

The Population Dynamics of the Mediterranean Fruit Fly, *Ceratitis capitata* Wied. Diptera: Tephritidae in Some Fruit Orchards in Gaza Strip

ديناميكية تغير أعداد ذبابة فاكهة حوض البحر الأبيض المتوسط في بساتين الفاكهة
بقطاع غزة

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Abstract

A field study was carried out on the population dynamics of Medfly *Ceratitis capitata* Wied. males in three governorates groves of Gaza Strip (North, Gaza and Middle). Forty two orchards of Valencia orange as host plants of the fruit fly, thirty one orchards of olive as nonhost plants and sixteen backyards as urban area representing three different ecological environments of the fly, were chosen during two successive growing seasons. During the first growing season (2002), the grand mean of captured males/trap/day (CTD) of *C. capitata* for all inspection dates were: 1.99, 1.19, 1.2, 1.67, 1.35, 0.93 and 0.94 in Valencia orchards, North, Gaza, Dair Al Balah zone, total area, olive orchards and backyards, respectively. In 2003, the CTD for the above mentioned sites were 3.26, 1.12, 1.99, 1.81, 0.93, 1.03, and 1.02, respectively. Mean percentages of *C. capitata* host fruit infestations were 12.5-35.1% in collected samples during two successive seasons. All the sites contained mixed host plants of citrus, stone and pome fruits, guava, figs and other host fruits. More than two population peaks at the fruit ripening period of Valencia orange (April-June), peach, fig, guava (June-August) and Shamoty orange, grapefruit, guava, clementine (November-December) were obtained. The Medfly activity continued in most of the season, but decrease to a very low level in all studied locations during early spring months (February -March), due to the absence of host fruits and unfavorable climatic conditions. There was relationship between the average daily temperatures and daily activity period of the insect during summer seasons, as the traps captured a greater number of males at moderate temperatures. The mean number of CTD was significantly different in all 36 dates of inspection in each season for the three governorates and in three ecological environments (Valencia orange, olive orchards and backyards) of *C. capitata* during 2002 and 2003 seasons. In the same, time the means CTD's were not significantly different among the three

governorates. Results obtained could be exploited in management of this insect pest especially, in its control programs

Key words: Population dynamics, Mediterranean fruit fly, *Ceratitis capitata* Wied. and Gaza strip

ملخص

أجريت دراسة حقلية خلال موسمي نمو متتاليين 2002 و2003 حول ديناميكية تغير أعداد ذكور ذبابة الفاكهة *Ceratitis capitata* Wied., Diptera:Tephritidae في بساتين الفاكهة لثلاث محافظات: الشمال وغزة والوسطى. وقد اختير لتمثيل ثلاث بيئات مختلفة لذبابة الفاكهة 42 بستان فلسطينيا كعائل نباتي لهذه الحشرة و31 بستان زيتون كنبات غير عائل و16 حديقة منزلية في المناطق السكنية، إضافة لجميع المساحات المزروعة في المحافظات الثلاث. في عام 2002 كان المتوسط الإجمالي لأعداد الذكور/ مصيدة/ يوم (CTD) لجميع مواعيد مراقبة ذبابة الفاكهة في بساتين الفلنسيا ومحافظه الشمال وغزة ودير البلح وإجمالي المساحات المزروعة وبساتين الزيتون والحدائق المنزلية بالترتيب كما يلي: 1.99 و1.19 و1.2 و1.67 و1.35 و0.93 و0.94، وفي عام 2003 كان متوسط الأعداد ل CTD للاماكن السابقة الذكر بالترتيب هي كما يلي: 3.26 و1.12 و1.99 و1.81 و0.93 و1.03 و1.02. وكان متوسط النسبة المئوية لإصابة هذه الحشرة لثمار عوائلها يتراوح بين 12.5% و35.1% خلال الموسمين 2002 و2003م. لقد احتوت جميع مواقع الدراسة على عوائل مختلطة من الحمضيات واللوزيات والتفاحيات والجوافة والتين وعوائل أخرى، كما تم الحصول على أكثر من منحنى لأعداد مجتمع ذبابة الفاكهة خلال مواعيد نضج كل من الفلنسيا (أبريل - يونيو) والخوخ والتين والجوافة (يونيو - أغسطس) والشموطي والجريب فروت والجوافة والكلمنتينا (نوفمبر - ديسمبر). وتبين النتائج أيضاً أن نشاط الحشرة يستمر في معظم الموسم، ولكنه ينخفض، في جميع مواقع الدراسة، خلال اشهر الربيع (فبراير - مارس) وقد يعود ذلك إلى انعدام وجود عوائل الحشرة من الفواكه وظروف المناخ غير المناسبة. تبين وجود علاقة بين معدل الحرارة اليومية ومواعيد نشاط الحشرة اليومي في أشهر الصيف. وأظهرت نتائج التحليل الإحصائي أيضاً وجود فروقات معنوية بين متوسطات أعداد ذكور ذبابة الفاكهة/مصيدة/يوم بين 36 ميعاداً لأخذ القراءات في الموسم الواحد وأيضاً بين البيئات الثلاثة (بساتين الفلنسيا والزيتون والحدائق المنزلية) خلال موسمي 2002 و2003. وفي نفس الوقت عدم وجود فروقات معنوية بين المحافظات الثلاثة (الشمال وغزة والوسطى). ويمكن استثمار النتائج التي تم الحصول عليها في إدارة الحشرة وخاصة في برامج مكافحتها.

Introduction

The Mediterranean fruit fly *Ceratitis capitata* Wied (Diptera: Tephritidae), known also as the Medfly, is one of the most widespread and damaging pests of horticulture in the fruit fly group and is

recognized by some as the worst pest of citrus and other fruits⁽¹⁻³⁾. The Mediterranean fruit fly was reported in the Middle East, and was first detected in orchards in the early 1900s in Palestine⁽⁴⁾.

C. capitata is adapted to various climates and it attacks most citrus varieties, deciduous and subtropical fruits as well as some vegetables⁽⁵⁻⁶⁾. The variability in host range is influenced mainly by the habitat, environment factors and by chemical and physical characteristics of the fruits⁽⁷⁻¹⁰⁾. Heavy infestation by *C. capitata* has been recorded on several fruit crops mainly citrus fruit in Gaza strip⁽¹¹⁾.

The appearance, biology, distribution, behaviour, natural enemies, control and life history of *C. capitata* in different geographical regions have been described in many studies⁽¹²⁻¹⁴⁾. The population dynamics of the Medfly fly have been studied extensively in the tropics and subtropics to a lesser extent in temperate areas of its current geographical distribution. Tropical studies deal primarily with adults trapping in different habitats, although some examined the effect of host fruits on population dynamics^(8, 15-17). In areas such as the Mediterranean region, host fruits (eg. various citrus species) are available around the year and, therefore, the main factors regulating level of populations in this areas were the relatively low winter temperatures⁽¹⁸⁻²²⁾.

To determined adult fly population, Jackson sticky traps were used not only in this study but also in the other countries in the world^(15-18, 20-21). This trap is a delta shaped object made of waxed cardboard material. The additional parts include 1) a white rectangular insert of waxed cardboard covered with a thin layer of sticky material used to trap *C. capitata* males. 2) A polymeric plug and a plastic basket that holds the lure plug and 3) a wire hanger placed at the top of the trap body. The Jackson trap was used with 2 gm trimedlure male attractant pheromone (tetra 4 (and 5) - chloro -2 methylcyclo - hexane -1- carboxylate)⁽²³⁾. The effectiveness and use of pheromone traps in capturing and monitoring the population of *C. capitata* adult in fruit groves were described and discussed by many researchers Harries, et al.⁽²⁴⁾, El-Sayed et al.⁽²⁵⁾ and Mogahed⁽²¹⁾.

Cultivated area with fruits in Gaza Strip reached 18322 ha fruit trees

in 2000/2001 growing season ⁽²⁶⁾. In the districts of the Gaza strip *C.capitata* is controlled in citrus and guava orchards by Bait Application Technique (BAT) (ground bait spray). This BAT is used in Gaza strip as one main method against *C.capitata* ⁽²⁷⁻²⁸⁾.

Several specific control methods have been developed and applied successfully in many countries against the *C. capitata*. These methods are cover - spraying, hygiene, the Sterile Insect Technique (SIT) and the Bait Application Technique (BAT). All the above methods are recommended for control and suppression of the population of *C. capitata* in citrus groves ⁽²⁹⁻³²⁾.

In Gaza strip, no studies are available on population dynamics of *C.capitata*. The present study deals with the population dynamics of *C.capitata* in different ecological environments: Valencia orange, olive orchards and backyards throughout the season. It aimed to monitor the flight activity of the Medfly in three Governorates groves, establishing the importance of host fruits for population development and comparing populations of the fly in citrus (Valencia) orchards with olive as non-host and backyards in urban area.

Materials and Methods

Study area, Fruit types and climate

The study was carried out during 2002-2003 seasons in three ecological environments of Mediterranean fruit fly: host fruits (Valencia orange), non host-plants (olive orchard), backyard (urban area) extending to the total area of three governorates: North Gaza, Gaza and Dair Al-Balah. The primary *C.capitata* hosts in Gaza strip are citrus (*Citrus* spp.), pears (*Pyrus communis* L.), apple (*Malus sylvestris* Mill.), figs (*Ficus carica* L.), peach (*Persica vulgaris*); apricots (*Prunus armeniaca* L.), guava (*Pisidium guava* L. ⁽⁵⁻⁶⁾). The climate of study area is characterized by a warm, dry summer and wet winter with low temperatures but over zero degree. The average seasonal temperature was ranged from 19.69 to 21.16° C and average seasonal R.H. was ranged from 62.85 to 69.85 % ⁽³³⁾.

Technique of studying population dynamics of C.capitata

Jackson sticky traps described by Harris⁽²⁴⁾ were used for monitoring population of *C. capitata* males. Effectiveness and use of attractive traps in capturing *C.capitata* adults were demonstrated by Kapoor⁽³⁴⁾, El-Abbassi & Makkar⁽³⁵⁾ and Dias & Arthure⁽³⁶⁾.

To study the flight activity of adults Medfly in various ecological environments, the adult populations were monitored in all areas of the three governorates, among forty - two Valencia orange orchards, thirty - one olive orchards and seventeen backyards. In this area a small number of non - host trees such as olives (*Olea europea* L.) and almonds (*Prunus amygdalus*) are cultivated. Seventeen sites of isolated backyards without neighboring host plants for *C.capitata* located in Jabalia camp, Gaza and Dair Al-Balah districts were used in this study. Seventeen sticky traps were released in backyards area at a rate of one trap per 100 ha. Forty - five and fifty - one sticky traps were distributed in the Valencia and olive orchards, respectively at a rate of one trap per 10 ha. A total number of 346 traps at a rate one trap per 10 ha was distributed in all orchards of north Gaza, Gaza, Middle governorates including groves of Valencia orange, starting from January 2002 to 31 December 2003 for the two successive growing seasons. Each trap was suspended on tree branches in a shaded area at a height 1.5-2.5m then, baited with the male attractant trimedlure imported from International Atomic Energy Agency (Vienna), offered from USDA- APHIS. Traps were inspected once every ten days (three times per month). The numbers of flies captured by the sticky cardboard located inside the trap were counted and the cardboard strips were then renewed. Average number of captured males per trap per day (CTD) were calculated and then used as a parameter for flight activity monitoring. After every two weeks, new sticky inserts were installed in each trap.

Host survey and fruit infestation by C.capitata

A total number of 1980 fruits of Valencia and Shammoty orange, clementine, grapefruit, figs, guava, navel orange and apple fruits were collected randomly from host fruit orchards of *C.capitata* during 2002-2003 growing seasons. The fruit samples (fallen or harvested) were used

in studying the fruit infestation by *C.capitata* during the period of fruit maturity (from early March to the end of November) during the two successive seasons 2002 and 2003. The collected samples were weighed, measured and then stored separately in the laboratory in plastic cages (30cm diameter) which were covered with fine gauze to prevent entry of other flies and ants. The fruits were then placed on a plastic sieve and the emerged larvae were allowed to pupae in sand placed at the bottom of cages or plastic sieves. Pupation mostly took place for a period of 5-14 days after the fruits started rotting. Pupae were then removed and stored in plastic vials covered with fine gauze, and they were incubated until the adult flies emerged. These methods are based on Saafan et al. ⁽³⁷⁾.

Statistical Analysis

Data obtained from Valencia orange, olive orchards, backyards, North, Gaza and Middle Governorates experiments were statistically analyzed by Analysis of variance (ANOVA) and least significant differences (LSD) tests, performed by Genstat 5 computer program.

Results and Discussion

Seasonal abundance and fluctuation of C. capitata populations:

Data presented in Tables 1 and 2 and illustrated in more details in Figures 1, 2, 3 and 4 show that the mean numbers of CTD^s which were significantly different in the three ecological environments (Valencia orchards, olive orchards and backyard) of *C.capitata* and in 36 dates of inspections for the three governorates during the two growing seasons (2002 & 2003). Therefore, the differences in the first case (ecological environments) might be due to the effect of host fruits habitats (Valencia orange) and agricultural habitats. Harris ⁽⁷⁾ and Conti ⁽³⁸⁾ reported that the biotic and abiotic factors in host habitats have influencing on population trends of Medfly, *C. capitata* in host habitats in Tunisia. However the differences in the 36 seasonal inspections could be attributed to the climatic conditions. Data also indicated, that Medfly populations were much higher during the second season (2003) than the first (2002) season in Valencia orange groves as well as in the area of Gaza and Middle Governorates. These data are in agreement with previous finding

Conti⁽³⁸⁾, Israely⁽⁹⁾ and Harris⁽⁷⁾ who reported that climatic condition have been effect on population of Medfly *C. capitata* in host fruits groves, in addition there is relationship between temporal and spatial distribution of Medfly *C. capitata* population and host phenology. Also these researches showed that Medfly dispersion and captures was found to be closely related to host ripening sequence, temperature and climatic condition. However, there are no significant differences between CTD's within the three governorates (North, Gaza and Middle). This may be due to the similar distribution of *C. capitata* host plants and the sameness of climatic condition in three governorates (Table 1; Figures 1 and 2).

The results also indicated that *C. capitata* male populations during the first season (2002) was high in June to September; CTD=0.79-3.49, 1.19-2.48 and 1.28-2.01 in North, Gaza and Middle Governorates, respectively. In addition, the populations were high at the end of October to 15th December; CTD=0.76-1.63, 1.19-3.28 and 2.52-4.79 in North, Gaza and Middle governorates, respectively. Between 15th December and 25th April, the populations were low as a result of cold weather; CTD=0.01-0.19, 0.06-0.66 and 0.12-1.12 in North, Gaza and Middle governorates, respectively (Figure 1).

During the second season (2003), the adult population of *C. capitata* was high in 15th June to 15th September; CTD=0.36-1.43, 1.75-3.9 and 0.29-0.70 in North, Gaza and Middle governorates, respectively. In addition the population was high in 5th November to 15th December; CTD=0.78-1.5, 3.96-4.87 and 0.66-0.81 in North, Gaza and Middle governorates, respectively (Figure 2). It is noteworthy to mention that peak population densities were reached quickly in the dry season during March-August, when the last citrus and other host fruits (navel orange, grapefruits, figs, peach and apricot) were repining.

Comparison between captured *C. capitata* in the three governorates using the values of CTD in two years (2002 & 2003) showed similar fluctuation patterns during the study periods. These patterns are characterized by more than two major population peaks; March- April, June - July, August and November - December in the ripen host fruits examined (Fig. 1 & 2). In addition, the populations of *C. capitata* were

higher during June-November (CTD=0.62-3.49) in North Gaza governorate during 2002 than Gaza and Middle governorates. In contrast, during 2003 *C.capitata* population in Gaza was higher (CTD=0.6-4.57) than North and Middle governorates. These differences might be due to change in host fruits groves densities ⁽²⁵⁾. These results, are in agreement with those obtained by other researchers ^(20, 22) who showed that, the peak population in the coastal region of Syria and Jordan was at the middle of citrus growing season (December), whereas when there were differences in host maturation (peaches and citrus), two peaks or more were observed. Also, Avidov and Harpaz ⁽⁵⁾ reported that *C.capitata* produced 4-5 generations in valleys of the interior it produces 6-7 generations a year under normal natural conditions in the coastal plain depending upon the type of citrus fruits. Mustafa, & Abdel-Jabbar ⁽²⁰⁾ reported that 3 generations of *C.capitata* on peach were produced in Jordan; the first in early August, the second and third were in late August and mid October, respectively. Ahmed & Mofleh ⁽²²⁾ showed that nine generations for fruit fly *C. capitata* per year were registered in the coastal region of Syria.

Table (1): The grand mean numbers of captured males for thirty six dates of inspection in Jackson traps per trap per day (CTD) of *Ceratits Capitata* in the three governorates of Gaza Strip during 2002 and 2003 growing seasons.

Growing season**	Average monthly CTD of <i>C.capitata</i> males*			Average monthly total rainfall mm.	Average monthly R.H.%	Average monthly Temperature° C
	North	Gaza	Middle			
CTD 2002	1.19	1.21	1.67 X	32.85	69.85	21.16
K* LSD at 0.05%	X*	X 1.0	1.6			
	1.16					
CTD 2003	1.12 Y	1.99	1.81 Y	43.66	62.85	19.69
L* LSD at 0.05%	1.12	Y	0.0.75			
		1.36				

* Means followed by the same letter within a row and column are not significantly different (LSD test at 0.05% Genstat 5 program.)

** Means CTD within a date of inspections are significantly different (LSD test, at 0.05% Genstat 5 programme).

Table (2): The mean numbers of captured males for thirty six dates of inspection in Jackson traps per trap per day (CTD) of *Ceratits Capitata* in Valencia orange orchard, olive orchards, backyards and total area in three governorates during 2002 and 2003.

Growing ** Season	Valencia Orchard	Olive Orchard	Backyard Urban	Total NGM Gov.
CTD 2002* K	1.99 X	0.93 Y	0.94 Z	1.35
LSD at 0.05%	0.92	1.08	1.09	0.59
2003* K	3.26 W	1.03 ZY	1.02 Z	0.93
LSD at 0.05%	2.7	1.65	1.15	0.89

* Grand means CTD followed by the same letter within a row and columns are not significantly different (LSD test at 0.05%).

** Means CTD within a date of inspection are significantly different (LSD test, at 0.05%).

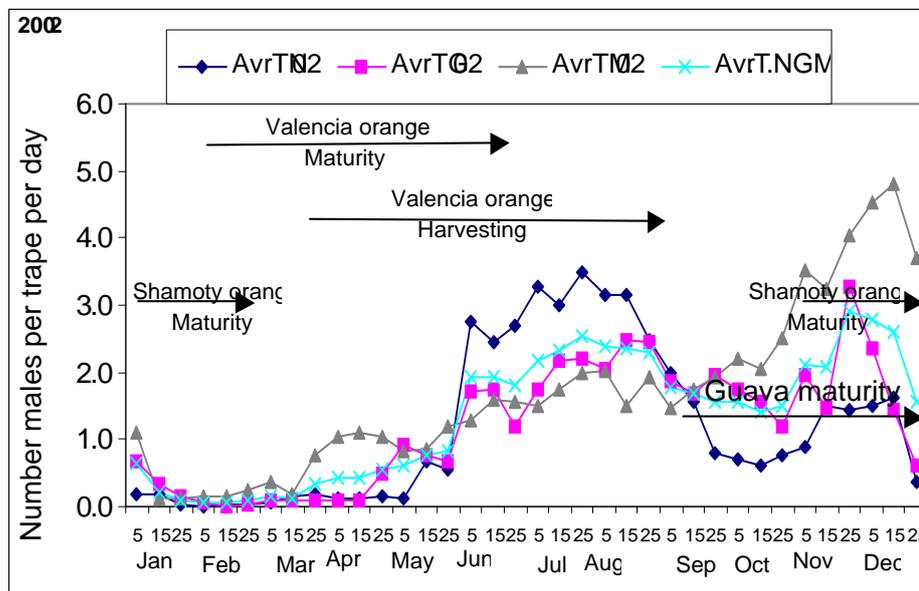


Figure (1): The mean numbers of captured *Ceratits capitata* males per trap per day (CTD) in total area of North (ToN), Gaza (ToG), Middle zone (ToM) and average the three Governorates (TNGM) during the year 2002.

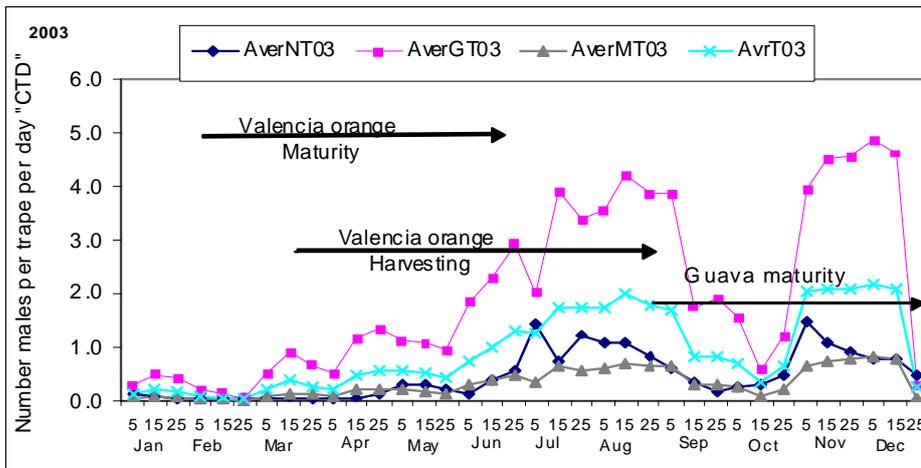


Figure (2): The mean numbers of captured *Ceratitidis capitata* males per trap per day (CTD) in total area of North (NT), Gaza (GT), Middle zone (MT) and average the three Governorates (ToNGM) during the year 2003.

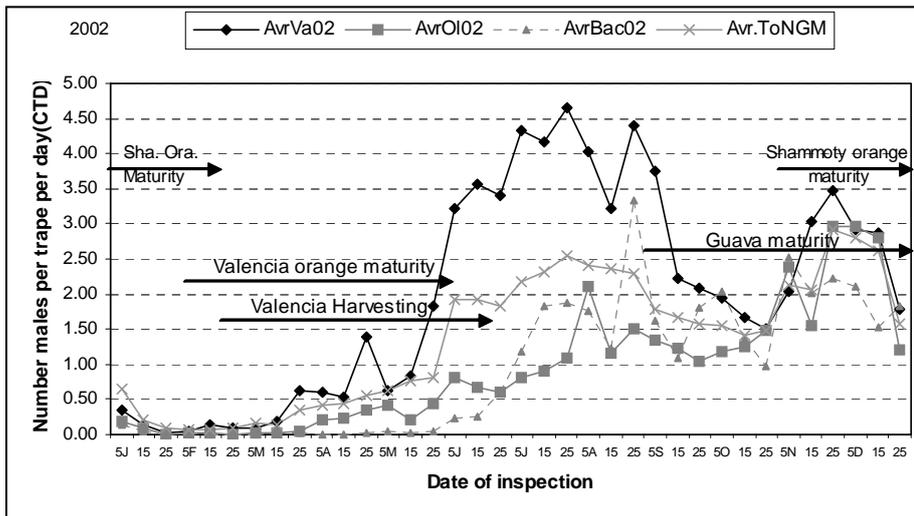


Figure (3): The mean numbers of captured *Ceratitidis capitata* males per trap per day (CTD) in Valencia orange orchards (Va.), olive orchards (Ol.), backyards (Ba.) of the three Governorates (N,G,M) and all area of North, Gaza, Middle (ToNGM) Governorates during the year 2002.

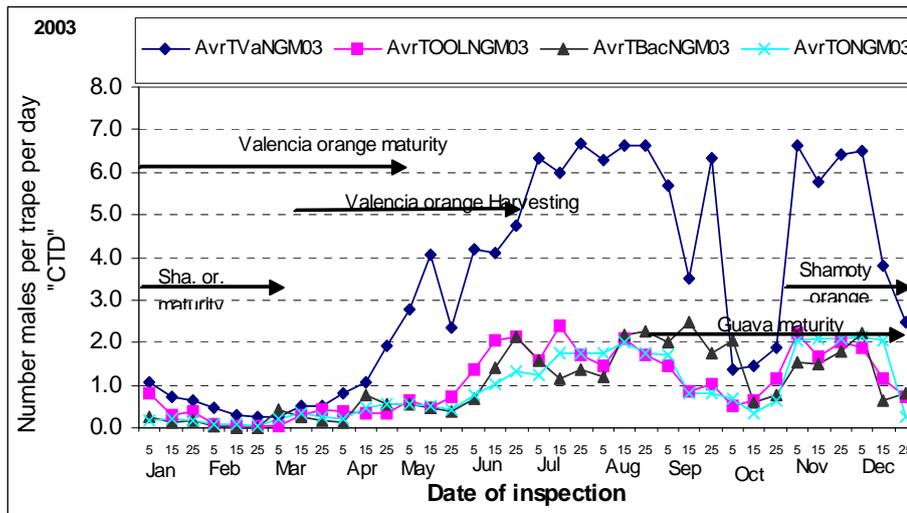


Figure (4): The mean number of captured *Ceratitidis capitata* males per trap per day (CTD) in Valencia orange orchards (Va.), olive orchards (Ol.), backyards (Ba.) of the three Governorates (N,G,M) and all area of North, Gaza, Middle (ToNGM) Governorates during the year 2003.

Data illustrated in Figure 1 and 2 shows that the *C. capitata* activity did not stop to but it decreased to a very low level in all studied sites during spring months due to the absence of host fruits. The temperature had a clear effect on the daily activity period of the insect during summer season since traps captured a greater number of males under moderate temperatures. These results are in agreement with those obtained by Israely et al. ⁽⁹⁾ who reported that, the *C. capitata* adult population decreased to a zero levels during the winter months and remained at this level until spring, when early flies were again captured by the traps. Thereafter, the spatial distribution and buildup of the population during summer and autumn were closely associated with the phenology of the different fruit host and with their spatial distribution, insecticide applications, density of host fruits and distance between hosts.

Results presented in Figures 3 and 4 showed that the *C. capitata* population was highest in Valencia orange orchards than in olive orchards, or in backyard in mid April to mid August of 2002

(CTD=0.53-4.56, 0.21-2.11, 0.00-1.87 and 0.44-2.56, respectively). These values were CTD = 0.05-6.36, 0.33-2.39, 0.39-2.19 and 0.44-1.99, respectively, 2003 (Figure 4). In addition, the population was higher in Valencia orchards from early October to the end of December, 2002 (CTD=1.51-3.47) and 2003 (CTD=1.37-6.62) in comparison with other orchards. The above mentioned results indicate that host fruit availability affects on fruit fly population fluctuations. Also there is a correlation between fly numbers and ecological environment of fruit fly (fruit availability). The mean number of CTD varied significantly from one ecological environment type to another (Table 2). This is in agreement with results obtained in other investigators^(7, 9, 16, 39-40).

Nevertheless, the overall results obtained in two growing seasons and in three governorates in Valencia and olive orchards and in backyards were almost similar to that reported by other researchers who worked on the population dynamics of this fruit fly^(8, 10, 15-16, 20, 22, 37, 40-42).

Survey of host plants of *C. capitata*

We found that *C. capitata* attacks the following host fruits existing in North, Gaza and Middle governorates: Valencia orange (*Citrus aurantium* L.), Shamoty orange (*Citrus sp*), Navel orange (*Citrus sienensis* L.), Grapefruit (*Citrus x paradise* Macfady), clementin (*Citrus mitis*), Sweet orange (*Citrus sinensis* L.), Lemon (*Citrus lemon* L.), Guava (*Pisidium guajava* L.), Fig (*Ficus carica* L.), Pear (*Pyrus communis* L.), Apple (*Malus pumla*), Peach (*Prunus persica* L., *P. amygdalus* L.), Apricot (*Prunus armeniaca* L.), Mango (*Mangifera indica*, L.), Avocado (*Persea americana* Mill), Loquat (*Eriobotrya jabanic* Thunb.), Prickly pear (*Opuntia sp.*), Grapvine (*Vitis vinifera* L.), Date palm (*Phoenix dactylifera* L.).

Infestation with *C. capitata* on various hosts

The Highest mean percentage of *C. capitata* infestation was observed on figs (35.1%)and the lowest was an apple (12.5%) , whereas infestation rate on other hosts was intermediate (Table 3). These results are in agreement with that obtained by Mustafa and Abdel-Jabar⁽²⁰⁾ who reported that infestation percentage of pear reached 90%, apple 52% and fig reached 35% in Jordan. Also Hashem et al.⁽⁴⁰⁾ show that the degree

of Medfly infestation on the different host fruits was extremely heavy as it was ranged from 5.7% on Valencia orange to 74% on apricot in Egypt.

Results of this study provide useful information used for *C. capitata* management in Gaza district. Further research is needed to study the seasonal abundance and host susceptibility of Medfly which will help in planning integrated pest management programme for controlling the insect.

Table (3): Mean percentage of *Ceratitidis capitata* infestation on different host fruits collected from Gaza Governorats during 2002-2003 growing season.

Host fruits	Sampling months	Mean of % infestation
Valencia orange	May-August	14.12
Shammoty orange	Nov. -Dec.	13.65
Navel orange	Oct.-Nov.	23.85
Grapefruit	Oct.-Nov.	26.7
Clementine	Oct.-Nov.	31.1
Guava	August-Nov.	28.9
Fig	August-Nov.	35,1
Apple	July	12.5

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