PHENOLOGY MODEL ON SUMMER FRUIT TORTRIX MOTH *ADOXOPHYES RETICULANA* HB. (LEPIDOPTERA: TORTRICIDAE) AND PREDICTING EMERGENCE TIMING

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Abstract. The summer fruit tortrix moth *Adoxophyes reticulana* is an important pest in some orchards in Romania, its damages increasing in the last years. In many cases the control treatments do not showed good results. That is the reason why to improve the warning system based on the model for the development of the pest with temperature sums is essential. To understand the mechanism of seasonal occurrence of this species, the population dynamics model that explicitly incorporates the temperature – dependent development is used. Knowledge of the phenology of the summer fruit tortrix moth *Adoxophyes reticulana* is likely to allow the prediction of the timing of appearance for each development stage, which can provide a well – timed control method. The model predictions were compared with observed captures in pheromone traps at the Research-Development Station for Fruit Tree Growing Voinesti. The results demonstrated that the timing of peak appearance of adult population varied among years.

Key words: *orchard, Adoxophyes reticulana, prediction, pheromon traps.*

INTRODUCTION

The summer fruit tortrix moth *Adoxophyes reticulana* Hb. is a serious pest of the apple orchards, its damages increasing in the last years in Romania. Many studies were done in the Western Europe from the mid-20th century, in order to understand the population dynamics and to find the control methods for this pest insect (Balachowsky, 1966; De Jong and Minks, 1981; Stamenkovic, 1984; Charmillot, and Brunner, 1990, Balazs, 1992). Knowledge about the phenology of the summer fruit tortrix moth allows the prediction of the timing of appearance for each developmental stage, which can provide a well-timed control method. The rate of insect development is strongly associated with the exposure of the environmental temperature. That is the reason why, monitoring degree-day accumulation is a valuable tool for predicting pest activity. Insects emerge earlier in warm years than in cool ones. The critical assumption in the use of phenology to predict pest activity is that the phonological sequence (the order in which phenological events occur) remains constant from year to year. The models for temperature-dependent development of pest insects have been widely used as decision-support tools to improve the efficiency of pest management, such as accurate forecasting (Baumgaertner and Charmillot, 1983; Charmillot et Megevand, 1983; Baumgaertner, Favre and Schmid, 1988).

In Romania there are some previously studies (Irimie, 1982; Ghizdavu, 1986; Iacob and Drosu, 1993) about the summer fruit tortrix moth biology and control; more recently concern (Drosu, 2002) resumes the interest for this pest. The present study shows a simulation model of *Adoxophyes reticulana* population dynamics using field temperature data. The prediction data from the literature has been compared with the Research-Development Station for Fruit Tree Growing Voinesti observation data.

MATERIAL AND METHOD

Biological background

In Romanian condition summer fruit tortrix moth develops two generations per year. The dia-pausing larvae hibernate in the second-forth stage (L_2-L_4) and in the spring begin their development again. The over-wintering larvae feed on buds, young leaves and then became pupae. The damages are caused by the caterpillars that feed on the leaves and fruits (Fig. 1). The damage to the leaves is not so harmful, but the damage to the fruit can be extensive and costly. Summer or first generation larvae actively feed on leaves, buds, flowers and developing fruit. During the first generation the damage is not evident, in many situations the means of the control delay. That is the reason why, it is very important to prevent the attack by a good forecasting method.

Data description and analysis

Observation data were collected during May – September 2004-2006, in apple orchard at the Research-Development Station for Fruit Tree Growing Voinesti, using pheromone traps synthesized by the Institute of Chemistry Cluj-Napoca. Pheromone traps were checked twice per week to determine the initial emergence of over-wintering first generation moths; for the rest of the season, the traps were used to monitor the population cycle. In addition to the pheromone trap catch data, the daily maximum and minimum temperatures were monitored. These temperature data are used to calculate the cumulated sum of degree-days. A degree-day (heat unit) is a measure of the amount of heat that accumulates above a specified base temperature (the lower temperature threshold for development) during a 24 hour period. There are some methods for calculating degree-days. In this study *the average method* was used. That means the number of degree-days is the sum of differences between the average daily temperature and a cited threshold, the zero development point of the species.

Model

The model proposed describes the dynamics of the life cycle of the pest insect based on daily temperature. The parameter values from the literature (Table 1) were compared with registered dates during the study years.

RESULTS

Seasonal occurrence of the adult populations of the summer fruit tortrix moth during 2004-2006 in the Romanian conditions is presented in figure 2. The peak emergence date of adults and population size varied among years as a reflection of annual variation of temperature. The table 2 shows the date of occurrence of the phenological events for summer fruit tortrix moth *Adoxophyes reticulana* life cycle stages and cumulated heat units for each stage. The time differences of peak emergence date were as large as 11 days, between May 26 (2005) – June 5 (2004). The differences between the date of cumulated degree-days for the first adult and the first captures in the traps are presented. The first adults appeared two days earlier than the date when was registered degree – days in 2004, 6 days after in 2005 and 5 days after in 2006. The period of eggs lying, when registered degree-days for the oviposition (Table 2) were, corresponds to the first peaks of the curves (Fig. 2). The predicted peaks emergence dates are mostly in agreement with those observed; the difference fell within the period of 6 days.

The studies carried out in Romanian conditions were comparable with those obtained by Charmillot (1990) who find sum of degree-days above threshold 163-173^0 C from 1st January to the first captures in the pheromones traps, registered in the period of 3-9 June. The total degree-days for 1st generation was 616-693^0 C (to July 29-August 8).

The table 3 shows the stage duration of the summer fruit tortrix moth. The duration from degree-days for the over-wintering larvae to first adults in the pheromones traps varied between 12 (2006) and 30 (2004) days. Duration of oviposition is longer in the first generation (19-26) then the second one (13-17 days). Summer larval stage lasts for 33-35 days and the pupae 8-11 days. The first generation lasts for 74 days in 2004, 75 days I 2005 and 81 days in 2006. Balachowsky (1966) presented for over-winter-spring stage 10-20 days, eggs development 8-20 days, pupae first generation 6-16 days. The first flight in Switzerland was the period between 15-20 May - 15 June till the beginning of June- the beginning of July to middle June-middle July.

Overlapping was observed between appearance periods of several developmental stages within and between generations. The diagram presented in figure 3 shows an example (2004) of this situation that suggests the difficulties to control this pest. Flight periods of the first and second generation usually may overlap and the attacking larvae period too. In this case the efficacy of the control methods depends on the well timed warning.

The first captures of the first flight can be used as a biologic reference point to initiate cumulative degree-days for simulation. Thus, forecasting for the second generation is more exact. The hatch of eggs in spring determines the phenology of larvae later on, so accurate estimation of oviposition are needed to predict the development of larvae in the summer, the period of damage.

CONCLUSIONS

The population dynamics model of summer fruit tortrix moth *Adoxophyes reticulana* that explicitly describes a temperature-dependent development showed that the emergence timing of the insect observed in the field is determined primarily by temperature, although the potential impacts of other factors, e.g., sensitivity to photoperiod and precipitation, still remain.

Thus, we can concluded that by measuring temperature, managers of apple orchards could roughly predict the emergence timing of each of the development stages of *Adoxophyes reticulana*. The efficacy of the control methods depends on the well timed warning.

Knowledge of when each of the developmental stages is present in the field should allow the prediction of when the infestation level will be highest.

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Table 1

Development threshold and degree day requirements for summer fruit tortrix moth *Adoxophyes reticulana*

Stage	Development threshold (°C)	Degree day (°C)	Longevity (days)
Egg	10	90	8-10
Larva • 1st generation (summer) • 2nd (enter diapause; overwinter as late instars/spring) • prediapause	 7-8 9-10 15	 430 67 420	 20-25
Pupa	10	90	10-20
Oviposition	10	135 (after flight begins)	

Table 2

Phenological sequence including date of occurrence and cumulative degree-days (DDs) for summer fruit tortrix moth

Phenological event	Date of registered DDs			Cumulative DDs (°C>base temperature)		
	2004	2005	2006	2004	2005	2006
Overwinter as late-instars/ pupation	5.V	9.V	16.V	69	67.9	68.4
First adults in spring*	5.VI	26.V	28.V	90.8	95.6	91.8
Oviposition	24.VI	16.VI	23.VI	135.8	142.6	140.3
Hatching	4.VII	27.VI	2.VII	91.6	92.6	98.8
Pupation first generation	8.VIII	31.VII	5.VIII	435.7	443.2	439.6
Emergence of adult second generation	18.VIII	8.VIII	16.VIII	92.5	92.7	97.0
Oviposition	1.IX	24.VIII	2.IX	143.7	136.2	136.0
Hatching	22.IX	4.IX	17	91.2	94.1	91.0

		2004	2005	2006
* First adults in spring:	- Date of registered DDs	5.06	26.05	28.05
	- Date of the first captures in the traps	3.06	1.06	2.06
	- Differences	2 days	6 days	5 days

Table 3

Phenological occurrence and the stage's duration of the summer fruit tortrix moth *Adoxophyes reticulana*

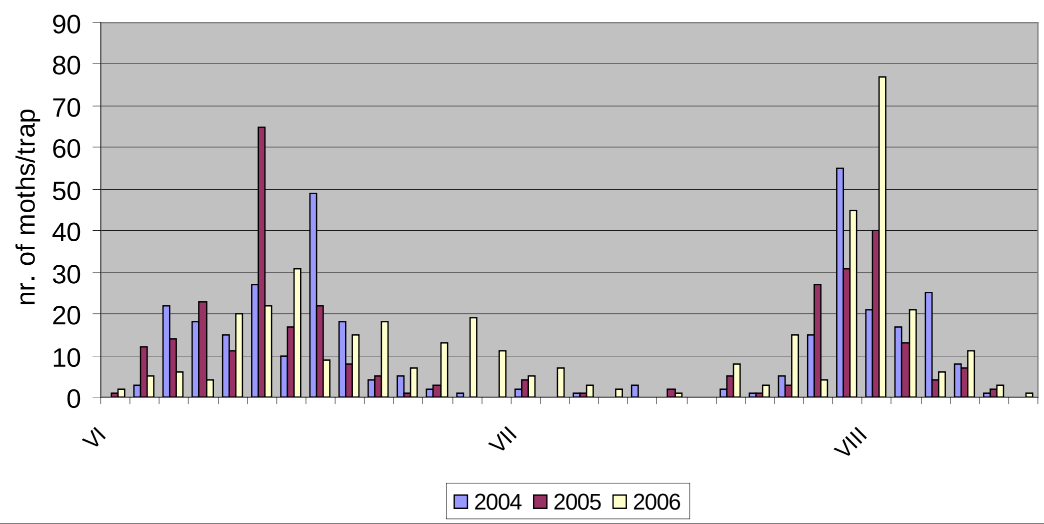
Years	Overwinter as late-instars/pupation		First adults in spring		Egg stage		Larvae		Pupae		First adults 2nd generation		Egg stage 2nd generation		Over-wintering larvae
	Date	Duration (days)	Date	Duration of oviposition (days)	Date of laing	Duration of eggs development (days)	Date of hatching	Duration of larval stage (days)	Date	Duration (days)	Date	Duration of ovoposition (days)	Date of laing	Duration of eggs development (days)	
2004	5.V	30	5.VI	19	24.VI	10	4.VII	35	8.VIII	10	18.VIII	13	1.IX	21	22.IX
2005	9.V	17	26.V	22	16.VI	11	27.VI	33	31.VII	8	8.VIII	16	24.VIII	10	4.IX
2006	16.V	12	28.V	26	23.VI	9	2.VII	34	5.VIII	11	16.VIII	17	2.IX	15	17.IX

a

b

Fig. 1 Apple damages produced by summer fruit tortrix moth *Adoxophyes reticulana*
a. on leaves; **b.** on fruit

Fig. 2 The population dynamics of the summer fruit tortrix moth



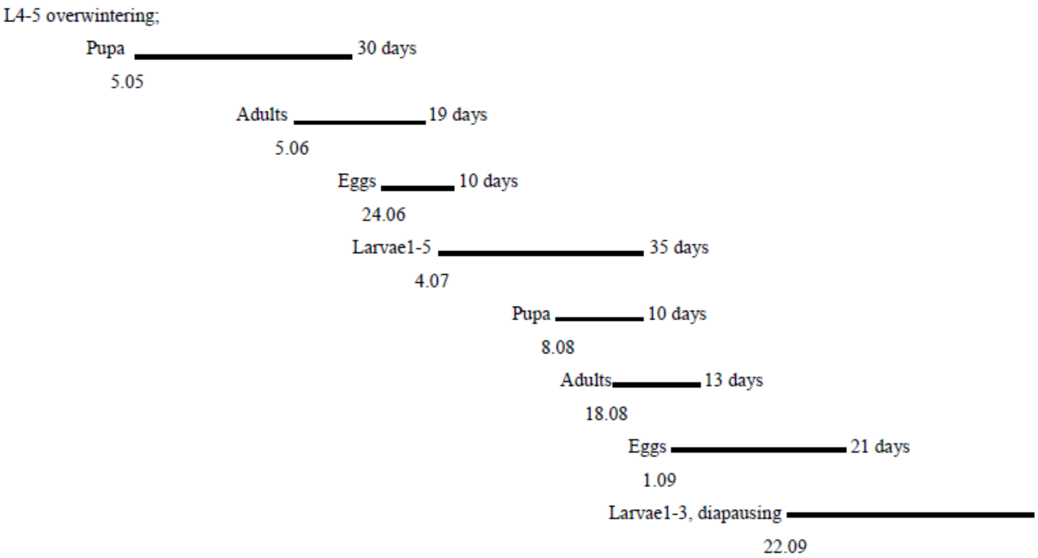


Fig. 3. Diagram of phenological occurrence and the stage's duration of the summer fruit tortrix moth, *Adoxophyes reticulana,* in 2004