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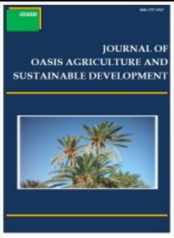

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Influence of different hosts on biological parameters of the fruit fly *Ceratitis capitata* (Diptera: Tephritidae) in Tunisia

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Abstract

The Mediterranean fruit fly, Medfly, *Ceratitis capitata* (Wied.), is one of major and destructive insect pests of fruit crops worldwide. The influence of seven species of fruit on the biological parameters of *C. capitata* was examined. The fruits tested were: *Citrus sinensis* (Thomson navel L.), Clementine (*Citrus clementica* L.), Mandarin (*Citrus deliciosa or reticulate* L.), Lemon (*Citrus limon* L.), Maltese (*Oranger de Malte*), bitter orange (*Citrus aurantium* L.), and Peach (*Prunus persica* L.). The highest number of eggs laid by the females was observed in *Citrus aurantium* (13.62±0.69) and the lowest in *Citrus deliciosa* (10.05±0.20). The longest egg incubation time was observed in *Citrus limon* (2.66±0.51) and the shortest was observed in *Prunus persica* (2±0.00). The shortest pupal development time (8.83 days) was observed in *Prunus persica*, whereas the longest (11.66days) was in *Citrus limon*. Adult emergence rates were generally high (>60%), except for *Citrus sinensis*. The highest sex ratio was observed in *Citrus aurantium* (0.579±0) and the lowest was observed in *Citrus limon* (0.271±0.01). Life expectancy at pupal eclosion was recorded at adult *C. capitata*. The lives of adult flies were shorter or longer according to the species. Males lived longer than female on all host plants. Results showed the most suitable host-fruit for *C. capitata* was peach; although *Citrus aurantium* were shown to be the preferred host for oviposition and seem to have an important role as alternative host between Mars and Mai, allowing the continuous development of *C. capitata* throughout the year. The importance of these results could be used to determine perfect times for management treatments.

1. INTRODUCTION

The Mediterranean fruit fly *Ceratitis capitata* (Wiedemann) (Diptera, Tephritidae), also designated as “medfly”, is one of the most polyphagous and important pests of fruits worldwide (Alonso, M., Asís, J.D., Beitia,F., Gayubo, Sand Tormos, J., 2010; Asís, J.D., Beitia, F.Sabater-Muñoz, B., and Tormos, J., 2014; Cunningham, R.T , Liquido, N.J.and, Shinoda, L.A., 1991). It takes its origin from Africa (White & Elson- Harris 1992). This species has a great ability to disperse. It extended first to the Mediterranean region during the early 19th century, and from there to the rest of World (Goeden & Headrick 1996). The main adult traits include high mobility and dispersive powers, high reproduction rates, and extreme polyphagy, make this insect able to easily invade and survive in new habitats. Furthermore, the careless transportation of infested fruits has allowed it to spread rapidly and the most challenging task is to export pest-free fruits. It has become a cosmopolitan species. *Ceratitis capitata* is recorded as a highly polyphagous species, having more than 300 host fruits (Liquido et al. 1990), from 50 botanical families; however, approximately 40% of its hosts are included in 5 families (Myrtaceae, 6%; Rosaceae, 10%; Rutaceae, 9%; Sapotaceae, 9%; and Solanaceae, 6%) (Liquido et al., 1991). This fact makes this species one of the most important worldwide threats to fresh fruits (Rössler, 1988), most with high commercial value (Liquido et al. 1991). Because of its economic importance and its impact on the trade of several types of fruits; many studies on the biology and behavior of *C. capitata* were addressed to the relationship between medfly and its host plants. Many studies were dealt the host choice behavior of tephritidis, and the effect of plant compounds on their reproductive success. Adults of the Mediterranean fruit fly, use a variety of chemical, visual and tactile stimuli to locate hosts and oviposition sites, as well as mating resources. Fletcher and Prokopy, (1991) reported that the ovipositing females laid their eggs directly into fruit, and there is absolutely no chance for the larvae to move between hosts. Reproductive success is strongly influenced by the capacity of females to situate and oviposit in fruits of the appropriate host species that are able to maximize offspring survival and development.

Tsitsipis (1989) reported that the nutritional resources in larval stage have an important role, not only to provide energy and building material for survival, growth and development, but also for stored nutrient to be utilized in the pupal stage.

Thus, the nutritional resources selected by adult females can affect its biological traits such as larval development time, adult emergence, female size, pre-oviposition period and oviposition period, egg production, sexual acceptance, adult longevity (Tsitsipis1989; Chan et al. 1990; Zucoloto, 1991; 1993a, b; Cangussu & Zucoloto, 1997).

Although *C. capitata* is well documented as a key pest of stone and citrus fruits in several parts of the world, various levels of sensitivity among different species and variety to medfly infestation that ranges from "immunity" – no infestation (lemons) – to high sensitivity (Mandarins, bitter oranges) were stated. (Papadopoulos et al., 2015). Similarly, Back and Pemberton (1915) and Bodenheimer (1951), mentioned that the different citrus fruits and cultivars exhibit various levels of resistance to medfly infestation.

In fact, Citrus species have developed several mechanisms to defeat infestations of fruit flies as well as infestations by other insect species. These mechanisms affect adult and immature performance (Papachristos et al., 2008; Papachristos and Papadopoulos, 2009; Staub et al., 2008). In general, multimodal factors such as the qualitative and quantitative aspects of essential oils of the flavedo layer (the outer part of citrus fruit rind, bearing oil glands and pigments), peel thickness, elasticity, and mechanical resistance constitute a strong barrier against attack of *C. capitata* and that of other tephritid fruit flies (Aluja et al., 2003; Aluja and Mangan, 2008; Back and Pemberton, 1915; Bodenheimer, 1951; Birke et al., 2006; Lloyd et al., 2013; Greany et al., 1983; Muthuthantri and Clarke, 2012; Papachristos et al., 2008; Staub et al., 2008; Spitler et al., 1984).

In this study the suitability of seven species of fruit as hosts to *C. capitata* was evaluated by comparing the number of eggs laid per female during its life, the duration of the incubation period of eggs, duration of the biological cycle, rate of emergence, sex ratio and adult longevity, when reared on these hosts.

2. MATERIAL AND METHODS

2.1. Rearing conditions of flies

The *C. capitata* strain was established from different infested fruits: Citrus sinensis (Thomson navel L.), Clementine (Citrus clementica L.), Mandarin (Citrus deliciosa or reticulata L.), Lemon (Citrus limon L.), Maltese (Oranger de malte), bitter orange (Citrus aurantium L.), and Peach (Prunus persicaL.), collected in fields in Gabes, a southern country region of Tunisia. Ripe and, occasionally, unripe fruits were sampled from the tree and the ground between October 2015 and March 2016.

Infested fruits were transported to the laboratory and were incubated in trays containing sterilized and humidified soil. This process would allow the larvae to pupate under laboratory conditions. Few days later, newly formed pupae were collected. The pupae were then kept in Plexiglas boxes (28 x 27 x 9.5 cm), until adult emergence. The box was covered with muslin on the top. Laboratory rearing was conducted at 25 ± 1 ∘ C, 65 ± 5% R.H and a 12:12 LD cycle for all stages. Light was provided by daylight fluorescent tubes and by natural light entering in the room from two windows. The colony of *C. capitata* was maintained for one generation under identical laboratory conditions and the F1 generation was used for the experiment. Adults were held in Plexiglas boxes (28 x 27 x 9.5 cm) provided with water and a dry food mixture of 1 part sugar and 2 parts yeast hydrolysate. For the earlier stages, individuals comprising a cohort were collected directly from sampled fruit and used in the experiments.

2.2. Daily egg production per female

Female fecundity was determined using six replicates of five sexually mature couples. Each five couples of newly emerged flies were confined in a plastic containers aerated by meshed openings. Adult flies had free access to a sucrose solution, water and yeast based diet in order to increase eggs production. The production of eggs increases with adult protein intake (Cangussu & Zucoloto, 1997). Approximately 15 days after emergence (at the oviposition peak), the tested fruits were offered in two small pieces (5.0g) placed at equidistant locations to evaluate the female oviposition. Every twenty-four hours, the old pieces were replaced by fresh ones. Eggs were counted daily until the female death. The same test was conducted for each fruit.

2.3. The average number of eggs laid per female during its life was calculated.

2.3.1. Egg stage duration and survival

A small piece (5.0g) of tested fruits was placed in the cage for egg collection. The following day, new pieces of host material were replaced by fresh ones. Eggs of *C. capitata* were collected from each variety. The duration of the egg stages was determined by placing 100 eggs of flies, reared in each fruit, on a moist filter paper in a Petri dish. Eggs were observed every two hours for larvae eclosion. The duration of embryonic development and hatching percentage were recorded for a period of 3 days. Six replications were executed during the process.

2.3.2. Larval and pupal development

Twenty-five newly emerged larvae were placed into Petri disch lined with moist filter paper containing a small portion (±5g) of host material. New amount of fruit were added as the larvae grew, until the end of larval development. Six replicates of each fruit were tested. Larval instars were differentiated by their size, body surface sculpturing, mouth-hook morphology and color (White & Elson-Harris, 1994). In this experiment, the duration for the whole larval development was recorded.

To evaluate the duration of pupal stage, twenty-five newly formed pupae which were collected after being incubated separately on different plant species were transferred in plastic containers for emergence. The number of newly emerged adults was recorded twice a day and the development time was indicated. Six replicates of each fruit were maintained. The following data were analyzed: survival rates for all stages of immature development, duration of larval and pupal stage, emergence percentage and sex ratio (number of females/total number of adults).

2.3.3. Life span of adults

Adult longevity was measured in twenty pairs of newly emerged adults in each fruit. The specimens were separated by sex, placed in transparent containers and fed on saturated sugar solution and water ad libitum. Mortality of each sex was recorded daily. Three replications were maintained. Adult survival rate was determined by dividing the number of individuals alive at the end of each stage by the initial number.

2.4. Statistical analysis

All development tests for immature stages were replicated 6 times. Standard analysis of variance (ANOVA) was used to analyze developmental compared by Student Newman-Keuls multiple range tests, at a critical value for an error probability of 5%. Longevity was determined using three replicates of twenty females and twenty males. Fecundity of females was determined six times in five couples.

3. RESULTS

3.1. Daily egg production per female

The average number of eggs per female per day varied significantly among hosts (F = 27.109; df = 6; P = 0.0001). Flies laid a low egg number on Citrus limon. In general, fruits providing better larvae development were also well accepted for oviposition.

The average number of eggs is significantly higher in C.aurantium and P. persica compared to the other host fruits. Pre-oviposition period varied significantly among varieties (F = 39,254; df = 6; P = 0.0001). It was significantly shorter for females ovipositing in P. persica than in all others hosts (Table1).The females exhibited a longer preoviposition period in Citrus limon with 17.16 days.

3.2. Pre-imaginal development time and survival rate of *C. capitata*

The average duration of egg development varied between 2 - 2.66 days. There was no significant difference among the different host species (P = 0.220) (Table 2).

The larval duration (Table 1) varied significantly in the different hosts (F = 10.262; df = 6; P = 0.0001). Larval development lasted from 9.33days for those reared on peach to 11.33 days for those reared on C*itrus limon* and *Citrus aurantium*. Development for all hosts was within a 9-11 day range. These results generally were similar to previous reports by Rivnay (1950) for medflies reared on fig, peach and pear (Table 2).

Table 1. Daily egg per female and pre-oviposition period. Means followed by same letters in column do not differ statistically.

Hosts	Number eggs /female/ day (±SD)	pre-ovipositionperiod(±SD)
Citrus sinensis	12.12±0.56 b	13.5± 0.54 bc
Citrus clementica	12.18±0.85 b	13± 0.63 ab
Oranger de Malte	12.07±0.59 b	13.66 ±0.81 bc
Citrus deliciosa	10.05±0.20 a	13.83 ± 0.40 bc
Citrus limon	10.55±0.18 a	17.16 ± 0.75 d
Citrus aurantium	13.62±0.69 c	14.16 ± 0.51 c
Prunus persica	13.19±0.65 c	12.33 ± 0.81 a

Table 2. Mean development time (in days) of *C. Capitata* reared on different host species.

Host	Eggs	Larvae	Pupae	Life cycle
Citrus sinensis	2.16± 0.40 a	10.666 ± 0.51 b	9,16 ± 0.40 ab	21.83 ±0.75 b
Citrus clementica	2.5 ±0.54 a	11 ± 0.63 b	9.5 ±0.54 ab	23 ± 0.00 c
Oranger de Malte	2,33 ±0.51 a	10.66 ±0.51 b	9.16±0.40 ab	21.83±0.75 b
Citrus deliciosa	2.33 ±0.51 a	10.83 ±0.40 b	9.66 ± 0.51 cd	22.83 ± 0.40 c
Citrus limon	2.66±0.51 a	11.33 ±0.51 b	11.66 ±0.51 d	25.5 ±0.54 d
Citrus aurantium	2.5± 0.54 a	11.16 ±0.40 b	10.16 ± 0.40 c	23.33 ±0.51 c
Prunus persica	2±0.00 a	9.33 ± 0.51 a	8.83 ±0,40 a	20.16 ±0.40 a

Mean followed by different letters show statistical differences, One-way Anova with 5 % significance level.

Also the pupal duration varied significantly with host species (F = 26.418; df = 6; P < 0.0001), varying between 8.83 and 11.66 days to emergence. The shortest pupal development time was observed for *C. capitata* grown on peach, while the longest on *citrus limon*. (Table 2).

The mean developmental period of immature stages, from egg to adult emergence, ranged from 20.16 ± 0.4 days for peach to 25.5± 0.54 days for *Citrus limon* (Table 2).

The survival rate of eggs varied significantly in the different hosts (P <0.0001)**.** Only 46.5 % of eggs laid reached the adult stage for *Citrus Limon*. Survival was high in all other host plants (>80%)**.** Larval survival among the remaining seven hosts ranged from a low of 38.66% for *Citrus limon* to a high of 69.33% for *Prunus persica*.Pupal survival ranged from a minimum of 84.66% for *Citrus limon* to a maximum of 95.33% for peach (Table 3).

Table 3. Average percent survival of preimaginal stages of *C. Capitata* reared on different host species.

Host	Eggs	Larvae	Pupae	Life cycle
Citrus sinensis	81.66 ± 0.51 b	66.66± 2.06 bc	92.66± 1.63 b	54.16 ±0.40 d
Citrus clementica	84.5 ±0.54 c	67.33±3.01 bc	93.33 ±2,06 b	55 ±0.44 e
Oranger de Malte	80.83±0 .75 b	65.33 ± 2.06 b	92±2.52 b	53.33 ± 0.25 b
Citrus deliciosa	81.16 ±0.75 b	66,66 ± 2.06 bc	92.66± 1.63 b	53.75 ±0.27 c
Citrus limon	46.5 ±0.54 a	38.66±2.06 a	84.66±3.01 a	32,25 ±0.27 a
Citrus aurantium	85 ±0.63 c	68± 2.52bc	94 ± 2.19 b	55.41 ±0.37 f
Prunus persica	92 ±0.63 d	69.33±2.06 c	95.33 ±0.75 b	62.08 ±0.37g

Mean followed by different letters show statistical differences, One-way Anova with 5 % significance level.

3.3. Rate emergence and sex ratio

The emergence rate of the adults of *C. capitata* varied significantly among the different hosts (F = 3058.488; df = 6; P < 0.0001).

Host fruit species also significantly influenced the sex ratio of *C. capitata* (F=1903.402; df=6; P<0.0001), with significantly heavier ratio when the host was *Citrus aurantium* followed by *Citrus deliciosa* and *Prunus persica* (Table 4).

3.4. Longevity

Life expectancy at pupal eclosion varied significantly between varieties for male (F = 1444.211; df = 6; P < 0.0001) and female (F = 48959.000; df = 6; P < 0.0001).

Males were able to live significantly longer than females according to the survival analysis (F = 7.28; df = 1; P < 0.008). The average life spans ranged from 39.5 ± 1 to 67± 0 days for males and 20± 0to 57.5 ± 0 days for female (Table 5).

resource consumed by immature insects has a significant influence on their early development, adult lives, and the demographic parameters of populations (Slansky & Scriber 1985).

In holometabolous phytophagous insects, the finding of suitable food during oviposition of adult females is a challenging task for the immature insects (Seenivasagan & Vijayaraghavan 2010).
Bernays (2001) argue that polyphagous insects have fewer opportunities than monophagous insects to perceive and discriminate among a lot of volatiles components because of neural limitation capacity. According to Edwards & Wratten (1980) the choice of polyphagous insects to their hosts is based primarily to the nutritional value of plants, and particularly by secondary substances.
In our study, *C. capitata*, although a polyphagous species, revealed a discrimination capability in oviposition preference for fruits tested. The results of biological parameters presented here demonstrated a significant different among the host plants tested. Females of this species are able to laying 899.5± 4.27 eggs during their lifetime. Similar studies conducted by Christeron and Foote (1960) following the egg-laying

Table 4. Emergence rate and sex ratio of the adults of *C. capitata* observed in seven host fruit species.

Hosts	Rate Emergence (%)	Sex Ratio
Citrus sinensis	69.83±0.53 e	0.305±0 b
Citrus clementica	68.25±1.41 d	0.435±0 c
Oranger de Malte	66.53±0.40 c	0.314±0 b
Citrus deliciosa	65.65±0.42 c	0.557±0.01 e
Citrus limon	19.46±0.20 a	0.271±0.01 a
Citrus aurantium	63.12±0.10 b	0.579±0 f
Prunus persica	82.5±0.17 f	0.531±0.010 d

Table 5. Life Span of *C. capitata*. Means followed by same letters in column do not differ statistically.

Hosts	Longevity	
	Male	Female
Citrus sinensis	66.5±0 e	55.5±0 c
Citrus clementica	67±0.5 e	57.5±0 e
Oranger de Malte	65±0 d	55.5±0 c
Citrus deliciosa	62.5±0 c	56.5±0 d
Citrus limon	39.5±1 a	20±0 a
Citrus aurantium	64.5±0.5 d	57.5±0 e
Prunus persica	50.33±0.28 b	42.66±0.28 b

In the same column, the values followed by the different letters are significantly different.

4. DISCUSSION

Food consumption is the single most important factor for the growth, development, and reproduction of species. Therefore, the availability in quantity and quality of food activity of female of *C. capitata*, showed that the number of eggs is about 911 eggs. However, our results differ from those obtained by Rossler (1975) and Bozzini and Murtas (1975) who proved respectively an oviposition between 301 to 699 eggs/female and 500- 1200 eggs/female depending on the population. Of all the fruits belonging to the *C. capitata* as tested in our study, females laid considerably fewer eggs on the citrus fruits, except for *Citrus aurantium*. In this context, Fitt (1983) demonstrated that the female of *C .capitata* lays a low number of eggs for small fruits, in order to reduce the intra-specific competition related to the food of the larvae favoring their good development. Subsequently, McDonald and McInnis (1985) reported that in female *C. capitata*, the number of eggs laid depends on the size of the infested fruit.

Other authors reported that this preference behavior may be related with the nutritional value of the fruit that maximize larvae survival and development (Thompson & Pellmyr 1991; Janz 2002); the fruits with the largest numbers of eggs provide also the best development of insect at the immature stage. Moreover, in support of the present findings, the low number of eggs laid in the orange is due to the presence of toxic oils in the rind of the fruit (Papachritos et al., 2008; Salvatore et al., 2004). Papachristos & Papadopoulos (2009) reported that the preference of femele to lay in citrus fruits rather than in odour-less domes, is a shorter preoviposition periods that corresponds to the period before maturity while green. In this case, the fruit punctred before it is liable to fly infestation remains safe (Bodenheimer 1951). Bodenheimer (1951) and Jerraya (2003) commonly called these punctures empty or sterile. This injury termed as "dry" stings were observed on clementines in September, when fruits are rich in acid (Leckchiri 1983).

Ceratitis capitata was able to complete the preimaginal development in all the hosts species tested in this study. These results generally were similar to previous reports by Dolinski & Lacey, (2007). Host fruit species influenced the time development of *C. capitata* and the rate survival. In our study, the average duration of larval stage development differed from one host to another. They were shorter in the case of peach hosts (9.33 days) and longer in the lemon fruits (11.33 days). Nutritional and physicochemical characteristics of host fruit influenced strongly the larval developmental duration of medfly (Nash and Chapman 2014; Krainacker 1986). The slow development of larvae observed in lemon fruits is resulted to the acidity of the citrus pulp (Papachhristos and al., 2008). Kaspi et al. (2002) pointed out that development of immature stages of *C.capitata* in diets rich in protein was faster and a large size of the emerging individuals. The protein rate in fruit hosts such as fig, peach and orange increase during ripening allowing shorter larval development.

According to Slansky and Scriber (1985), the quantity or quality of the food ingested by immature insects conclude their early development and adults lives, and affect the demographic parameters of populations. It seems that there is a strong affinity between *C. capitata* and its host plants beyond oviposition and larvae survival and development. Krainacker et al. (1987) reported that there is considerable variation in development time, growth, and larval survival rate of *C. capitata* on different host fruit.

Of all the fruits belonging to the Citrus genus tested in our study, *C.limon* was the only one to provide the lower survival rate of immature individuals and the longer larval development. *Citrus limon* probably is not one of the favorable hosts for *C. capitata*. *Citrus limon* was not adopted by the ovipositing females, supporting the few infestation records obtained in field. The correlation of results achieved in this study and the infestation data collected in the field propose that the low infestation by *C. capitata* was probably linked to the structure and the chemical composition of the skin and pulp of *citrus limon.* In general, the different citrus fruit species demonstrate various degrees of resistance to medfly infestation, as found by Back and Pemberton (1915) and Bodenheimer (1951).

As for the duration of pupal development, results showed that host fruit species can influence the pupal development times of *C. capitata*. According to our results, it was shorter in peach and longer in *C.limon*, indicating that this latter fruit is probably of inferior nutritional quality. Differences observed in pupal development times can be related to variations in the quantity or quality of the food ingested by insects (Chan et al., 1990; Chapman, 1998; Nylin & Gotthard, 1998; Honek et al., 2002).

The duration of life cycle *C. capitata* was shorter in peach than in the *Citrus limon* during our study. This difference could explain by the structure, the composition and the physiology of the pulp of the host fruit. Indeed some plant species is more conducive to larval development compared to other plants, which makes them the perfect host plants.

The emergence rate of the adults of *C. capitata* varied from one host fruit species to another. In our study, *C. capitata* larvae did not perform well on *Citrus limon*, resulting in low number of emergence. This suggests that *Citrus limon* cannot sustain well *C. capitata* populations from a nutritional standpoint. Zucoloto (1993a) noted that differences in adult emergence rates can be related to variations in the populations of *C. capitata* used in one study to another, or due to the difference of nutritive value among fruit themselves, which is depending of environmental factors. The immature individuals were selected during the larval stage. This resulted in the emergence of adults with minimum necessary nutritional reserves even when on poor hosts, which explain the different emergence percentage results obtained among all the fruits tested. The rate of adult emergence of *C. capitata* from peach was higher than from all citrus varieties. Comparing *C. capitata* emergence rates obtained in this analysis with data reported in other similar studies, some results are contradictory. For example, in peach, Zucoloto (1993a) found only 54% of the fruit flies emerged. Carey (1984) reported 64% of offspring, while in the present study the number of offspring was higher than 82.5 %. The difference in thickness and chemical composition of the skin of peach and citrus varieties could explain this variation.

The sex ratio also varied significantly among the different hosts ($P < 0.0001$). Maximum population percentage of females was observed in *Citrus aurantium* (0.579), followed by *Citrus deliciosa* (0.557) and *Prunus persica* (0.531). *Citrus limon* and *Citrus sinensis* gave a sex-ratio in favor of males. These finding are consistent with those reported of krainaker et al. (1985), who obtained a sex-ratio less than 0.5 in a temperature of 30±5º *C.* Moreover, Ali Ahmed-Sadoudi (2007) and Haliche et al. (2007), obtained on *Citrus sinensis* and *Citrus reticulate* a sex ratio less than 0.5. On the other hand, Mouazer and Yefsah (1996) obtained on the *Citrus sinensis* a sex ratio of 0.75 and Zoulim (2006), recorded a sex ratio of 0.57 at a temperature of 21 º C for *Citrus sinensis* and *Citrus reticulata*.

Like the development of immature individuals, adult features (adult longevity) apparently were also affected by larvae rearing on different fruits. The lives of adult flies were shorter or longer according to the varieties. Moreover, the longevity of *C. capitata* adult is affected by gender. Indeed, the male life span was longer than this of females. Similar studies reported that life expectancy in male adults of *C. capitata* often exceeds that of females (Carey et al., 1995; Papadopoulos et al., 2002). Indeed, the short longevity of female can be linked to the energy released during spawning. The variation in span of life of both sexes would be the fact of the high "reproductive cost" in females compared to males, and to hormonal as well as other behavioral and physiological differences (Vargas & Carey, 1989; Carey et al., 1995). These findings are consistent with those reported by Zannou (2000) on the *Callosobruchus maculatus* Fab in Benin. Indeed, the reproductive efforts in mating and egg laying, attributes to a strong decrease in the life span of females.

5. CONCLUSION

The highest number of eggs laid by the females was observed in *Citrus aurantium*. The longest egg incubation time was observed in *Citrus limon*. The longest pupal development was in *Citrus limon*. Adult emergence rates were generally high (> 60%), except for *Citrus sinensis*. The highest sex ratio was observed in *Citrus aurantium* and the lowest was observed in *Citrus limon*. Life expectancy at pupal eclosion was recorded at adult *C.capitata*. The lives of adult flies were shorter or longer according to the species. Males lived longer than female on all host plants.

Overall, *Citrus aurantium* were shown to be the preferred host for oviposition and seem to have an important role as alternative host between March and May, allowing the continuous development of *C. capitata* throughout the year. The importance of these results could be used to release for an Integrated Pest Management (IPM) against this pest in Tunisian oases in the perfect times.

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