ENTOMOLOGIA HELLENICA 6 (1988): 7-10

Induction of Dormancy in *Lobesia botrana* by Long Day and High Temperature Conditions[1]

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ABSTRACT

Lobesia botrana (Denis and Schiffermueller) (Lepidoptera: Tortricidae) is known to enter a facultative autumnohibernal diapause-mediated dormancy in the pupal stage, when the embryonic and early larval stages are exposed to short-day photoperiods. Yet, in a laboratory stock originating from northern Greece and reared for years on an artificial larval diet, dormancy occurred also under a long-day photoperiod. When the eggs were incubated at 30°C in the dark or at 26° under the natural daylength of August in northern Greece, and the larvae grew at L:D 16:8 and 25°-26°, but not 20°, a substantial percentage of the pupae entered dormancy. This dormancy seems to be diapause-mediated. It is not known whether it is a typical summer diapause.

Introduction

Lobesia botrana (Denis and Schiffermueller) (Lepidoptera: Tortricidae) is one of the two species of European grape berry moths. It is especially destructive in southern Europe. Besides grapevine it can feed and develop on a number of other plants. It completes 2 or 3 generations per year, and exceptionally a partial or complete 4th. First - generation larvae damage the flowers, and those of the following generations damage the green, ripening and ripe grape berries. Damage to ripe or nearly ripe berries is often accompanied by infection of the grape by the gray mold fungus, *Botrytis cinerea* Persoon, which further lowers the quality or causes up to complete destruction of the infected grapes.

L. botrana is a polyvoltine long-day insect with a facultative autumnohibernal diapause-mediated dormancy in the pupal stage. This dormancy is induced when the embryonic and/or early larval stages are exposed to short-day photoperiods (Komarova 1949, Roehrich 1969, Geoffrion 1970, Deseö et al. 1981). In the field, dormancy does not occur in the first generation. The percentage of dormant pupae in the generations that follow depends on the time of year the diapause-sensitive stages develop in the field, the percentage being very high to 100% in pupae of the last generation(s) (Komarova 1949, Bovey 1966, Roehrich 1969). Here we report on a dormancy which was induced in the laboratory when larvae grew under long day and a relatively high temperature, i.e. under conditions which would be expected to induce dormancy in a short-day rather than a long-day insect.

Materials and Methods

The insects were of a laboratory colony. This colony was started in 1971 with advanced larvae collected on olive inflorescences of a grove adjoining a vineyard in coastal Halkidiki (northern Greece). Ever since, the stock colony has been maintained on arti-

[1] Received for publication January 9, 1989.

ficial larval diets of the following composition, by weight: tap water 50, agar fine powder 2, tomato juice 25, carrot baby food 5, brewer's yeast powder 10, vitamin mixture (Vanderzant modification) 2, alfalfa meal 10, salt mixture W 0.5, potassium sorbate 0.1, methyl p-hydroxybenzoate 0.15. In recent years it has been necessary to increase the quantity of both potassium sorbate and methyl p-hydroxybenzoate to 0.17 to reduce the growth of undesirable fungi. The diets were prepared and used as described by Tzanakakis and Savopoulou (1973). The stock colony was maintained under a constant temperature of 21°C and artificial light of a long day photoperiod (L:D 16:8) to prevent diapause. Once a year, embrya and larvae grew at L:D 10:14 and 21° to produce diapausing pupae and maintain the stock colony at low cost during the period no experiments were carried out. No attempt has been made to select for or against diapause.

Four or 5 pairs of adults were placed in each 5 × 7.5 × 9 cm truncated conical cup of transparent hard plastic, and provided with 5% sucrose solution on a soaked piece of cotton wool. The eggs were laid on the inner walls of the cups. Cups were renewed daily. Those containing the eggs were rinsed with 5% ethanol, then with water, allowed for the water drops to evaporate, and taken to the experimental conditions. Upon hatching, the neonate larvae were placed in Petri dishes or cups containing the above artificial diet and maintained under the experimental photoperiod and temperature regimes. When the larvae approached full growth, a strip of corrugated paper was added to each dish or cup to provide suitable pupation sites. Paper strips with spun up fully grown larvae or pupae were taken every second day and maintained at L:D 16:8 and 25°C. Pupae not giving adults within 25 days while being alive were recorded as dormant.

Results and Discussion

The results are given in Table 1. In the October 1971 experiment, the percentage of dormant pupae was zero when the larvae grew under a long, 16 h photophase at 20°C. This is in line with previous work which has established that *L. botrana* is a long-day insect (Komarova 1949, Roehrich 1969, Geoffrion 1970, Deseö et al. 1981). Under the higher temperature of 26° we should expect also a zero percentage of dormancy, because 26° should be less favorable than 20° for the induction of an autumnohibernal dormancy (Lees 1955, Danilevskii 1965, Beck 1968, Tauber et al. 1986). Yet, 7% and 8% of pupae were dormant. This low percentage of dormancy could have been interpreted as representing the individuals with a high tendency for dormancy. However, it could also be interpreted as showing a more general tendency for dormancy when the larvae grow under high temperatures. The experiments that followed support the latter view.

In August 1972, the eggs were exposed to natural daylight coming from a northeastern window. When the larvae grew at 20°, a long 16 h photophase induced dormancy in a very small percentage of pupae. Yet, contrary to what one would expect for a long-day insect, under a long photophase combined with a relatively high temperature of 26°, half the pupae entered dormancy. In 1972, as well as in 1977, 1980 and 1984, short photophases of 12, 10, or 8 hr, during the larval stage, whether at 20° or 25°, induced dormancy in a high percentage of the population. This is known from work by the investigators referred to above.

In June 1977 too, 20° and a long photophase averted dormancy while when the eggs were incubated at a high, 30°, temperature and the larvae grew under a long photophase and a relatively high 26° temperature, 36% of the population entered dormancy. By contrast, when egg incubation was at 20°, and the larvae grew under the same long photophase at 26°, the incidence of dormancy was very low. The results of 1979, 1980 and 1984 substantiate the results of 1972 and 1977. Thus, the general conclusion from our work is that, when eggs were incubated at 30° in the dark or at 26° under the natural daylight of August in northern Greece and the larvae grew at a photophase of 16 h and 25°-26°, but not 20°, a substantial percentage of the pupae entered dormancy. This percentage in 5 out of the 7 experiments was from 28.6 to 50%. Therefore, a substantial portion of the population entered dormancy under conditions typical of a short-day insect, while most or all the population also exhibited its typical response of entering dormancy under short days.

The fact that the above "unexpected" dormancy is induced by high temperature acting on a stage preceding considerably the stage in which it is manifested, suggests that it is a diapause-mediated dormancy. Our data do not allow us to conclude whether we are dealing with a summer diapause as defined by Masaki (1980) and found in certain other long-day polyvoltine plant-feeding Lepidoptera of temperate regions (Masaki 1956, 1980, Masaki and Sakai 1965).

TABLE 1. Induction of dormancy in pupae of *Lobesia botrana* reared under various phoroperiod and temperature conditions, on an artificial larval diet.

Photophase and temperature during Embryo	Larva	Dormant pupae %	Total pupae
	October 1971		
Oh, 20°	16h, 20°	0	44
Oh, 28°	do.	0	59
Oh, 20°	16h, 26°	7.1	28
Oh, 28°	do.	8.1	37
	August 1972		
Nat.* 26°	10h, 20°	100.0	24
do.	16h, 20°	4.3	23
do.	16h, 26°	50.0	30
	June 1977		
Oh, 20°	10h, 20°	100.0	42
Oh, 30°	do.	100.0	18
Oh, 20°	16h, 20°	2.1	47
Oh, 30°	do.	4.8	21
Oh, 20°	16h, 26°	4.5	66
Oh, 30°	do.	36.0	25
	March 1979		
Oh, 20°	16h, 26°	0	29
Oh, 30°	do.	28.6	21
	April 1979		
Oh, 20°	16h, 26°	7.3	41
Oh, 30°	do.	50.0	70
	February 1980		
Oh, 30°	12h, 20°	93.0	97
do.	12h, 25°	87.3	79
do.	16h, 20°	15.2	59
do.	16h, 25°	36.8	95
	January 1984		
Oh, 20°	16h, 25.5°	6.0	166
do.	16h, 20°	7.1	84
do.	8h, 20°	82.0	162
16h, 20°	16h, 25.5°	3.0	133
16h, 25.5°	16h, 25.5°	17.6	57

*Natural photoperiod.

In the vineyards of Greece, during summer, *L. botrana* is likely to be exposed to relatively high temperatures during embryonic development, and to long days and relatively high temperatures during larval growth. Work with wild populations, growing on natural food and exposed to summer field conditions is needed to determine whether pupal dormancy occurs also under summer field conditions.

Acknowledgment

We thank Prof. D.A. Prophetou-Athanassiadou for comments on the manuscript.

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KEY WORDS: Grape berry moth, High temperature effects, Insect diapause, Insect dormancy, *Lobesia botrana*, Photoperiod effects

Πρόκληση Διάπαυσης στο *Lobesia botrana* υπό Συνθήκες Μακράς Ημέρας και Υψηλών Θερμοκρασιών

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ΠΕΡΙΛΗΨΗ

Η Ευδεμίδα του αμπελιού, *Lobesia botrana* (Denis and Schiffermueller) (Lepidoptera: Tortricidae), είναι ένα πολυκυκλικό έντομο μακράς ημέρας. Παρουσιάζει προαιρετική φθινοπωρινοχειμερινή διάπαυση, στο στάδιο της νύμφης, όταν το εμβρυακό και τα πρώτα προνυμφικά στάδιά του εκτεθούν σε φωτοπεριόδους βραχείας φωτόφασης. Σε εργαστηριακή αποικία του εντόμου αυτού προέλευσης Βόρειας Ελλάδας, που είχε εκτραφεί επί πολλά έτη σε τεχνητή προνυμφική τροφή, προκλήθηκε διάπαυση και υπό συνθήκες που θα μπορούσαν να θεωρηθούν μη αναμενόμενες, δηλαδή, με φωτοπερίοδο μακράς φωτόφασης και με σχετικά υψηλή θερμοκρασία. Συγκεκριμένα, όταν τα αυγά επωάστηκαν σε 30° C σε συνεχές σκοτάδι, ή σε 26° C και φυσική φωτοπερίοδο Αυγούστου στη Β. Ελλάδα και στη συνέχεια οι προνύμφες αναπτύχθηκαν σε φωτοπερίοδο 16:8 και 25°–26°, ένα αξιόλογο ποσοστό των νυμφών εκδήλωσε διάπαυση. Σε 5 από τα 7 πειράματα που έγιναν σε 6 διαφορετικά έτη, το ποσοστό νυμφών που διέπαυσαν κυμάνθηκε από 28,6% ως 50%. Η διάπαυση αυτή, που δεν είναι ακόμα γνωστό αν είναι τυπική θερινή, δεν προκλήθηκε όταν τα αυγά επωάστηκαν σε 20° και συνεχές σκοτάδι.
Το πλείστο ή το σύνολο του πληθυσμού μπήκε σε διάπαυση και όταν τα προνυμφικά στάδια εκτράφηκαν σε φωτοπεριόδους με βραχείες φωτοφάσεις 12:12, 10:14, ή 8:16 ωρών, όπως αναμενόταν από προηγούμενες εργασίες άλλων ερευνητών.