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Influence of the grape-growing area on the phenology of *Lobesia botrana* second generation

Francesco PAVAN[1], Pietro ZANDIGIACOMO[1], Laura DALLA MONTÀ[2]
[1]*Dipartimento di Biologia applicata alla Difesa delle Piante, Università di Udine, Italy*
[2]*Dipartimento di Agronomia ambientale e Produzioni vegetali, Università di Padova, Italy*

Abstract

A two-year study on the phenology of the European vine moth, *Lobesia botrana* (Denis *et* Schiffermüller) (Lepidoptera Tortricidae), was carried out in two vineyards (cv. Tocai friulano) in two different grape-growing areas of the Friuli Venezia Giulia region (north-eastern Italy). The areas are affected respectively by negligible (locality 1) and large (locality 2) larval population levels during the 3rd generation. In each vineyard the 2nd- and 3rd-male flights were recorded by pheromone traps and the phenology of 2nd-generation larvae was studied by sampling the clusters periodically.

In locality 2, where the 3rd generation is more harmful, the 2nd and 3rd flights were earlier and the interval between the 50% of the two flights was about seven days shorter than that observed in the other locality. This fact was caused by a faster development of the 2nd-generation larvae. Locality 2 was warmer than locality 1, but in any case to cover the interval between the two flights *L. botrana* required more degree-days in the latter than in the former locality. Therefore, factors other than temperature need to be considered to explain the different length of larval development.

An earlier 3rd-flight period enables the *L. botrana* females to lay eggs on still receptive berries and the 3rd-generation larvae to complete their development before the harvest. Therefore, this change in the 2nd-generation phenology appears crucial to explain the new occurrence of a harmful 3rd generation in some localities of north-eastern Italy.

Key words: *Lobesia botrana*, life history, phenology, second generation, degree-days.

Introduction

The European vine moth, *Lobesia botrana* (Denis *et* Schiffermüller) (Lepidoptera Tortricidae), is the major pest in European vineyards. This moth species normally has two generations a year in central Europe (Germany, Switzerland, central France) and three to four generations in southern Europe (southern France, southern Italy, Spain, Portugal, Greece) (Bovey, 1966; Galet, 1982; Coscollá, 1997). In the transition areas (e.g. northern Italy) two or three generations a year can occur in relation to different microclimatic conditions and years (Zangheri *et al*., 1987; Zangheri and Dalla Montà, 1989), but recently also larvae of a fourth generation were recorded mostly on unripe clusters of a second flowering (Marchesini and Dalla Montà, 2004).

In some areas of north-eastern Italy the number of generations a year varied during the last fifty years. In particular, in the fifties of the 20th century the species usually developed two generations a year both in the Veneto and Trentino regions (Zangheri, 1959), while in the eighties and early nineties heavy infestations of the 3rd generation were observed in some areas of Veneto on late-harvested grapevine cultivars (Dalla Montà, 1989; Pavan and Sbrissa, 1994). Recently, the 3rd flight was observed also in Trentino, but 3rd-generation eggs and larvae were detected only on unripe clusters of a second flowering (Varner and Mattedi, 2004).

A gradual evolution in the life history and harmfulness of *L. botrana* was recorded in the last twenty years of the 20th century in the Friuli Venezia Giulia region. During the eighties the 3rd flight occasionally occurred and a few 3rd-generation larvae were observed (Zangheri *et al*., 1987; Pavan *et al*., 1993). In the early nineties the 3rd flight was more frequent and larvae of the 3rd generation were found in all the grape-growing areas of this region but always at a low density (Pavan *et al*., 1994). From the mid-nineties serious infestations of 3rd-generation larvae were observed on all the cultivars in the plain grape-growing area of the Gorizia province and control measures were first adopted against this generation (Bigot *et al*., 2004). In this latter area the occurrence of a harmful 3rd generation was associated with an earlier 3rd flight; in fact, in the early eighties it began in late August (Zangheri *et al*., 1987), whereas from the mid-nineties it was observed from late July-early August (Bigot *et al*., 2004).

The aim of this study was to compare the phenology of *L. botrana* in two grape-growing areas of the Friuli Venezia Giulia region characterized respectively by large and negligible population levels of the 3rd generation. In particular, the phenology of adult flights and larval development were compared using respectively pheromone traps and cluster samplings.

Materials and methods

Grape-growing areas

The phenology of *L. botrana* was studied during 1997-1998 in two vineyards (cv. Tocai friulano) in different localities of Friuli Venezia Giulia (north-eastern Italy):

Locality 1 (Pasiano di Pordenone, 12° 40’ longitude E, 45° 51’ latitude N, 13 m above sea level). In this area of the Pordenone province, the 3rd flight of *L. botrana* begins in mid-August and larvae of the 3rd generation are only occasionally observed;

Locality 2 (Cormons, 13° 27' longitude E, 46° 58' latitude N, 63 m above sea level). In this area of the Gorizia province, the 3rd flight of the grape berry moth begins in late July-early August and heavy infestations by the 3rd-generation larvae occur on all the cultivars.

Temperature recording

During both years the average daily temperatures of the two localities were recorded (data of SAASD, province of Pordenone, for locality 1, and of the Consorzio Tutela Vini DOC Friuli Isonzo for locality 2) to calculate the degree-days (DD) from 1st January (10 °C basis) at specific dates.

Adult monitoring

The 2nd- and the 3rd-male flights were recorded by placing pheromone traps (Traptest®, Isagro) from the first decade of June to mid-September. The traps were examined twice a week.

The cumulated captures of adults were interpolated with the Weibull's regression ($y = 1-\exp[-(x/a)^b]$) using the SEMoLa framework (Danuso, 2003) to associate a date to each cumulated percentage of captures.

DD values were calculated for estimated dates corresponding to 50% of cumulated captures of the 2nd and 3rd flights.

Larval sampling

Phenology of 2nd-generation larvae of *L. botrana* was recorded periodically (every 7-10 days) from 15-20 days after the beginning of the 2nd flight until larvae of the 2nd-generation could still be found. On each date two persons sampled clusters for an hour or up to a maximum of 100 individuals.

The larvae were mounted on slides and the mandible length was measured under a dissection microscope. For each sample the average length of mandibles was calculated. The mandible lengths estimated for the two localities were compared using the Kruskal-Wallis test.

Larval growth-rate index

To describe the larval development during the time a growth-rate index (*li*) was used:

$$li = \frac{(m\bar{x} - me)}{(ml - me)} 100$$

where:

- $m\bar{x}$ = average length of mandibles in the sample (x);
- me = average length of mandibles of 1st-instar larvae (the only ones with a black and not a brown head-capsule);
- ml = average length of mandibles in the last sampling in which at least two larvae were found.

The cumulated percentages of *li* were elaborated in the same way as the cumulated captures.

Results

Climatic conditions

Both years locality 2 was warmer than locality 1 with higher differences in the second year (table 1). Differences in DD on the same date were observed from the early vegetative season.

Flight period

Both years the 2nd- and 3rd-flight periods of *L. botrana* males were earlier in locality 2 and the duration of the 2nd flight was longer in locality 1 (figure 1).

The earlier occurrence of 2nd flight in locality 2 compared to locality 1 is associated with the warmer climatic conditions (table 1). However, to reach the same flight phase took less DD in locality 2 than in locality 1 (table 2).

On the basis of the 50% of cumulated captures, both years the delay in the adult phenology observed in locality 1 compared to locality 2 increased from 2nd to 3rd flight (8 days in 1997 and 5 days in 1998) (table 2; figures 2 and 3). It can be only partially explained with the differences in temperatures, because to cover the interval between the 50% of the two flights *L. botrana* re-

Table 1. Degree-days (DD) (10 °C basis) for the two localities in 1997 and 1998.

dates	1997		1998	
	locality 1	locality 2	locality 1	locality 2
1 April	6	15	8	13
10 April	19	26	24	33
20 April	20	28	24	35
1 May	40	49	66	100
10 May	75	87	130	191
20 May	180	192	214	263
1 June	263	269	303	371
10 June	348	356	417	490
20 June	464	476	497	593
1 July	571	584	645	745
10 July	669	683	744	843
20 July	780	793	862	965
1 August	924	943	1045	1156
10 August	1036	1059	1181	1304
20 August	1160	1196	1338	1467
1 September	1294	1342	1456	1588

Table 2. Dates and degree-days (DD) (10 °C basis), corresponding to 50% of cumulated captures of males, for the two localities in 1997 and 1998.

years and localities	2nd flight		3rd flight	
	dates	DD	dates	DD
1997				
locality 1	1 July	571	25 August	1219
locality 2	22 June	500	8 August	1031
differences	(9 days)	71	(17 days)	188
1998				
locality 1	5 July	694	25 August	1400
locality 2	20 June	593	5 August	1224
differences	(15 days)	101	(20 days)	176

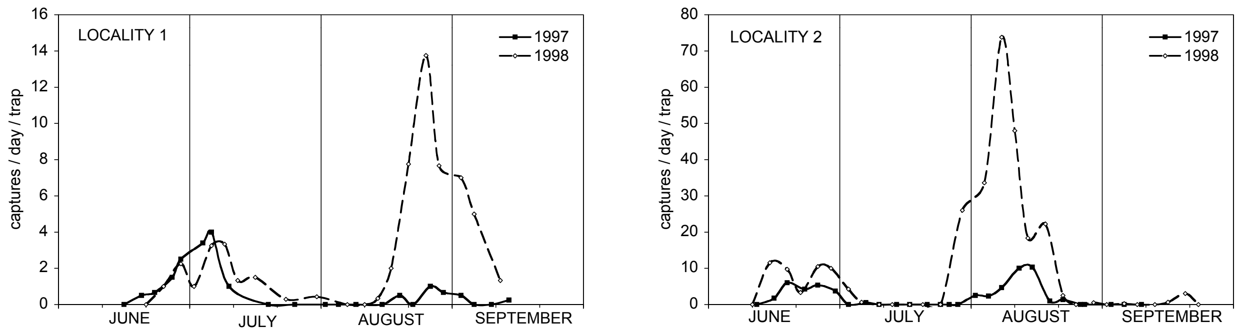

Figure 1. 2nd and 3rd flights recorded using pheromone traps in the two localities in 1997 and 1998.

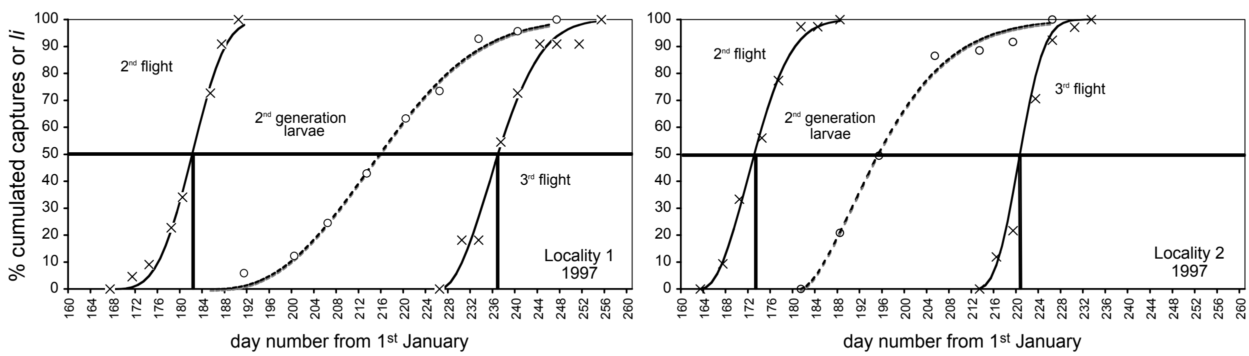

Figure 2. Data recorded (markers) and their interpolation lines on cumulated captures of males with pheromone traps (crosses and solid lines) and cumulated larval growth-rates (*li*) (circles and broken lines) in the two localities in 1997.

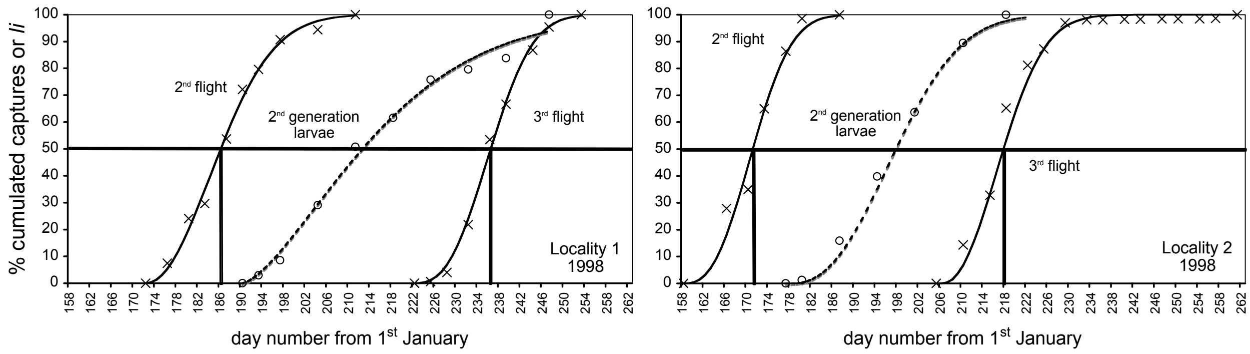

Figure 3. Data recorded (markers) and their interpolation lines on cumulated captures of males with pheromone traps (crosses and solid lines) and cumulated larval growth-rates (*li*) (circles and broken lines) in the two localities in 1998.

Table 3. Average mandible length (µ ± SD) of larvae for the two localities in 1997 and 1998. The mean within each row do not differ significantly at 0.05 level.

Considered larvae	1997		1998	
	locality 1	locality 2	locality 1	locality 2
1st- instar larvae	63.8 ± 3.5 n = 21	62.0 ± 4.4 n = 7	63.3 ± 0.6 n = 7	62.7 ± 2.1 n = 39
Larvae of last sampling	262.4 ± 33.4 n = 16	254.0 ± 19.8 n = 12	271.4 ± 16.0 n = 9	268.8 ± 23.0 n = 14

Table 4. Days needed to reach different percentages of cumulated larval growth-rates (*li*) from 50% of cumulated 2nd-flight captures for the two localities in 1997 and 1998.

Cumulated larval growth rate (%)	1997		1998	
	locality 1	locality 2	locality 1	locality 2
20	22	15	15	19
40	30	20	23	24
60	37	25	31	29
80	45	32	44	35
95	58	43	61	43

quired more DD in locality 1 than in locality 2 (117 DD more in 1997 and 75 DD more in 1998) (table 2).

The DD corresponding to 50% of two flights differed not only between localities, but also between the two years (table 2).

Larval development

The mandible length of 1st-instar larvae did not differ between localities and years (table 3); it was true also for larvae collected in the last sampling (table 3).

Both years in locality 2 the 2nd-generation larvae were observed for less days and the cumulated larval growth-rate index (*li*) increased more rapidly in comparison to locality 1 (figures 2 and 3). For example, to reach 80% of cumulated *li* in locality 2 the larvae needed about 10 days less than in locality 1 (table 4).

Discussion

Data on temperatures in the two localities show that high population levels of *L. botrana* during the 3rd generation are associated with warmer climatic conditions, confirming Italian and European scales (Zangheri *et al.*, 1987; Coscollà, 1997).

In the warmer locality the 2nd flight is earlier, but the DD are not sufficient to explain this occurrence. It could be due to (i) a non-linear influence of temperatures on population growth-rate, mostly in the early season, (ii) the selection of a population of *L. botrana* with a different response to temperature, and (iii) a different interaction of the insect with grapevine phenology. A non-linear phenology model for *L. botrana* was already proposed by Baumgärtner and Baronio (1989).

The further advance of about seven days in the 3rd-flight period observed in the warmer locality was caused by a faster development of 2nd-generation larvae. Because this fact is associated with a very lower requirement in DD, factors independent of temperature need to be considered to explain the differences in the phenology of 2nd-generation larvae.

The biological significance of an earlier 3rd flight could be to allow the larvae of the 3rd generation to develop before the harvest even on early-harvested grapevine cultivars. Two data support this hypothesis: (i) in the grape-growing areas, where the 3rd flight is delayed, heavy 3rd-generation infestations are observed only on late-harvested cultivars; (ii) the females do not lay eggs on ripe berries that are too close to harvest time (Marchesini and Dalla Montà, 2004; Varner and Mattedi, 2004). Therefore, an earlier 3rd flight would allow the females to lay eggs on receptive less ripe berries. If the biological significance of a faster larval development during the 2nd generation appears sufficiently clear, the mechanism of this occurrence must be investigated.

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Authors' addresses: Francesco PAVAN (corresponding author, francesco.pavan@uniud.it), Pietro ZANDIGIACOMO, Dipartimento di Biologia applicata alla Difesa delle Piante, Università di Udine, via delle Scienze 208, 33100 Udine, Italy; Laura DALLA MONTÀ, Dipartimento di Agronomia ambientale e Produzioni vegetali, Università di Padova, viale dell'Università 16, 35020 Legnaro (PD), Italy.

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