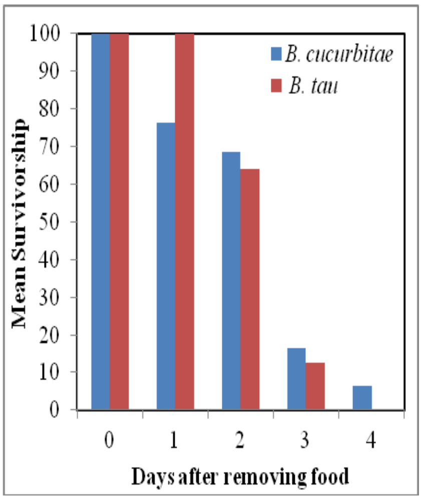

Fig 5: Mean survivorship of flies after removing of food on day 7

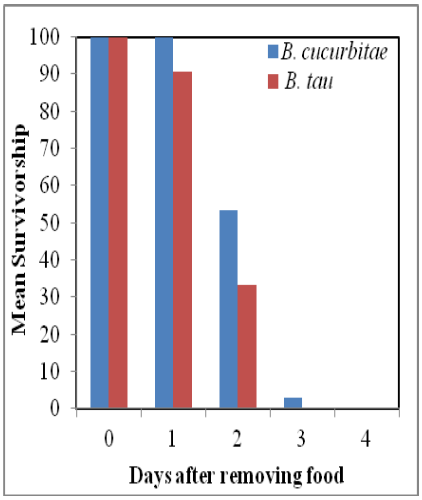

Fig 6: Mean survivorship of flies after removing of food on day 11

*Means are not significantly different in an ANOVA test (P=0.97>0.05, df=5, 24; F=0.16). Mean survivorship of *B. tau* flies fed no food (except water) for 4 days from day of eclosion was 58.48% against 68.4% for *B. cucurbitae*; 4 days from 7th day was 55.33% against 53.6% for *B. cucurbitae*; and 4 days from 11th day was 44.8% against 51.26% for *B. cucurbitae.*

On the contrary, *B. tau* fed only sugar showed large survivorship at the end of 4 days of feeding. Flies survived on only sugar from the day of eclosion showed mean survivorship of 98.66% (Fig. 7) where as changing optimal diet by sugar-only on 7th and 11th day resulted 100% and 99% respectively (Fig. 8-9). Mean survivorships of *B. cucurbitae* in the previous experiment for the three cases were 97.3%, 97% and 98.67% respectively that demonstrates good agreement with the present study [19].

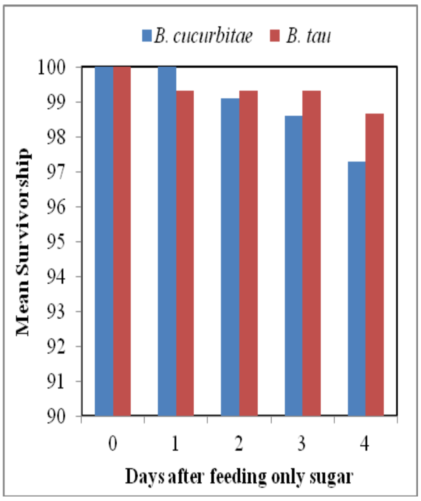

Fig 7: Mean survivorship of flies fed only sugar from the day of eclosion

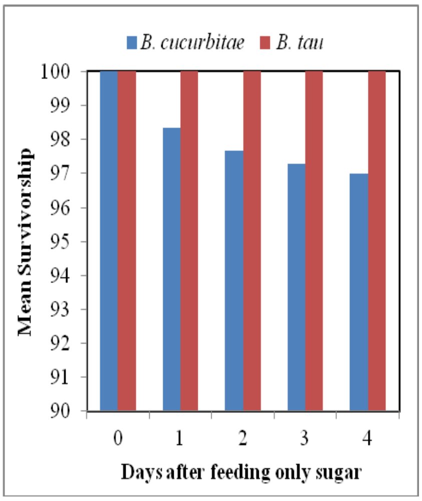

Fig 8: Mean survivorship of flies switched to sugar from optimal diet on day 7

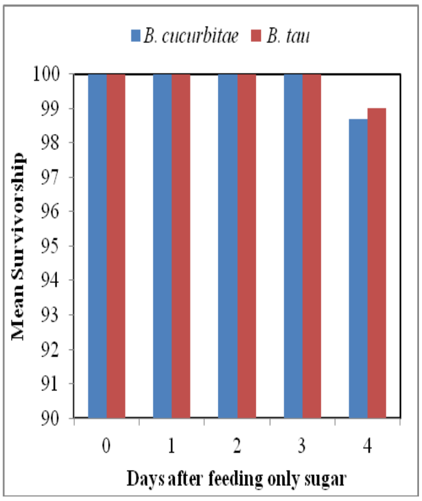

Fig 9: Mean survivorship of flies switched to sugar from optimal diet on day 11

*Means are not significantly different in an ANOVA test (P=0.96>0.05, df=5, 24; F=.18). Mean survivorship of flies fed only sugar for 4 days from day of eclosion was 99.33% against 99% for *B. cucurbitae*; 4 days from 7th day was 100% against 98.06% for *B. cucurbitae*; and 4 days from 11th day was 99.8% against 99.734% for *B. cucurbitae*.

4. Discussion

A number of studies on the effect of dietary supplements on Tephritidae family, that *B. tau* belongs to, conducted earlier shows that protein dietary supplement enhance sexual performance of adult male [20] and play positive effects on ovarian maturation and fecundity in female [21] of Tephritidae species. Another research also shows that sugar is necessary dietary requirement and is important for longevity of species [22]. Also removal of protein and carbohydrate from adult dietary supplements results rapid mortality of adult insects. However, there is very little information about the role of only sugar and if the protein can be a replacement of sugar. There has been no such research especially on *B. tau* so far.

The current research on flies fed optimal diet or only sugar from the day of adult eclosion, or fed only sugar switched from optimal diet showed no significant mortality in the study period. The research demonstrated clearly the absolute requirement of carbohydrate in the adult diet for survival of adult male insects. The same rate of survival of flies, provided with only protein or switched from carbohydrate to protein on 7th and 11th day, indicated strongly that *B. tau* flies have limited capacity to convert protein resources into energy as like as *B. cucurbitae*. Therefore it can't be the supplement of sugar.

At the same time the absolute requirement of carbohydrate and inability to live with metabolic energy of protein indicated the physiological adaptation of flies to the environment. Indeed, protein dietary supplements have been shown to have positive effects on ovarian maturation and fecundity of Tephritidae indicating that dietary protein is a critical component for reproductive success for egg production. Thus, a physiological strategy have probably been developed in flies in which they utilize the most available food source, sugar, to ensure survival, and take advantage of limited protein resources when available to achieve sexual maturity [22]. The findings in *B. tau* experiment in the present study have good agreement with that in *Anastrepha suspensa* as well as *B. cucurbitae* [19].

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