Peach Fruit Fly, *Bactrocera zonata* (Saunders): the coming danger to the Mediterranean fruit trees, how serious this pest and how to minimize their impact

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Abstract
Fruit flies (Diptera: Tephritidae) include some of the world's most serious agricultural pests causing economic losses in the fruit across the world, and are a major quarantine concern for most countries. The family Tephritidae contains more between 4,400 - 5000 species. *Bactrocera* is the genus, with about 440 described species, and including the majority of the economically important fruit flies, e.g. *B.zonata*, *B.invadens*, *B.dorsalis* and others invading a wide spectrum of hosts especially the fleshy fruits. *B.zonata* is the serious pest of tropical and subtropical fruits, in India alone cause damage between 25 to 100% in peach, apricot, guava and figs, in Pakistan 25-50% on guava. This genus is globally recognized to be frequent invaders and aggressive colonizers of new environment. Due to the expansion in the international trade, tourism, beside the weakness of the phytosanitary measures *B.zonata* introduced into Egypt in 1998 and Libya in 2007 and becomes one of the major concerns to the plant protection authorities in all Mediterranean regions. EPPO, FAO/IAEA organized workshops, conferences and sponsored projects to increase the awareness of farmers, operators and related authorities to contain this invasion. IAM-Bari participates also in these initiatives by facilitating some basic researches on fruit flies biology, ecology and control. The potential distribution of peach fruit fly has been investigated by many scientists based on the potential climate change impact CLIMEX, they found that *B.zonata* is able to establish itself in a new regions and the potential of expanding peach fruit fly in the south Europe is possible.

Keywords: *Bactrocera zonata*, Peach Fruit Fly, Mediterranean region, IAMB

Introduction
Increased attention has been given to the subject of invasive pests in the last two decades due to the economic damage caused on crops. The fruit flies expansion is due to the international trade for agricultural crops between different countries, weak sanitary measures in addition to the excessive use of pesticides. During the past twenty years, many pest outbreaks were occurred in some economic importance pests causing significant impact on agricultural market, affecting the food security and the socioeconomic of many farmers. Among the most destructive invasive pests introduced from Asia to the rest of the world are citrus leaf minor, *Phyllocnistis citrella* on many citrus varieties, the red palm weevil (RPW), *Rhynchophorus ferrugineus* on palm trees, and recently *Drosophila suzukii* on many fruit trees. Tomato borer, *Tuta absoluta* is the last challenge to all the implemented phytosanitary measures which introduced from South America into Europe, North Africa, Middle East and Gulf, and still threatens other countries. Fruit flies have provoked different plant protection organizations globally to be more alert facing the danger of tephritid flies after the invasion of the Mediterranean fruit fly, *Ceratitis capitata* which has high dispersive ability to different parts of the world on wide range of hosts.

Fruit flies (Diptera: Tephritidae) include some of the world's most serious agricultural pests causing billions of dollars indirect losses to a wide variety of fruit, vegetable and flower crops (e.g., citrus, apple, mango, sunflower), they limit the development of agriculture in many countries because of the strict trade quarantines imposed to prevent their spread. Of the more than 4,400 species known worldwide (Norrbom, 2004), around 350 species are of economic importance (Plant Health Australia, 2011).The *Bactrocera* as Vargas 2011 said is a tephretid fly genus of at least 440 species distributed primarily in tropical Asia, and the south Pacific and Australia. However, these species have been spreading throughout the world at an alarming rate over the past 15 years. Oriental fruit fly, *B. dorsalis* has become established and is spreading throughout French Polynesia. Carambola fruit fly (*B. carambolae*) is established and spreading throughout areas of South America. *B. invadens*, *B. latifrons*. Melon fly (*B. cucurbitae*) in Africa and peach fruit fly (*B. zonata*) in Africa and the Mediterranean region. http://cecolusa.ucanr.edu/Master_Gardeners/?blogtag=Roger%20Vargas&blogasset=22198 . Globally out of 5000 tephritid fly species about 1400 species develop in fruits, out of these, about 250 species are pests. In Africa, out of 915 native fruit fly species, 299 species develop in fruits (Mohamed *et al*.2012).

One of the main research lines of CIHEAM / IAMB is to strengthen the Mediterranean phytosanitary networking through a solid database for the native and invasive pests in the Mediterranean region. The institute builds up its data from the researcher results conduct in the institute or through the cooperation with local and international experts. Regarding the fruit fly pest the institute started the initiative since 2011, when two master projects have been proposed, the first was on the economic importance and control of *Ceratitis capitata* in Tunisia (Boagga 2012) while the second was on the spotted wing drosophila, *Drosophila suzukii* in Italy (Jasim 2012).Recently another three students are preparing their degree on the evaluation of male annihilation technique and 'attract and kill' measures for the control of mixed populations of *Bactrocera zonata* and *Ceratitis capitata* on mango and peach in Egypt (Al-Jazar 2013).The second researcher is tackling some biological , ecological and control of African fig fly, *Zaprionus indianus* in Jordan (Alawamleh 2013) which is first recorded by Al-Jboory and Katbeh-Bader 2012 on date palm.The fifth ……. The outcome results from the above mentioned five topics will target the main objective goal of IAMB "developing and harmonized pest alert system in the Mediterranean region".

Peach fruit fly or guava fruit fly, *Bactrocera zonata*

The genus *Bactrocera* is globally recognized to be frequent invaders and aggressive colonizers of new environment. Due to globalization of trade and ever-growing tourism coupled with the fragile nature of the quarantine facilities and lack of phytosanitary expertise in Africa and Middle East countries, these regions continue to be under continuous threat of invasion by species belonging to this genus (Mohamed *et al*, 2012). The peach fruit fly, *Bactrocera zonata* (Saunders) is a polyphagous species, but it is particularly a pest of peach, mango and guava. It also infests some vegetables as a secondary pest; around 400 species belonging to the genus *Bactrocera* are widely distributed in tropical Asia, South Pacific and Australia regions, but very few species of such genus were recorded in Africa (Drew and Hancock, 1994).

Many features have been used to differentiating species based on morphological characters among them the one used by Iwahashi and Routhier (2001) who differentiated *B. dorsalis*, *B. correcta* and *B. zonata* based on aedeagal length measurements. A comparison of profiles of phenylpropanoid volatiles metabolites accumulated by three species of very high economic and quarantine importance, *Bactrocera invadens*, *B. zonata* and *B. correcta*, with that of *B. dorsalis* has been conducted by (Tan *et al.*, 2011) as a tool for species identification. Molecular techniques are best used to support or augment morphological identification which is used to identify early larval stages and eggs and also incomplete adults (Plant Health Australia, 2011). Another research has been investigated the genetic structure and the phylogeny of the Egyptian peach fruit fly using the total RNA (Abd-El-Samie and El-Fiky, 2011).

Distribution

B.zonata is widespread in south Asia from Pakistan, India and Sri Lanka to Southeast Asian countries such as Thailand, Laos, Vietnam and Indonesia. Introduced and established in the Arabian Peninsula since at least 1982, well established in Egypt since the late 1990s, in Libya 2007 also present on the Indian Ocean island of Mauritius. Detected numerous times in California since 1984, and as recently as August 2010, but not established there (White and Elson-Haris, 1992; EPPO, 2005; Steck, 2010; Kafu, 2012).

Host plants

The hosts plants of *B.zonata* have been listed by many researchers include more than 50 different fruit, vegetable and wild plants belong to 22 families. The major hosts are mango, guava and peach and other soft fleshy fruits. (White and Elison-Harris, 1992; Allwood, 1999; EPPO, 2005; Delrio and Cocco, 2012).

Biology

The biology and economic importance of *B.zonata* have been extensively reviewed in India, Pakistan and Egypt (Qureshi *et al*., 1993; OEPP/EPPO 2005, Khalil, 2010; Fetoh *et al*., 2012). Aleryan *et al.* (2006) investigated the natural oviposition stimulants on egg depositing under laboratory conditions of 23 ± 0.8°C, 69.32% ± 1.73 RH. Results showed that the numbers of eggs harvested from perforated cups supplied with mandarin juice were highly significantly exceeding the other stimulants like banana, orange, guava, mango, and orange juices. Total numbers of eggs/female were 92.41 and 235.21 for females collected from guava and mandarin fruits, respectively. Elnagar *et al*. (2010) based on the seasonal abundance of both *B.zonata* and *C.capitata* found that milder climate conditions is favorable for *C.capitata* however high temperature supported survival of *B.zonata.*

Damage

The oviposition-site punctures in the fruit are commonly referred to as ‘stings’. Stings are usually identified by making a shallow cut through the skin of the fruit. In fruits such as peaches, the stings are not very noticeable, while in pale, smooth-skinned fruits, the sting mark may be easily detected and can disfigure the fruit when marked by ‘gum bleed’ (Plant Health Australia, 2011).

Fruits with high sugar content, such as peaches, exude a sugary liquid, which usually solidifies adjacent to the oviposition site (EPPO 2005).

Tephritid fruit flies cause direct losses to many fresh fruit and some vegetable industries, resulting in adverse impacts on trade and economies of many countries (Li *et al*., 2010; Stephenson *et al.,* 2003). Current annual costs of damage in the Near East are estimated at 320 million EUR, and intensive control measures are needed to grow susceptible crops commercially. In Egypt, *B. zonata* has caused an estimated 190 million EUR damage a year (OEPP\EPPO, 2005) while El-Henedy 2012 mentioned that the *B.zonata* poses a threat to many Egypt’s export markets. It causes estimated levels of infestation reached up to 30-40% (approx.

177 million US$ loss yearly). If no control measures applied against *C.capitata*, the annual fruit losses are estimated to be about U.S. $365 million (Lysandrou, 2009). *B. zonata* is known in India and South-East Asia as a serious pest of tropical and subtropical fruits. It is one of the three most destructive flies in India, causing crop losses of 25 to 100% in peach, apricot, guava and figs. In Pakistan, *B. zonata* alone has caused 25-50% damage to guava fruit (Siddiqui *et al*., 2003 in CABI International, 2010).

Control

The control measure of *B.zonata* are not far away from the conventional methods used for fruit flies, starting with population monitoring, field sanitation, protein bait, male annihilation technique, biological control and sterile insect technique (SIT) (Haw-Flypm, 2002).The implementation of the conventional insecticides is still the dominant measure to control fruit flies in many parts of the world (El-Aw *et al*., 2008; Ahmad *et al*., 2010; Mosleh *et al*., 2011). Resistance was induced ranging 3-19 folds in *B. zonata* against trichlorfon, malathion, lambda-cyhalothrin and bifenthrin in Pakistan (Ahmad *et al*., 2010). Few biorational insecticide have been used against *B.zonata* such as Neem oil which showed a good efficacy against *B.zonata* in different concentrations (Mahmoud and Shoeib, 2008) and entomopathogenic nematode *Steinernema feltiae* Cross N 33 against 2^{nd} and 3^{rd} larval instars and pupa of 1, 4 and 6 days old of the peach fruit fly (Mahmoud and Osama, 2007). The quarantine threshold of *B.tryoni* is different from country to others e.g. five male catches in the trap indicate an outbreak which need quick action, however another countries consider two males or even one as threshold for an outbreak (Dominiak *et al.*, 2011). Regulatory action is required if more than five adult flies or an unmated female and a male are found in an area less than 3 km^2 within one estimated PFF life cycle, or one mated female, or larva, or pupa are detected, or a single adult fly is found which is determined to be associated with a current eradication project (FAO/IAEA 2000).

Monitoring with different traps is the first step used to detect the fruit flies in the fields. Rodríguez Palomino (2012) described one of the successful eradication campaign for oriental fruit fly *Bactrocera dorsalis* in an Island in Chile when a trapping network were set up throughout the area of the captures. Malathion/Methyl Eugenol traps and protein-baited traps were checked twice a week in order to determine the magnitude of the outbreak and possible dispersal. After four month of extensive work they achieve complete eradication for this pest.

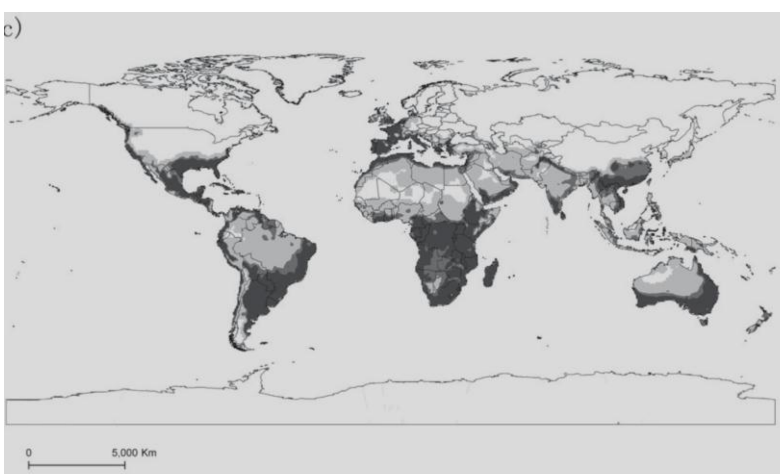
El-Gendy (2012) compared between two different Jackson trap colors yellow and white provided with the sex attractant methyl eugenol, he found that white color trap, hanging about 1.5 m above ground, in the West or North or West-North direction was captured more males than the yellow. Ba Angood and Sunaid, 2012 used methyl eugenol to monitor the movement of peach fruit fly in mango and guava fields in 2010/2011 in Lahij province in Yemen, they found that the pest is available almost all the year around, and there is a positive correlation between the increase of temperature and the number of adults caught in the traps. Ali *et al* 2010 evaluated different control methods including cultural control, Bait Application Technique (BAT) and Male Annihilation Technique (MAT) against *B.zonata* comprise in Peshawar/Pakistan, they found that the farmers favored MAT as it was found to be economically feasible, environment friendly with high efficiency. The World Bank sponsored a project in 2010 for combating fruit flies in Eastern and Southern Africa in which many achievements have been reached among them, problem assessment, using of different control techniques like biopesticide, establish a fruit fly database, and facility of identification tools as well as advanced training and others (Ekesi, 2010) .Sterile insect technique(SIT) was successfully used against *C.capitata* in South Africa therefore the program will be expand to cover 70% of all deciduous fruits and table grape between 2013 and 2015 (Barnes, 2012) **.** The effect of Gamma rays on the peach fruit fly female pupae were investigated showing that the dose of 40 Gy seems to be the suitable for sterilizing *B.zonata* female and no indication of ovarian recovery till 7 weeks of female life (Younes *et al.,* 2007).

Climate Change as a parameter for *B.zonata* expansion in the Mediteranean region

Despite its economic importance, *B. zonata* has been insufficiently investigated, and its potential for colonizing new areas has been inadequately estimated (Ni *et al*., 2012). In addition, global climate change is widely accepted to have produced global temperature increases of approximately 0.6 °C throughout the 20th century, with temperatures expected to continue to increase in the current century (Christ *et al*., 2002). *B.zonata* was considered as exclusively in tropical area (e.g. Mauritius and Reunion) (EPPO,2005) ,however after the invasion of Egypt and Libya the insect ranges are likely to expand pole ward to the cooler area in response to changes in temperature, soil moisture, and humidity patterns.

The attributes and applications of the CLIMEX modeling software have been extensively documented elsewhere (Sutherst and Maywald, 1985, 1999; Sutherst *et al*., 1995, 1999; Sutherst, 1998). It uses a combination of 'growth' and 'stress' indices to describe responses over the full range of climatic conditions that occur in different seasons in different places around the world. Experience with CLIMEX has shown how little biologists know about the role of climate in limiting species' distributions. Sutherst et al. (1995) and Kriticos and Randall (2000) compared the different ways in which various climate matching approaches matched climates. Rather than repeat a description of the model here, the opportunity is taken to highlight or elaborate on a number of features and issues related to CLIMEX and climate-matching that are not widely appreciated (**http://www.ento.csiro.au/climex/climex.htm**).

Ni et al., 2012 Delrio and Cocco (2012), draw a map shows a tentative distribution of *B. zonata* based on the Ecoclimatic Index, under current climate conditions, the model predicts the establishment and persistence of the peach fruit fly in coastal areas of North Africa and Near East. The climatic suitability of European countries for *B. zonata* establishment was limited to southern areas of Portugal, Spain, Greece and all the main Mediterranean islands. The potential geographical distribution of the peach fruit fly appears to be narrower than that of *C. capitata*, which is more adapted to low temperatures. Moreover, the predicted range of *B. zonata* seems to coincide with most of the Mediterranean citrus-growing areas.



Fig(1) Climatic suitability (EI) for the peach fruit fly in the 2070s projected using CLIMEX™. Source meteorological data adjusted using CSIRO Mark 2.0 GCM running the SRES (Ni *et al*., 2012.

Conclusion

Peach fruit fly is a large threatens to the Mediterranean countries and especially the south of Italy, Spain, Greece and the Mediterranean islands. Based on the results of Ni *et al.* (2012) the peach fruit fly is predicted to invade many new regions in the tropical and subtropical, South Carolina, Southern China and Australia.This forcast have been predicted for 2070.

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