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Contributions to the knowledge of *Ceratitis capitata* Wied. (Diptera, Tephritidae) in Northern Italy I. Observations on the biology (*)

Abstract - Rearings carried out in Lombardy (Northern Italy) under variable conditions on different fruits and starting from wild populations have given the opportunity to ascertain some aspects of the biology of the Medfly in this region. The Medfly is active until the beginning of December, it can lay eggs until mid October, but only eggs laid no later than mid September permit the completion of the developmental cycle. The pre-imaginal development does not only depend on temperature but also on the host fruit. The development requires on average from 3 to 6 (8) weeks on peaches, and between 5 and 9 weeks on apples. The egg and larval stages are completed in 9-57 days, the pupal stage in 9-42 days, without any differences between the sexes. The sex ratio was very close to 1:1 and the average adults longevity was extremely variable, about 2.5 months in 2001 and 1-2 months in 2003, but with peaks of almost 150 days. One generation requires 1-2.5 months or more. On the basis of these data we can calculate that in one year in Lombardy there are 3-4 generations according to the climatic conditions, and that the fourth is completed only by a small number of precocious specimens, even in the most favourable years for the Tephritidae.

Riassunto - *Contributi alla conoscenza di* Ceratitis capitata *Wied. (Diptera, Tephritidae) in Italia Settentrionale. I. Osservazioni sulla biologia.*

Allevamenti condotti in Lombardia (Italia settentrionale) in condizioni variabili su diversi frutti e partendo da esemplari selvaggi hanno permesso di appurare alcuni aspetti della biologia della Mosca della frutta in questa regione. La Mosca della frutta è attiva fino a inizio dicembre, e può ovideporre fino a metà ottobre, ma solo le deposizioni non più tardive della metà di settembre consentono il completamento del ciclo. Lo sviluppo preimmaginale non dipende solo dalla temperatura, ma anche dal substrato. Richiede in media da 3 a 6-(8) settimane su pesche, e tra 5 e 9 su mele. La fase ovo-larvale è completata in 9-57 giorni, quella pupale in 9-42 giorni, senza differenze tra i sessi. La sex-ratio è stata molto prossima alla parità e la longevità media degli adulti estremamente variabile, in media è stata di circa 2,5 mesi nel 2001 e di 1-2 mesi nel 2003, ma con massimi di quasi

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150 giorni. Una generazione richiede 1-2,5 mesi o più. Sulla base di questi dati si può stimare che in Lombardia in un anno si succedano 3-4 generazioni, a seconda dell'andamento climatico, e che la quarta venga completata solo da una minoranza di esemplari precoci, anche negli anni più favorevoli al tefritide.

Key words: Medfly, Northern Italy, wild population, developmental duration, rearing under variable condition.

INTRODUCTION

The Mediterranean fruit fly is one of the most important fruit pest that attacks over 300 host species (Liquido *et al.*, 1991) and it has adapted to several tropical and subtropical environments. Its biology has been object of many studies, mainly carried out in the laboratory under constant conditions on laboratory-adapted populations (Shoukry & Hafez, 1979; Vargas *et al.*, 1984; 1996; 1997; Crovetti *et al.*, 1986; Delrio *et al.*, 1986; Conti, 1988). More rarely have studies on wild populations, or under variable conditions been carried out and they have mainly interested tropical environments (Back & Pemberton, 1918; Costantino, 1930; Fimiani & Tranfaglia, 1972; Vargas & Carey, 1989; Harris *et al.*, 1991). On the other hand there is a complete lack of data for the extreme northern areas of the Medfly distribution, such as Lombardy, where its virulence has increased remarkably in the last 15-20 years (Caroli & Loni, 1991; Cayol & Causse, 1993; Romani, 1997; Rigamonti *et al.*, 2002). This kind of informations could be useful to develop pest management strategies adequate to local conditions too. For this reason and for the uncertain transfer of laboratory data to field conditions, it has been decided to carry out a rearing in the open, in Lombardy (Northern Italy), under variable conditions, but under many aspects similar to the field ones, on different fruits and using wild specimens of the Tephritidae.

MATERIALS AND METHODS

The research was carried out in 2001 and 2003 in Meda, a town on the outskirts of Milan, at about 45°45' North latitude. The climate is considered a transitional one between the Mediterranean climate and the European continental one, with cold winters, characterised by mean temperatures in December and January between 0 and 5°C, and warm summers with mean temperatures in July and August between 20 and 25°C. The experimental material was kept under a porch to protect it from the meteorological adversities and, furthermore, a wooden screen 1.5 metres high was installed in order to avoid direct sunlight. During all the period of the experiment the daily minimum and maximum temperatures were recorded.

The rearings were carried out with the intention of getting as close as possible to the field conditions. Both years they started with adults that were obtained the previous autumn from naturally infested fruits. These adults had overwintered in a protected environment, in unheated rooms of a house. In 2002 no rearing was carried out as no adult had overwintered.

The rearings started at the beginning of June. At that period the adults were about 190 days old. They were kept in plastic BugDorm-1[(1)] cages (30 by 30 by 30 cm), in which fruits were periodically put for some hours so that the females could lay the eggs. In 2001 the adults that had overwintered were used until the 1st August, their descendants of the first generation from mid July to the 20th August, the second generation ones from the last decade of August onwards. In 2003 the adults that had overwintered were used until the 4th July, the F1 adults from the first decade of July (July I) to the first of August (August I), the F2 from the 11th August to the third decade of September (September III) and those of F3 from the end of September onwards. Apart from the adults that had overwintered, the laying females were between 6-8 and 35-55 days old. The fruits were put in the cages from the first decade of June at the same time as the first ripening fruits appeared in the field, until October II in 2001, and until November I in 2003. In order to simulate the field conditions in the summer period peaches were used (until August in 2001 and October I in 2003). In autumn Golden Delicious apples were used starting from August II in 2001 and from September II in 2003.

The infested fruits were transferred into plastic containers 12 cm high and with the same diameter, placed on blotting paper, whose purpose was to serve as a pupation site and to hold the exudate dripping from rotting fruits. The cages were closed with nylon tulle tied with rubber bands to favour good ventilation and then they were placed under the porch at about 40 cm above the floor. The fruits were checked daily to see if there were any pupae. These were collected and transferred in plastic test tubes 12 cm high and 3 cm in diameter covered with a layer of sand (2-3 cm). In this case, too, the test tubes were closed with nylon tulle tied with rubber bands and placed under the porch and checked daily.

The adults that emerged were collected and put in transparent polypropylene containers, 8 cm high and 6.5 cm in diameter. The containers were closed with their screw top where a hole (3.5 cm diameter) had been made and closed with a metal net in order to favour ventilation. No more than 25 specimens were put in each container. Those adults that were chosen as "reproducers" were transferred in BugDorm-1 type cages. All the containers with the adults were provided with water and food (10 parts sugar and 1 part yeast autolysate). In this way cohorts of specimens of the same age and which had the same egg-larval and pupal developmental times were formed. The containers were checked every day until the death of all the specimens.

RESULTS AND DISCUSSION

The data on the duration of the various phases of the development cycle are reported in Tables 1-6 (in total, of males and females). The data concerning to August

[(1)] Produced by MegaView Science Education Services Co. Ltd., Taichung – Taiwan.

Table 1 - Duration expressed in days of the development cycle of C. capitata *with reference to the laying period, total data. Year 2001.*

Laying decade	Egg - larva		Pupa		Pre-imaginal		Adult		Total	
	cases	Average (min. – max.)	cases	Average (min. – max.)	cases	Average (min. – max.)	cases	Average (min. – max.)	cases	Average (min. – max.)
June I	51	16.5 (12-24)	46	12.0 (11-13)	46	28.0 (24-37)	19	66.4 (9-129)	19	96.2 (39-159)
June II	46	13.3 (11-18)	39	12.0 (11-14)	39	24.9 (22-28)	27	73.8 (6-119)	27	99.1 (30-145)
June III	48	9.1 (9-11)	42	11.9 (11-13)	42	21.0 (20-23)	34	34.4 (5-108)	34	55.5 (25-131)
July I	45	9.7 (8-12)	35	12.0 (11-14)	35	21.6 (20-24)	19	80.9 (11-132)	19	102.5 (34-156)
July II	32	10.0 (9-11)	16	10.7 (10-12)	16	20.6 (20-22)	9	84.3 (4-110)	9	105.1 (24-131)
July III	310	10.2 (7-14)	226	11.5 (10-14)	226	21.6 (19-25)	167	73.3 (0-113)	167	95.3 (24-137)
August I	187	9.5 (7-13)	167	11.6 (10-13)	167	21.1 (18-26)	150	81.9 (1-109)	150	103.6 (22-131)
August II	15	12.6 (11-15)	15	21.2 (20-25)	15	33.8 (31-40)	12	68.7 (1-82)	12	102.9 (36-116)
August III beg.	212	30.1 (13-49)	169	27.2 (24-41)	169	57.7 (37-83)	146	33.8 (0-71)	146	91.9 (44-114)
August III end	121	56.9 (28-85)	5	28.6 (26-36)	5	61.4 (54-75)	5	32.0 (0-46)	5	93.4 (75-106)
September I	58	47.5 (34-66)	4	28.5 (28-30)	4	62.7 (62-64)	4	4.0 (0-16)	4	66.7 (62-78)
September II	41	41.3 (36-53)	0		0		0		0	

Table 2 - Duration expressed in days of the development cycle of C. capitata *with reference to the laying period, males. Year 2001.*

Laying decade	Egg - larva		Pupa		Pre-imaginal		Adult		Total	
	cases	Average (min. – max.)	cases	Average (min. – max.)	cases	Average (min. – max.)	cases	Average (min. – max.)	cases	Average (min. – max.)
June I	19	14.7 (13-22)	19	11.9 (11-13)	19	26.6 (25-34)	7	60.7 (12-100)	7	88.1 (39-127)
June II	21	12.8 (11-15)	21	12.0 (11-14)	21	24.7 (22-28)	15	74.1 (11-119)	15	99.0 (36-145)
June III	27	9.1 (9-11)	27	12.0 (11-13)	27	21.1 (20-23)	22	37.2 (5-108)	22	58.4 (25-131)
July I	18	9.3 (8-11)	18	12.1 (11-13)	18	21.4 (20-24)	12	76.3 (24-132)	12	97.6 (44-156)
July II	7	9.9 (9-10)	7	10.6 (10-11)	7	20.4 (20-21)	5	76.4 (4-110)	5	97.0 (24-131)
July III	91	9.9 (7-13)	91	11.3 (11-14)	91	21.2 (19-25)	74	76.9 (1-101)	74	98.7 (25-125)
August I	85	9.6 (8-13)	85	11.4 (10-13)	85	21.0 (19-26)	84	75.5 (1-105)	84	97.1 (22-130)
August II	7	12.3 (11-15)	7	21.3 (20-25)	7	33.6 (31-40)	7	77.0 (70-82)	7	110.6 (105-116)
August III beg.	99	31.1 (13-48)	98	27.3 (24-41)	98	58.2 (37-83)	81	31.9 (0-65)	81	90.7 (44-113)
August III end	1	39.0 (39-39)	1	36.0 (36-36)	1	75.0 (75-75)	1	0.0 (0-0)	1	75.0 (75-75)
September I	3	34.3 (34-35)	3	28.0 (28-28)	3	62.3 (62-63)	3	5.3 (0-16)	3	67.7 (62-78)
September II	0		0		0		0		0	

III are subdivided into two parts, as in both years there was a remarkable lowering of the temperatures (Table 7) starting from the last days of the month or from the beginning of September. This led to clearly different development times for eggs laid at the beginning and at the end of the decade.

In two years approximately 3000 specimens were reared, and precisely 1200 in 2001 and 1800 in 2003. The eggs were laid in 2001 and 2003 respectively, until the second and the first decade of October when the mean temperatures were above 15°C

Table 3 - Duration expressed in days of the development cycle of C. capitata *with reference to the laying period, females. Year 2001.*

Laying decade	Egg - larva		Pupa		Pre-imaginal		Adult		Total	
	cases	Average (min. – max.)	cases	Average (min. – max.)	cases	Average (min. – max.)	cases	Average (min. – max.)	cases	Average (min. – max.)
June I	26	17.1 (12-24)	26	12.0 (11-13)	26	29.2 (24-37)	12	69.8 (9-129)	12	100.8 (46-159)
June II	18	13.1 (11-16)	18	12.1 (11-14)	18	25.2 (23-28)	12	73.6 (6-117)	12	99.3 (30-144)
June III	15	9.1 (9-10)	15	11.8 (11-12)	15	20.9 (20-22)	12	29.3 (6-40)	12	50.2 (26-61)
July I	17	9.9 (8-12)	17	11.9 (11-14)	17	21.8 (20-24)	7	88.9 (11-130)	7	111.0 (34-154)
July II	9	10.0 (9-11)	9	10.8 (10-12)	9	20.8 (20-22)	4	94.3 (52-110)	4	115.3 (74-131)
July III	90	10.1 (7-13)	90	11.6 (10-13)	90	21.7 (19-24)	83	77.7 (0-113)	83	99.8 (24-137)
August I	69	9.6 (7-13)	69	11.7 (11-12)	69	21.3 (18-25)	65	91.1 (6-109)	65	112.7 (27-131)
August II	8	12.9 (11-15)	8	21.1 (20-23)	8	34.0 (31-38)	5	57.0 (1-75)	5	92.2 (36-110)
August III beg.	71	29.9 (14-41)	71	27.1 (24-33)	71	57.0 (38-74)	65	36.1 (0-71)	65	93.3 (47-114)
August III end	4	31.3 (28-33)	4	26.8 (26-27)	4	58.0 (54-60)	4	40.0 (34-46)	4	98.0 (90-106)
September I	1	34.0 (34-34)	1	30.0 (30-30)	1	64.0 (64-64)	1	0.0 (0-0)	1	64.0 (64-64)
September II	0		0		0		0		0	

Table 4 - Duration expressed in days of the development cycle of C. capitata *with reference to the laying period, total. Year 2003.*

Laying decade	Egg - larva		Pupa		Pre-imaginal		Adult		Total	
	cases	Average (min. – max.)	cases	Average (min. – max.)	cases	Average (min. – max.)	cases	Average (min. – max.)	cases	Average (min. – max.)
June I	82	9.1 (9-10)	65	10.4 (10-11)	65	19.4 (19-20)	54	36.3 (0-72)	54	55.7 (20-92)
June II	25	9.4 (8-12)	15	11.3 (10-12)	15	20.3 (19-23)	9	63.4 (1-117)	9	84.2 (22-137)
June III	47	11.4 (8-19)	27	11.1 (11-12)	27	21.7 (19-27)	24	48.1 (0-118)	24	69.8 (20-141)
July I	82	9.6 (8-12)	70	9.9 (8-14)	70	19.4 (18-26)	35	51.1 (1-128)	35	70.5 (19-147)
July II	276	7.8 (7-12)	208	10.8 (10-12)	209	18.5 (17-22)	161	32.7 (0-146)	161	51.1 (19-168)
July III	123	9.2 (8-12)	97	9.0 (8-10)	97	18.2 (17-21)	94	35.6 (0-140)	94	53.8 (19-157)
August I	62	7.9 (7-10)	55	10.5 (9-13)	55	18.4 (16-21)	46	69.9 (0-128)	46	88.3 (16-144)
August II	686	8.8 (7-16)	463	11.6 (9-16)	463	20.3 (17-30)	383	43.5 (0-125)	383	63.9 (18-143)
August III beg.	214	8.3 (8-11)	176	17.1 (16-19)	176	25.2 (24-30)	164	31.5 (0-106)	164	56.7 (25-130)
August III end	61	14.2 (13-21)	56	20.6 (19-33)	56	34.8 (32-54)	40	24.6 (0-80)	40	59.4 (33-113)
September I	51	15.2 (13-21)	28	29.5 (23-41)	28	43.8 (37-57)	24	10.2 (1-79)	24	55.0 (39-117)
September II	159	16.8 (15-23)	1	42.0 (42-42)	1	57.0 (57-57)	1	0.0 (0-0)	1	57.0 (57-57)
September III	1	19.0 (19-19)	0		0		0		0	
October I	24	55.9 (48-63)	0		0		0		0	

(Table 7). The completion of the cycle was possible only when the eggs were laid at the most in September I in 2001 in apples and in September II in 2003 in peaches (Table 8). Eggs laid after this dates, no later than September I in 2001 and October I in 2003 led to specimens that reached only the pupal stage. The difference is due to the fruit that was used: Golden Delicious apples the first year and peaches the second

Table 5 - Duration expressed in days of the development cycle of C. capitata *with reference to the laying period, males. Year 2003.*

Laying decade	Egg - larva		Pupa		Pre-imaginal		Adult		Total	
	cases	Average (min. – max.)	cases	Average (min. – max.)	cases	Average (min. – max.)	cases	Average (min. – max.)	cases	Average (min. – max.)
June I	31	9.0 (9-10)	31	10.3 (10-11)	31	19.3 (19-20)	24	41.5 (0-72)	24	60.7 (20-92)
June II	9	9.3 (8-11)	9	11.3 (10-12)	9	20.7 (19-23)	5	68.2 (1-106)	5	89.4 (22-128)
June III	16	10.8 (9-16)	16	11.0 (11-11)	16	21.8 (20-27)	14	46.4 (0-118)	14	68.2 (20-141)
July I	38	9.4 (8-11)	38	9.8 (8-11)	38	19.3 (18-21)	20	44.9 (1-106)	20	64.4 (19-127)
July II	106	7.7 (7-11)	106	10.8 (10-12)	106	18.5 (17-22)	81	31.3 (0-146)	81	49.7 (19-168)
July III	37	9.2 (8-12)	37	9.0 (8-10)	37	18.2 (17-21)	36	32.3 (1-140)	36	50.5 (20-157)
August I	24	7.9 (7-10)	24	10.4 (9-12)	24	18.3 (16-20)	21	61.5 (0-128)	21	79.7 (16-144)
August II	240	8.6 (7-14)	240	11.6 (9-16)	240	20.2 (17-30)	211	42.6 (0-118)	211	62.9 (18-139)
August III beg.	91	8.2 (8-11)	91	17.0 (16-19)	91	25.2 (24-30)	88	25.7 (0-103)	88	50.9 (25-128)
August III end	31	14.1 (13-21)	31	20.8 (19-33)	31	34.9 (32-54)	23	16.3 (0-70)	23	51.4 (35-106)
September I	14	14.3 (13-16)	14	28.6 (23-41)	14	42.9 (37-57)	10	9.2 (1-79)	10	54.2 (39-116)
September II	0		0		0		0		0	
September III	0		0		0		0		0	
October I	0		0		0		0		0	

Table 6 - Duration expressed in days of the development cycle of C. capitata *with reference to the laying period, females. Year 2003.*

Laying decade	Egg - larva		Pupa		Pre-imaginal		Adult		Total	
	cases	Average (min. – max.)	cases	Average (min. – max.)	cases	Average (min. – max.)	cases	Average (min. – max.)	cases	Average (min. – max.)
June I	32	9.2 (9-10)	32	10.4 (10-11)	32	19.6 (19-20)	30	32.1 (0-58)	30	51.7 (20-77)
June II	6	8.7 (8-9)	6	11.2 (10-12)	6	19.8 (19-21)	4	57.5 (2-117)	4	77.8 (22-137)
June III	11	10.3 (8-13)	11	11.4 (11-12)	11	21.6 (19-25)	10	50.6 (0-102)	10	71.9 (24-125)
July I	32	9.6 (8-12)	32	9.9 (9-14)	32	19.5 (18-26)	15	59.3 (1-128)	15	78.8 (19-147)
July II	98	7.6 (7-9)	98	10.8 (10-11)	99	18.4 (18-20)	80	34.0 (1-124)	80	52.5 (19-143)
July III	60	9.2 (8-11)	60	9.0 (8-10)	60	18.2 (17-21)	58	37.7 (0-137)	58	55.9 (19-156)
August I	31	7.9 (7-9)	31	10.6 (9-13)	31	18.5 (16-21)	25	77.0 (0-119)	25	95.5 (16-138)
August II	221	8.7 (7-13)	221	11.7 (10-16)	221	20.4 (17-29)	172	44.7 (0-125)	172	65.1 (18-143)
August III beg.	82	8.2 (8-10)	82	17.1 (16-19)	82	25.3 (24-28)	76	38.1 (0-106)	76	63.5 (25-130)
August III end	25	14.2 (13-17)	25	20.4 (19-23)	25	34.6 (32-40)	17	35.9 (1-80)	17	70.3 (33-113)
September I	14	14.3 (14-15)	14	30.4 (24-40)	14	44.7 (38-55)	14	10.9 (1-79)	14	55.6 (40-117)
September II	1	15.0 (15-15)	1	42.0 (42-42)	1	57.0 (57-57)	1	0.0 (0-0)	1	57.0 (57-57)
September III	0		0		0		0		0	
October I	0		0		0		0		0	

year. If apples are considered in 2003, too, then the time limit coincides with the one in 2001 (Table 8).

In 2001 (Tables 1-3) the development times of males and females were almost

Table 7 - Mean decade temperatures in the summer semester in the two years of the experiment. Mean (minimum - maximum).

Decade	2001	2003	Decade	2001	2003
June I	22.1 (19.4 – 24.9)	23.5 (21.0 – 26.0)	September I	20.2 (16.5 – 24.0)	19.3 (17.0 – 21.7)
June II	22.7 (20.0 – 25.4)	25.6 (22.7 – 28.5)	September II	17.3 (13.8 – 20.8)	19.7 (16.5 – 22.9)
June III	25.1 (22.1 – 28.1)	26.1 (23.4 – 28.7)	September III	16.8 (14.7 – 19.0)	17.9 (15.6 – 20.3)
July I	24.8 (21.6 – 28.1)	23.6 (20.9 – 26.4)	October I	18.9 (17.0 – 20.8)	16.0 (13.6 – 18.4)
July II	23.7 (20.5 – 27.0)	26.5 (24.2 – 28.9)	October II	17.8 (15.1 – 20.4)	12.9 (11.0 – 14.9)
July III	25.8 (21.7 – 29.8)	24.7 (22.1 – 27.3)	October III	14.9 (12.6 – 17.3)	9.0 (7.2 – 10.8)
August I	26.3 (22.9 – 29.7)	27.2 (24.4 – 30.1)	November I	10.9 (8.5 – 13.3)	9.9 (7.6 – 12.3)
August II	25.4 (21.1 – 29.6)	27.0 (24.2 – 29.7)	November II	8.4 (6.2 – 10.7)	8.5 (7.1 – 9.9)
August III	25.8 (22.5 – 29.1)	25.1 (22.6 – 27.6)	November III	5.7 (3.1 – 8.4)	10.0 (9.0 – 11.1)

Table 8 - Latest egg laying periods that have allowed to obtain the various stages of development of C. capitata *and the fruit used.*

	2001	2003
Stage	Decade of egg laying	Decade of egg laying
Adult	September I (Golden Delicious apple)	September II (peach)
Pupa	September II (Golden Delicious apple)	September II (Golden Delicious apple) October I (peach)
Larva	October II (Golden Delicious apple)	October I (Golden Delicious apple)

identical. The average length of the egg and larval development varied from 9 to 57 days. Referring to the laying period the lower values were recorded between June III and August I. These eggs led to individuals that developed at mean temperatures of around 25°C (Table 7). Eggs laid after mid August had a egg and larval development time progressively longer, up to 57 days for eggs laid the last days of August. The last pupations were recorded in November III, when the mean temperature was about 6°C and the maximum below 10°C.

The average length of the pupal stage was between 11 and 29 days (Table 1). The shortest time was recorded for eggs laid between June I and August I. For eggs laid from August II onwards (Table 1) the pupal stage was completed in 21-29 days. Adults emerged until November II. Nevertheless the last viable specimens, which lived more than 1 day, emerged about 10 days beforehand, when temperatures were on the verge of 10°C. These adults came from eggs laid at the beginning of September and the pupation was at the beginning of October.

Referring to the laying period, the percentage of adults emerged from the pupae (Table 9) was very high from the beginning of June to the end of August, about 80%. Later, it fell to 5% and then to zero for eggs laid from the second decade of September. The sex ratio was slightly in favour of males, 1.15:1, with 378 males and 328 females. The average adults longevity was 75-80 days for most of the season (specimens that

Table 9 - Percentage of adults that emerged from the puparia with reference to the egg laying period.

Decade	June			July			August				September			October
Year	I	II	III	I	II	III	I	II	III beg.	III end	I	II	III	I
2001	73.2	84.8	87.5	77.8	50.0	72.9	89.3	100.0	79.7	4.1	6.9	0.0		
2003	72.3	60.0	54.4	85.4	73.4	78.9	88.7	67.5	82.2	91.8	54.9	0.6	0.0	0.0

emerged between the beginning of July and September), gradually decreasing as time moved away from this period due to the more adverse climatic conditions. The adults survived at the most until December II. Females lived on average longer than males, approximately 63 days instead of 55, but on 4 decades out of 11 the opposite happened (Tables 2, 3). The life span was quite variable: some adults died a few days after the emergence or during the emergence itself, over 10% instead lived over 100 days, with a maximum of 132 days. This implies that even adults coming from eggs laid in June can survive and reproduce until later on in the season.

Even in 2003 no differences were noted in the duration of the pre-imaginal stages between males and females (Tables 5, 6). The average length of the development from egg to newly formed pupae varied from 8 to 56 days (Table 4). The year was clearly divided into three periods, with temperatures very different from each other. The first period went from the beginning of June to the end of August, with average temperatures between 24 and 27°C (Table 7). In this period, which grouped the eggs laid between June I and the beginning of August III, the egg and larval stages were completed in 8-11 days. At the beginning of September there was a sudden sensible lowering of the temperature, which went down to between 16 and 20°C and as a result the development time rose to 14-19 days. A further drop in temperature was recorded in mid October and this led to an average temperature below 10°C causing the end of the egg laying period, too. Only the most precocious larvae of this period pupated, in 48-63 days, while the others died due to the cold.

The average length of the pupal stage was between 9 and 42 days (Table 4). The trend was almost the same as the one described above (Table 4). Adults emerged until the first decade of November, with temperatures on the verge of 10°C. These specimens came from eggs laid the first half of September and that pupate at the end of the month.

Referring to the laying period, the percentage of adults emerged from the pupae (Table 9) was very high from the beginning of June until the end of August, on average around 70-80%. For eggs laid at the beginning of September the figure fell to 55% and it went down to zero for later ones. The sex ratio was very close 1:1 (637 males and 614 females). The average longevity of adults was 30-50 days, for specimens born up to the last days of August (Table 4) and it then decreased progressively. The life span of the imaginal stage was greater for females in 10 decades out of 12, on average 41 days against 37 for males (Tables 5, 6). About 7% of the specimens lived over 100 days, with a peak of 146. The last adults survived until the beginning of January.

The pre-imaginal development, apart from the temperature, was influenced by the host fruit. The development was completed on peaches in 3-4 weeks in summer and 6-(8) in autumn, while on apples 5 and 8-9 weeks were necessary respectively. These results confirm that apples are a low quality host fruit (Rivnay, 1950; Papadopoulos *et al.*, 2002). This is due to the characteristics of the pulp, the level of pectin and low protein content, which lower the nutritional value and make up an unfavorable environment, especially for young larvae (Mourikis, 1965; Zucoloto, 1993; Papadopoulos *et al.*, 2002). The data on the development time obtained with peaches, which is an optimal host, is very close to the data obtained in laboratory rearings on artificial medium, at a temperature corresponding to the mean temperature of the decades to which it refers (Crovetti *et al.*, 1986; Conti, 1988). This is probably related to the fact that in Lombardy, in summer, temperatures always remain within the range of linear development of the Tephritidae. In this way the different development times at temperatures lower and higher than the mean compensate each other. The situation could be different in autumn when the minimum temperatures frequently go below the lower development threshold. Unfortunately, due to the different host fruits and the excessive climatic variations it was not possible to obtain significant information.

In relation to what has been reported in literature for rearings on fruit in some cases growth was faster, while in others slightly slower. Rivnay (1950) reported a larval developmental time of 10-16 days in peaches and 16-25 days in apples at 29°C. Costantino (1930) reported 21-24 days for the pre-imaginal stages in July and August at mean temperatures of 28°C and 32-38 days in October at 19°C. Taking into consideration peaches, Back & Pemberton (1918) indicate 6-9 days at 25°C for the larval development, whilst for the pre-imaginal development Mourikis (1965) indicates 17 days at 27°C, and Carey (1984) 22.5-25 days at 25°C (the shortest period in reference to nectarines). These differences can be due to various factors, as the different varieties, the level of ripeness or the fact that whole or parts of the fruit were used.

On the basis of the data obtained, it is possible to state that the Medfly is active in Lombardy for approximately six months, from June to the beginning of December. This period is much shorter than the favourable period for the Tephritidae in the centre and south of Italy, where the activity never stops in the warmest areas and lasts 9-11 months in the others. There is a break only during the coldest months or, in some areas, at the height of summer due to the excessively hot and dry climate. Under these conditions 6-7 generations take place (Cirio *et al.*, 1972; Fimiani & Tranfaglia, 1973; Delrio, 1986). In reality, in Lombardy the unfavourable period could be shorter as temperatures permit the development of the Medfly starting from April, but the lack of maturing fruits prevent its reproduction until June. The Medfly can lay eggs from June to October, but the development cycle can be completed from eggs laid at the most at the beginning of September. For eggs laid in this fringe period the percentage of specimens that reaches the adult stage is in any case quite low. Taking into consideration a preoviposition period of one week in summer, the Medfly in Lombardy can complete 3-4 generations in one year, according to the climatic conditions. These generations overlap thanks to the longevity of the adults and the long fertile period of the females. This is in contrast with the two generations indicated for the south of France and the 2-3 generations reported for central Italy (Delrio, 1986; Cayol & Causse, 1993), while it is close to the situation reported by Papadopoulos *et al.* (2001) for Northern Greece where 4-5 generations are recorded. It is possible that these differences are also due to the local fruit-growing characteristics. In France and in central Italy (Niccoli *et al.*, 1991; Cayol & Causse, 1993) the researches were carried out in orchards with one fruit variety or with a very short fruiting period and the results show a little number of generations and / or little harmfullness. It is well known, on the contrary, that mixed fruit cultivations with long fruiting periods are very favorable to the Medfly (Delrio, 1986). The early ripening hosts like apricots are very important, above all in areas at the verges of distribution, where their lack can inhibit the development of the first generation with drastic consequences on the size of the population and probably on its survival (Papadopoulos *et al.*, 2001). The fruit growing situation in Lombardy reflects this last type and is very similar to the one in Northern Greece, where fruit ripens from the end of May until the end of November and there are adults from the end of June until November, which allows 4-5 generations to occur (Papadopoulos *et al.,* 2001). In Lombardy the favorable period for the Tephritidae is shorter by over a month and only 3-4 generations occur. The first generation is completed in 4-5 weeks, within the beginning of July, with adults from the end of June and this corresponds to what has been recorded in the field (Rigamonti *et al.*, 2002). The following two generations require about a month and take place in July and August. The last generation, completed by only a few specimens and only in favourable years, is completed in September and October. This implies a great multiplication of the Tephritidae, which in favourable years can reach high densities and cause significant damages from August onwards (Rigamonti *et al.*, 2002). Eggs laid later than mid September have no results because, with the arrival of the winter, the larvae and the pupae die (Rigamonti, 2004) unless they are taken into protected environments. This is of practical importance since apples that have not been picked up, and remain in the field in this period haven't any importance in the beginning of the new infestation in the following year even though they are heavily attacked by *C. capitata.*

CONCLUSIONS

The studies have given the possibility to ascertain some aspects of the biology of the Medfly in Lombardy, where it appears to be active until mid November - beginning of December, period of the last adults emergence and pupations respectively. The pre-imaginal development requires from 3 weeks on peaches in full summer to 9 on apples at the beginning of autumn. No differences have been found between males and females development time. For the completion of the egg and larval stages 9 to 57 days are necessary, while the pupal stage needs 9-42 days. These lengths are comparable to those recorded in the laboratory rearing on artificial medium and on fruit. The adults longevity was extremely variable, on average about 2.5 months in 2001 and 1-2 months in 2003, but 7-10% of the specimens lived over 100 days. The Tephritidae lays eggs from the beginning of June to mid October, but only eggs laid by the beginning or mid September, on apples and peaches respectively, permit the completion of the cycle. Considering the preoviposition period too in a climatically normal year, a generation needs about a month, at the height of summer with average temperatures of approximately 25°C, and up to 2.5 months or even more in autumn. On the basis of this data we can calculate that there are 3 to 4 generations in one year, depending on the climatic conditions, and that the last generation is completed by only a few early specimens even in the most favourable years.

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