POPULATION DYNAMICS OF THE CINNABAR MOTH 
(TYRIA JACOBÆAE): OSCILLATIONS DUE TO FOOD 
LIMITATION AND LOCAL EXTINCTION RISKS*

by

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SUMMARY

We report on a 17-year study on the population dynamics of the cinnabar moth (Tyria jacobaeae). As in other long-term studies of this species scramble competition for food leads to periodic crashes in abundance. This results in delayed density-dependent oscillations in the rate of increase of this insect with strikingly similar amplitudes. Recovery after a crash is delayed for a second year, although food is then not limiting. Delayed density-dependent factors such as parasitism and food quality reduction are assumed to be responsible. During a crash the cinnabar moth goes extinct in most local patches of ragwort. Mechanisms that may prevent extinction over large areas containing many such local populations (metapopulations) are heterogeneity in environmental conditions that affect oviposition and predation, and the distribution of egg production in time during the season.

KEY WORDS: population dynamics, cinnabar moth, Tyria jacobaeae, ragwort, Senecio jacobaea, scramble competition, delayed density dependence, parasitism, food quality, extinction.

INTRODUCTION

The relationship between the cinnabar moth (Tyria jacobaeae L.) and ragwort (Senecio jacobaea L.) is spectacular because of the periodic total defoliation over large areas followed by mass migration and starvation of caterpillars. Earlier studies (DEMPSTER & LAKHANI, 1979, VAN DER MEIJDEN et al., 1985, VAN DER MEIJDEN, 1989 and CRAWLEY & GILLMAN, 1989) showed that yearly variations in local weather factors are most important in determining the amount of plant biomass in populations in widely different habitats (sandy as well as mesic grasslands and sand dunes) in Great Britain and the Netherlands. The amount of plant biomass sets the carrying capacity for the population

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of the cinnabar moth. Periodic starvation is the only feed-back mechanism that relates maximum insect numbers to plant biomass. Using a key-factor analysis Dempster (1971, 1982) demonstrated that starvation and the resulting reduction in the fraction of larvae that pupate, and reduction in pupal size and consequently in adult fecundity, are the main correlates with population size of the cinnabar moth.

We have monitored ragwort as well as cinnabar moth populations for 17 years. Further studies have focussed on insect nutrition (Soldaat, 1991a), on plant chemical defence (van Zoelen & van der Meijsen, 1991; Vrielings, 1991) and on performance of ragwort in relation to herbivory (Prins, 1990). A model study on the interaction between foodplant and herbivore is in preparation.

Most of the earlier papers on this dynamic relationship drew attention to the influence of food limitation on moth numbers without studying the mechanisms that prevent the cinnabar moth from going extinct. In the Dutch dunes, ragwort has a very patchy distribution. Local extinction of the moth in these patches can be observed each year, while other patches become colonized (van der Meijsen, 1979). The question remains what buffers the total population against extinction? In earlier papers (Dempster, 1982, van der Meijsen, 1979) it was suggested that the local heterogeneity of the environment might be responsible.

In this paper we will report on fluctuations in a dune population of the cinnabar moth and consider the effect of local heterogeneity and the specific biotic circumstances in those patches where the moth survives after large scale crashes. Questions that will be considered are:

1. to what extent is food limitation causing the cycles of abundance of the cinnabar moth?
2. what is the course of recovery of the insect’s numbers following a crash from food limitation? It is dependent only upon \( R_{\text{max}} \) of the cinnabar moth?
3. can heterogeneity in food availability between local patches in the same and/or in different habitat types explain survival during periods of food limitation?
4. might early-laid eggs have a better chance of surviving food shortage?
5. what are the characteristics of the food-plant patches that are colonized after a crash?

Finally it will be discussed how the typical cycles of insect numbers that we will describe in this paper may be explained by a combination of food quantity and quality and by delayed density-dependent parasitism.