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EFFECT OF NUTRITION ON BIOLOGICAL CHARACTERISTICS OF *BACTROCERA ZONATA* UNDER LABORATORY CONDITIONS

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Abstract

The peach fruit fly, *Bactrocera zonata* became a serious pest in Egypt; however, it is attacking a wide range of fruit species, Host plant is very important factor that affecting the biological aspects of *B. zonata*, so that the aim of this study was to evaluate host plant effect on biological characteristics. The peach fruit fly, *Bactrocera zonata* was reared in laboratory on three host plants (mango, pear and fig) in addition to control treatment which reared on artificial diet. Biological parameters were estimated during the second generation of the reared *B. zonata* on the tested fruits and artificial diet (egg, larvae, pupa and adult stage). Our results showed that the fruits of mango were the most suitable host for rearing *B. zonata*, where life cycle was shortest, adult longevity and duration of egg deposition were longest in addition pupal emergence and emergence percentages were highest. On contrary, fig fruits were the less suitable host for rearing *B. zonata*, where life cycle was longest, adult longevity was shortest, pupation and adult emergence percentages were lowest, fecundity and hatchability percentage were the lowest and duration of egg deposition was shortest. Both of pear fruits and artificial diet ranked moderate in suitability for rearing *B. zonata*. Also, there were relatively high fecundity and hatchability on pear fruits. The results of this study indicate that mango fruits were the most suitable host for rearing *B. zonata* but fig fruits were the less suitable host for rearing *B. zonata.*

Key words: *Bactrocera zonata*, biological characteristics, host plant, artificial diet, chemical analysis.

Introduction

One of the largest families of order Diptera is the family Tephritidae which fruit flies are belonged to. More than 500 genera representing about 4000 species are belonging to this family and spread throughout the world (Mosleh *et al.,* 2011; El-Gendy 2012). Native to tropical Asia, the peach fruit fly, *Bactrocera zonata* (Saunders) (Diptera: Tephritidae) is spreading to other regions of the world including the Middle East as it has proved to be a destructive pest in every country where it has become established (El-Minshawy *et al.,*1999). Females of *B. zonata* lay their eggs inside fruits and the hatching maggots devour into the pulp. Subsequently, secondary infestations with bacterial and fungal diseases mostly exist and the infested fruits drop down and make fruits unfavorable for marketing and exportation (Devi and Jha, 2017).

The first record of *B. zonata* in Egypt was in the 1920s, but that appears to have been based on a quarantine interception (Efflatoun, 1924). Recently in 1990 the peach fruit fly (PFF) *Bactrocera zonata* (Saunders), a polyphagous, was recognized as causing significant damage. In Egypt (Saafan, 2005) recorded *B. zonata* in many orchards in several Governorates and only recently have control measures been initiated against it (Duycky *et al.,* 2004).

In Egypt, *B. zonata* became a serious pest attacking a wide range of fruits that differ in their ripening time all over the year including mango, pear, fig and others (Shehata *et al.,* 2008; Ghanim *et al.,* 2015). This pest can affect both fruit yield and quality causing direct damage to fruits that ranged between 25 and up to 90% particularly in the summer season (Ghanim, 2009; Shinwari *et al.,* 2015). Also, *B. zonata* impede exportation of fresh fruits due to the quarantine restrictions. Thus, in some regions *B. zonata* as well as other fruit fly species inhibit the economic development of potential fruit and vegetable crops (Darwish, 2016).

Mediterranean fruit fly *Ceratitis capitata* (Wied.) was a highly polyphagous Tephirtidae reported as the major pest early last century (El Ghawabi, 1928). *B. zonata* has gradually become so widely spread that it surpasses domination of *C. capitata* as the major fruit pest. Both flies have sources of food all year round due to mixed plantations of fruit species in the same area (Saafan *et al.*, 1993). It is possible that climate change is responsible for the appearance of *B. zonata* as a pest over the past 20 years, as *B. zonata* has a higher threshold of temperature than *C. capitata*, the latter being the major pest in Egypt.

Host plant as food source is one of the most important factors affecting biological aspects of *B. zonata* and *C. capitate* (Campos *et al.,* 2011; Rauf *et al.,* 2013; El-Gendy, 2017; Rasool *et al.,* 2017). The physical and chemical factors associated with plants influence the choice and the balance between positive and negative stimuli that determine the final selection of the appropriate host of *B. zonata* and *C. capitate* (Darwish, 2016). According to (Joachim-Bravo *et al.,* 2001; Fontellas-Brandalha and Zucoloto, 2004), females of *C. capitate* oviposit based on the suitability of the fruit for their offspring's performance. Muthuthantri and Clarke, 2012 investigated oviposition preference and offspring performance of the polyphagous fruit fly *Bactrocera tryoni* (Froggatt) in citrus and demonstrated an oviposition preference hierarchy of *B. tryoni* among the citrus fruits host tested. These findings provide evidence for possible role of adult preference for host which plays a most important function in differential response for oviposition.

The objective of investigation was studied the effect of host plants varieties on some biological characteristics of *B. zonata* in comparison with artificial diet under laboratory conditions.

Materials and Methods

Insect Rearing Technique

A laboratory strain of *B. zonata* kept in the Horticultural Insects Research Department, Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza under constant conditions 25±2ºC and 65±5% RH and a photoperiod of 16:8 h (L:D) to provide insects used in the present investigation (EL-Aw *et al.*, 2003). Adults were reared in a wooden cage (40x60x50 cm^3) provided with food consisting of sugar and protein hydrolyzate at a ratio of 5: 1. Eggs were deposited in perforated mandarin like model inside cage as egg receptor. Eggs were scattered on the surface of artificial diet [consisted of sodium benzoate (4 gm.), wheat bran (330 gm.), Brewer's yeast (80 gm.), citric acid (4 gm.), molasses (80 gm.) and water (500 ml)] at a rate of 1ml egg /kg medium (Awadallah and El-Hakim, 1987).

Experimental Design

Three varities of host plant fruits were used in these experiments, mango (*Mangifera indica* L.) family Anacardiaceae, pear (*Pyrus communis* L.) family Rosaceae and fig (*Ficus carica* L.) family Moraceae in addition to the control treatment which was the previously mentioned artificial diet.

Fruits were washed carefully with tap water, left to dry and then sterilized with ethanol alcohol (98%). At a sterilized atmosphere (next to Bunzin fire), small cuts were made in fruit peels using sharp sterilized cutters and cavities of 1.5 x 1.5 x 0.5 cm^3 (length, width and depth) were induced in fruit flesh using sharp spatula. A black filter paper was cut into small pieces (1x1 cm^2). Twenty fresh eggs (deposited and collected within a period of maximum one hour) were arranged on the black filter papers wetted with distilled water. Eggs were inspected with drawing fine brush under illuminated stereoscope (4x) where cracked, crushed, damaged or unhealthy eggs were eliminated. The black filter paper cards loaded with eggs were transferred using sterilized forceps, inserted into fruit cavities, covered by the fruit peels and then fixed again with sticky tape. Each fruit was put in a sterilized plastic container and kept under the laboratory conditions. Six replicates of each fruit varieties were used. In the case of artificial diet, 20 g of media were put in a sterilized plastic cups and the egg card (20 eggs / card) was installed on it. The cups were put in another sterilized plastic container. Six replicates of artificial diet were used too. (EL-Aw *et al.*, 2003).

Estimating Biological Parameters

Biological parameters were estimated during the second generation of the reared *B. zonata* on the tested fruits.

Egg stage: All fruits and plastic cups were examined every 6 hours for 2 days and the time of hatching as well as number of hatched larvae were recorded.

Larval stage: Sterilized filtered sand was put in the plastic containers under the fruits or the plastic cups after two days of starting the experiment. Sand were examined twice daily till all larvae were pupated, during that the number of pupae and duration of larval stage were estimated.

Pupal stage: All pupae were collected from the containers and transferred to sterilized tubs (diameter = 3cm and length = 11cm); till the emergence of the adults. The duration pupal stage was estimated.

Adult stage: Emerged adults were counted and sexed. Adults emerged in the same day were put in the same cage which had an egg receptor. Each cage was provided with food like previous. Adults were followed up and the daily egg laying was recorded. The number of dead adults (male and female) and its life time were recorded.

Statistical analysis

Data were analyzed with the MSTAT-C (Version 2.10) computer program using analysis of variance (ANOVA) (Kaufmann and Schering, 2014) followed by Least Significant Difference (LSD Test) to determine the differences between the obtained means. Probability of 0.05 or less was considered significant (Salkind, 2010).

Results and Discussion

Data in Table 1 show that the longer mean of egg incubation period (2.25 days) was recorded for mango fruits, while larvae reared on fig fruits had the longer duration (14.04 days).

As for pupal stage, it was significantly ($p = 0.0090$) the shortest in the case of artificial diet (8.95 days). Respecting adult stage, flies resulted from mango fruits significantly ($p = 0.0000$) survived the longest period (56.00 days), concerning life cycle or immature stages periods, individuals reared on fig fruits showed significantly ($p = 0.0000$) the longest period of life cycle (26.02 days), meanwhile Individuals of *B. zonata* reared on mango fruits significantly ($p = 0.0001$) had the longest life span (76.64 days)

Figure 1 indicate that the highest percentage of pupation was recorded on mango fruits (88.55%) while the lowest was recorded in fig fruits (59.70%), with respect to adult emergence percentage, the same trend was observed, where the highest value was recorded on mango and the lowest was resulted from fig fruits (84.60 and 56.70%,).

The obtained data showed that females reared on pear fruits exhibited the highest fecundity; where the mean number of eggs per female reached 135.17 (Figure 2). meanwhile, females reared on fig fruits, recorded the lowest fecundity (69.15 eggs / female). The percentage of egg hatchability for females reared on artificial diet reached 100%, while those reared on fig fruits was the lowest (94.17%)

Despite the different number of adults resulted from different hosts, in all cases the percentages of females were always higher than males (Figure 3). The highest percentage of females was recorded on fig fruits as 56.52% of the total emerged adults reared on this host plants. But in other both host plants, the percentages of females were approximately similar.

As shown in Figure 4, *B. zonata* females started to oviposit eggs after 17days in the case of those reared on mango fruits, and after 23 days when it reared on artificial diet. Females reared on mango and pear fruits lasted the longest period of egg deposition (36 days); while, on fig fruits, egg deposition lasted only 24 days.

On the other hand, the highest daily number of deposited eggs (6.39 eggs / female) was recorded on artificial diet in the 37^{th} day. After 42 days of adult emergence, the peak of deposited eggs by females reared on fig fruits was recorded (Figure 4).

Data illustrated in Table 2 show the chemical analysis of the tested host plant fruits (mango, pear and fig) compared to the used artificial diet. As it shown, protein percentage was obviously the highest in artificial diet (8.38%). On the contrary, the percentages of total sugar, reducing sugar and total carbohydrates were the highest in fruits of fig (58.00, 35.46 and 73.47% respectively).

The percentages of total soluble solids (TSS) reached 26.76, it's highest in figs. In artificial diet, ash percentage was the highest (6.25%), meanwhile mango fruits had the highest humidity percentage 82.08%. Concerning volatile oils, it reached the highest percentage (4.86%) in fig fruits. The level of hydrogen ionic potential (pH) was the highest in artificial diet (6.72).

The present results reported that biological characteristics of *B. zonata* affected by host plant varieties. Also, it was reported (Aleryan *et al.,* 2006; Rwomushana *et al.,* 2008; Shehata *et al.,* 2008; Campos *et al.,* 2011; Rauf *et al.,* 2013; El-Gendy, 2017) that host plant is an important factor affecting biological characteristics of fruit flies. It was reported that females of fruit flies (Tephritidae) oviposit its eggs into a fruit according to the suitability of these fruit for its offspring's performance (Joachim-Bravo *et al.,* 2001; Fontellas-Brandalha and Zucoloto, 2004; Wisotsky *et al.,* 2011; Akol *et al.,* 2013). The obtained results reported that fruits of mango were the most suitable host for rearing *B. zonata*; where life cycle was the shortest, adult longevity and duration of egg deposition were the longest in addition pupation and adult emergence percentages were the highest. On the contrary, fig fruits were less suitable for rearing *B. zonata*; where life cycle was the longest, adult longevity was shortest, pupation and adult emergence percentages were the lowest, fecundity and hatchability percentage were the lowest and oviposition period was the shortest. Both of pear fruits and artificial diet moderately was suitability for rearing *B. zonata*.

Our results were agree with Amro and Abdel-Galil, 2008 and Hafsi *et al.,* 2016 as they reported that *B. zonata* preferred mango more than fig fruits. Also, Sarwar *et al.,* 2013 and Rasool *et al.,* 2017 found that mango fruits were the most preferred host plants for *B. zonata*. In addition, Rwomushana *et al.,* 2008 found that mango fruits relatively resulted in higher pupation and adult emergence percentages, fecundity and hatchability of *Bactrocera invadens* Drew, Tsuruta & White. With respect to studies of Shehata *et al.,* 2008 and Singh and Sharma, 2013 pear fruits were the most favorable to *B. zonata* according to the percentage of adult emergence followed by guava, peach, apple and apricot. The present results showed relatively high fecundity and hatchability on pear fruits.

Host quality nutritional content is considered the main factors affected the fruit fly's progeny (Sarwar *et al.,* 2013; El-Gendy, 2017). Mango fruits have sufficient nutritional value to maximize performance of Tephritids such as *B. zonata* and *Bactrocera dorsalis* (Clarke *et al.,* 2005). According to chemical analysis of the tested fruits in the present study, the relatively higher contents of protein, humidity and pH-level in mango fruits may be the reason of its preference to *B. zonata*. On the contrary, the lowest preference of *B. zonata* to fig fruits may be attributed to its low content of humidity and pH-level in addition to its high contents of volatile oils, ash, total soluble solids (TSS) and carbohydrates.

Our result was agree with those of Hafsi *et al.,* 2016 who reported that water, lipid, carbohydrate and fiber contents of fruits may explain the variability in the larval performance of Tephritid species. They added that larval survival of *B. zonata* was positively correlated with carbohydrate, lipid and fiber contents and negatively correlated with water content; while, larval survival of *Dacus demmerezi* and *Zeugodacus cucurbitae* was positively correlated with water content and negatively correlated with carbohydrate and lipid content.

Behmer, 2009 reported that the larvae of some phytophagous insect species (*Locusta migratoria* grasshopper) prefer high-carbohydrate diets, whereas others prefer high-protein diets (*Helicoverpa zea* caterpillars). The total soluble solids (TSS) of mango may be affected the adult preference of *Bactrocera dorsalis*. The differences between the present results and others may be attributed to the tested insect pest species/strain and/or the tested host plant varieties which differ in chemical components.

The physical and chemical factors associated with plants influence the choice and the balance between positive and negative stimuli that determine the final selection of the appropriate host of fruit flies (*B. zonata* and *C. capitata*) (Darwish , 2016). Joachim-Bravo *et al.,* 2001 and Fontellas-Brandalha and Zucoloto, 2004, were showed that the females of fruit flies (*C. capitate* and *Anastrepha obliqua*) are known to make decisions about into which fruit to oviposit based on the suitability of the fruit for their offspring's performance.

Presence of antixenosis and/or antibiosis phenomenon as one of the host plant resistance factors could be responsible for the variation between preferred and non-preferred host plants; whereas, antixenotic plants can be avoided or less colonized by pests seeking for oviposition sites; while, antibiosis is described as the position of some property by the plant which directly or indirectly affected the performance of the pest in terms of survival, growth, development rate, fecundity, etc. (Amro and Abdel-Galil, 2008).

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