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Larval development and reproductive characters of field and laboratory populations of the Mediterranean fruit fly *Ceratitis capitata* Wied.

INTRODUCTION

Ceratitis capitata Wied. is a permanent pest of various fruit crops in the Mediterranean area. The most important control measures are based on the extensive use of insecticides or insecticidal baits. However, the use of the sterile insect technique (SIT) has been investigated in most of the affected countries but its development requires an efficient and economic mass rearing method. Rearing efficiency depends on the adaptation of insects to artificial conditions (Rössler Y., 1975), but the prolonged isolation from field populations may produce partial or even total reproductive barriers between the laboratory and field individuals. As Manoukas pointed out, some of the most important new conditions to which the wild insects have to face when they are brought into the laboratory, are the oviposition devices and the artificial diets. So, each individual larva must adapt to them in order to survive (Manoukas A.G., 1983).

In a former study it was pointed out that starting with 4 pairs of this species from grapefruits collected in Valencia (Spain), a population of 2000 adults was obtained after two months of rearing with our laboratory methodology (Muñiz M., 1986). In this paper we study the adaptation progress of this colony, one year after it was established and the reproductive differences between the laboratory and field strains are reported.

MATERIAL AND METHODS

Two different populations of the Mediterranean fruit fly were used in this study: A laboratory colony ("LAB"), which had been established since 1965 at the Instituto Español de Entomologia (CSIC) and is reared in the Instituto de Edafologia y Biologia Vegetal (CSIC) with a new larval diet (Andrés Mª.P. and Muñiz M., 1984; Muñiz M. and Andrés Mª.P., 1983). A field population ("VAL"), collected during April, 1984 in Valencia (Spain) and maintained since in the laboratory under the same conditions as the "LAB" one. A hybrid F_1 population between the "LAB" and "VAL" strains was obtained through reciprocal crosses. F_2 hybrids were taken from the offspring of a pooled F_1 population. The experiments were conducted with all populations during May 1985-May 1986.

From eggs laid by females of these populations, 80 neonata larvae were daily introduced in glass vials containing 5 g of a larval diet that includes *Hansenula anomala* as protein source; this process was carried out during the period of larval production. Larval development time, pupal yield and weights of 7 day-old pupae were obtained.

From these pupae, single pair matings were carried out as follows: 1. - Homogamic crosses with the "LAB" and "VAL" populations; 2. - Reciprocal heterogamic crosses between the "LAB" and "VAL" populations; 3. - F_1 hybrid homogamic crosses; 4. - F_2 hybrid homogamic crosses. These pairs were introduced in specially designed oviposition cages at the rate of one pair per cage (Muñiz M., 1986).

Eggs were daily collected during the oviposition period; hatching, adult emergence and longevity were also recorded. Using a computer Control Data CYBER 180/855, three different functions (polygonal, polynomial and power-exponential) have been fitted to the experimental data in order to study the daily variation of fecundity along the female's life span.

Statistical analysis were carried out for the differences between two reproductive parameters. Means followed by the same letter are not different by Student's t-test at the 0.05 level.

Conditions during the experiments were 26± 1°C, 65± 5% RH and a 12:12,L:D regime (1900 lux).

RESULTS AND DISCUSSION

The larval development parameters of the considered populations are presented in Table 1. In general, there were not significative differences at the 95% level in the pupation time, pupal yield and weights of 7 day-old pupae. In all cases the values observed for these parameters were the usually obtained in our laboratory experiments.

The reproductive characters are showed in Table 2. The preoviposition and the oviposition periods of the four populations were statistically identical. Likewise, they did not differ significantly in the total egg production or daily oviposition rate. The highest daily oviposition was reached on the same day for "LAB" and "VAL" populations. "LAB" females laid more eggs than the "VAL" ones (104 and 90 eggs respectively). Except for the preoviposition period, fecundity parameters were higher than the ones reported by Rössler in a similar study (Rössler Y., 1975).

As it was reported in an former study carried out with this species, the power-exponential function was the most appropiate to explain this bio-

Tab. 1 - Larval development of the Mediterranean fruit fly, Ceratitis capitata *Wied.* ($\bar{x} \pm S.E.$)

Population	Pupation time (days)	Pupation (%)	Weight of 7 day-old pupae (mg)
"LAB"	7.83± 0.27 a (n=16)	52.65± 9.64 a (n=16)	9.54± 0.07 ab (n=54)
"VAL"	8.32± 0.17 a (n=15)	40.14± 9.38 a (n=15)	9.44± 0.07 ab (n=40)
F_1 (Hybrids)	8.19± 0.16 a (n=18)	49.17± 8.91 a (n=18)	9.61± 0.07 a (n=71)
F_2 (Hybrids)	8.26± 0.19 a (n=16)	40.95± 8.78 a (n=16)	9.40± 0.08 b (n=56)

Tab. 2 - Fecundity of the Mediterranean fruit fly, Ceratitis capitata *Wied.* ($\bar{x} \pm S.E.$)

Population	Preoviposition period (days)	Oviposition period (days)	Total eggs per female	Daily eggs per female
"LAB"	3.40± 0.23 a (n=15)	26.00± 2.46 a (n=15)	1795± 90 a (n=15)	48.29± 5.51 a (n=41)
"VAL"	3.20± 0.12 a (n=15)	25.40± 1.04 a (n=15)	1573± 94 a (n=15)	42.86± 5.09 a (n=33)
F_1 (Hybrids)	3.50± 0.22 a (n=15)	23.40± 1.59 a (n=15)	1768± 129 a (n=15)	50.91± 5.83 a (n=37)
F_2 (Hybrids)	3.60± 0.31 a (n=15)	23.60± 2.15 a (n=15)	1624± 88 a (n=15)	40.71± 4.26 a (n=37)

Tab. 3 - Parameters of the power-exponential function $Y=A \cdot e^{BX}, x^C$ *for the different populations of* Ceratitis capitata *Wied., fitted with the daily fecundity rate, expressed as average of number of eggs per female. (***, significant at the 0.001 level).*

Population	A	B	C	X^2	r^2	fd
"LAB"	14.24887	- 0.171498	1.608943	44.56	0.959***	40
"VAL"	2.81693	- 0.237717	2.505383	14.45	0.967***	32
F_1 (Hybrids)	8.32697	- 0.180246	1.869207	30.82	0.980***	36
F_2 (Hybrids)	11.14903	- 0.162443	1.520735	14.40	0.965***	36

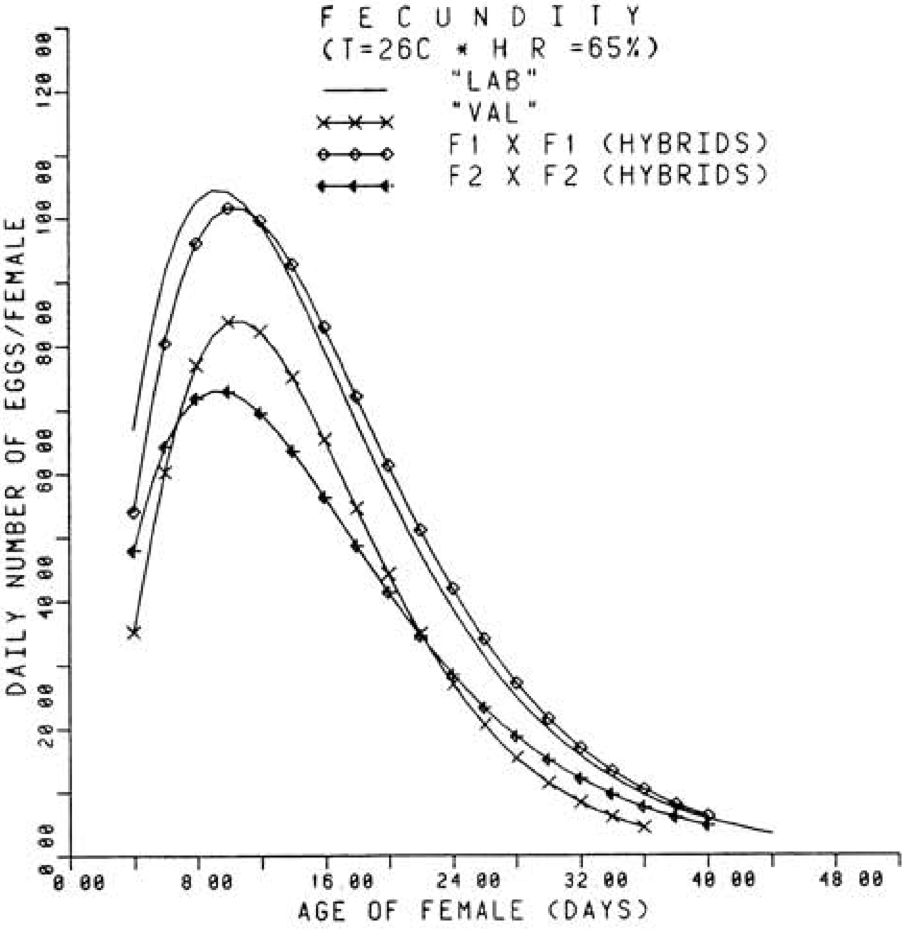

Fig. 1 - Estimated daily oviposition of *Ceratitis capitata* Wied. using the power-exponential function.

logical phenomenon (Muñiz M. and Gil A., 1984). In the Fig. 1 appears the daily variation of the estimated fecundity rate with this function; different parameters for all populations, as well as χ^2, r^2 and freedom degrees (fd) are expressed in Table 3. The values of χ^2 and r^2 show a good fitting degree of this technique to the experimental data.

The fertility parameters are presented in Table 4. In general, populations did not differ significantly in the total and daily larvae per female; the highest mean values were obtained with the heterogamic cross ♂ "LAB" x ♀ "VAL" and with the F_1 hybrids. With regard to egg hatch (total number of larvae/total number of eggs), the heterogamic crosses involving "LAB" females showed the highest value (80%), but the lowest average of daily fertility rate was obtained for the ♂ "VAL" x ♀ "VAL" cross.

Tab. 4 - Fertility of the Mediterranean fruit fly, Ceratitis capitata *Wied.* ($\bar{x} \pm$ *S.E.)*

Cross	Total larvae per female	Daily larvae per female
♂ "LAB" x ♀ "LAB"	1135± 128 a (n=15)	28.99± 4.47 a (n=34)
♂ "LAB" x ♀ "VAL"	1009± 79 ab (n=15)	30.54± 4.47 a (n=31)
♂ "LAB" x ♀ "VAL"	1306± 80 a (n=15)	36.62± 4.83 a (n=28)
♂ "VAL" x ♀ "LAB"	893± 109 b (n=13)	31.67± 3.10 a (n=34)
♂ F_1 x ♀ F_1	1202± 105 ab (n=15)	38.89± 5.10 a (n=35)
♂ F_2 x ♀ F_2	1089± 83 ab (n=15)	30.81± 3.44 a (n=38)
	Total egg hatch (%)	Daily egg hatch (%)
♂ "LAB" x ♀ "LAB"	68.42± 6.05 ab (n=15)	67.62± 2.94 a (n=34)
♂ "VAL" x ♀ "VAL"	71.82± 2.96 ab (n=15)	60.65± 5.09 a (n=31)
♂ "LAB" x ♀ "VAL"	75.36± 8.46 ab (n=15)	63.08± 4.93 a (n=34)
♂ "VAL" x ♀ "LAB"	79.82± 2.46 b (n=13)	70.00± 3.67 a (n=28)
♂ F_1 x ♀ F_1	70.38± 4.85 ab (n=15)	62.36± 4.28 a (n=35)
♂ F_2 x ♀ F_2	69.83± 3.09 a (n=15)	64.86± 3.08 a (n=38)

Adult emergence (males and females) in homogamic and heterogamic crosses involving "LAB" and "VAL" individuals was statistically identical;

however, the values from these populations were higher than the ones obtained with the F_1 and F_2 hybrids, but did not differ significatively from each other; the adult yield was also adequate. In general, percentages of males and females were statistically identical (Tab. 5).

Tab. 5 - Adult emergence and longevity of the Mediterranean fruit fly, Ceratitis capitata *Wied.* ($\bar{x} \pm$ *S.E.)*

Cross	Adult emergence (%) (referred to pupae)		
	Males and females	Males	Females
♂ "LAB" x ♀ "LAB"	97.33± 0.94 a (n=16)	48.01± 3.57 a (n=16)	49.32± 3.67 a (n=16)
♂ "VAL" x ♀ "VAL"	96.08± 1.00 a (n=15)	43.02± 5.60 a (n=15)	53.06± 6.19 a (n=15)
♂ "LAB" x ♀ "VAL"	94.55± 1.83 a (n=12)	48.73± 7.39 a (n=12)	44.82± 7.22 a (n=12)
♂ "VAL" x ♀ "LAB"	93.55± 2.42 a (n=12)	46.27± 5.38 a (n=12)	47.38± 5.81 a (n=12)
♂ F_1 x ♀ F_1	92.43± 1.69 a (n=18)	43.52± 3.55 a (n=18)	48.92± 3.92 a (n=18)
♂ F_2 x ♀ F_2	90.69± 3.52 a (n=16)	49.47± 4.08 a (n=16)	41.22± 5.40 a (n=16)

Population	Adult longevity (days)	
	Males	Females
"LAB"	63.40± 6.56 a (n=15)	32.80± 2.29 a (n=15)
"VAL"	119.00± 6.42 b (n=15)	36.20± 1.28 a (n=15)
F_1 (Hybrids)	77.60± 9.50 a (n=15)	37.30± 2.74 a (n=15)
F_2 (Hybrids)	68.44± 2.85 a (n=15)	30.22± 2.24 a (n=15)

On the other hand, the highest longevities were obtained in males from the field-collected population (119 days); averages of the life span for females were similar in all cases, but the lowest values were found in the F_2 hybrid population. Significant differences between longevities of males and females were obtained for all populations ($p<0.001$); this result has been always showed in our laboratory studies. As it was pointed out with regard to the fecundity parameters, longevity data were also higher than those reported by Rössler. The life span for females was not shorter than 30 days and it is considered that this period is a very good survival time for the experimental conditions of this work.

The results obtained show that the reproductive parameters of the six populations were almost identical and for this reason it is possible to affirm that, after one year of rearing with our laboratory techniques, a high adaptation level of the field-collected colony was obtained.

In the present study, reproductive barriers were not evident; so, it will be possible a partial or total replacement of the laboratory strain after the before mentioned period: the protein quality and the oviposition cages were the most important requirements for this success.

RIASSUNTO

Sviluppo larvale e capacità riproduttiva di ceppi di campo e di laboratorio di Ceratitis capitata *Wied.*

Sono stati effettuati alcuni esperimenti con singole coppie di *Ceratitis capitata* Wied. per valutare il potenziale riproduttivo di un ceppo raccolto in campo, dopo essere stato allevato in laboratorio per un anno.

L'esame comparativo tra una colonia di laboratorio di 20 anni ed una di campo, dopo 11 generazioni di allevamento ha mostrato che, nel complesso, queste popolazioni non differiscono significativamente per quanto riguarda lo sviluppo larvale e la fecondità.

In altre parole, non sono state trovate differenze tra i caratteri riproduttivi degli ibridi F_1 e F_2. Si può quindi affermare che in una popolazione raccolta di recente si può ottenere un soddisfacente processo di adattamento ed un alto grado di salute degli adulti dopo un anno di allevamento. I più importanti requisiti per questo successo sono stati la composizione della dieta larvale e le gabbie di ovideposizione. Per elaborare i dati sperimentali e per studiare le variazioni di fecondità delle femmine sono state applicate le funzioni poligonale, polinomiale ed esponenziale. Quest'ultima è risultata essere la più appropriata per spiegare questo fenomeno biologico e pertanto vengono riportati i suoi parametri.

SUMMARY

Several experiments with single pair matings have been carried out in order to estimate the reproductive parameters of a field-collected population of *Ceratitis capitata* Wied., after one year of continuous rearing under constant laboratory conditions.

The comparative study between a 20 year-old laboratory colony and a field-collected strain (11th generation) showed that, in general, these populations did not differ significantly in larval growth and reproductive parameters.

On the other hand, differences between reproductive characters of the F_1 and F_2 hybrids were not found. So, it was concluded that a good adaptation process of a newly field-collected population of this species can be obtained and it is possible to get a high adult fitness after one year of rearing with our laboratory methodology. It was also considered that the composition of the larval diet and the oviposition cages were the most important requirements for this success. Polygonal, polynomial and power-exponential functions have been fitted to the experimental data in order to study the variation of the fecundity rate along the female's life span. The last one was the most adequate to explain this biological phenomenon, and its parameters are reported.

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