

## FOOD PLANT PREFERENCE OF THE CABBAGE MOTH, *MAMESTRA BRASSICAE* (L.)

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### Abstract

The aim of the present study was to elucidate plants preferred by cabbage moth, *Mamestra brassicae* larvae and the dynamics of their numbers on these plants. The experiment included white cabbage (*Brassica oleracea* var. *capitata* f. *alba*), rutabaga (swede) (*B. napus* var. *napobrassica*), collard (ornamental kale) (*B. oleracea* var. *acephala*), red cabbage (*B. oleracea* var. *capitata* f. *rubra*), and nasturtium (*Tropaeolum majus*). Our experiments revealed that cabbage moth larvae had feeding preferences within the same *Brassica* family. The *M. brassicae* preferred white cabbage; 51.2% of larvae counted during the observation period were gathered from this plant. The next choices were collard, by 32.1%, and red cabbage, by 16.5%. On rutabaga only few larvae of *M. brassicae* were found. No *M. brassicae* were discovered on nasturtium. White cabbage had the biggest number of larvae at the end of July; thereafter their numbers decreased, and in mid-August only single larvae were found there. Red cabbage had larvae only during the first two analyses; later samples did not show any larvae. Collard had a relatively small number of larvae during the first two observations, after that their number started to increase, reaching its peak in the fourth week of the observations. Thereafter the numbers decreased until by mid-August none remained.

**Key words:** *Mamestra brassicae*, foodplant preference, white cabbage, rutabaga, collard, red cabbage, nasturtium.

### Introduction

The cabbage moth (CM), *Mamestra brassicae* (L) is a highly polyphagous species, particularly associated with cruciferous crops (Bretherton et al. 1979), but also feeding on a wide range of other plant species (Turnock & Carl, 1995). The occurrence of CM as a pest in Estonia is variable. During the last years, the population levels in general have been low, but with sporadic, local outbreaks. In different climatic zones, CM can produce a number of generations during a summer; in Estonia it is mainly an univoltine species, hibernating as diapausing pupae in the soil. The adults emerge at the end of June or at the beginning of July. Since the butterflies lay their eggs during a longer period of time, the larvae may be found in nature during a few months. Females oviposit at night and lay their eggs in a single-layered cluster mainly on the underside of host-plants leaves. Egg clustering may protect eggs from desiccation (Clark and Faeth, 1998) as well as from other detrimental environmental factors (Ulmer et al., 2003). In general there is a viewpoint that young larvae of CM remain clustered during the first instar, however, Johansen (1997) found that the larvae started to spread all over the host plant within a few hours after hatching, and continued to disperse radically from the original infested plant throughout the larval stage. In younger instars, the larvae feed mainly on the external leaves. From the fifth instar, they display a negative phototaxis (Omono et al., 1973) and they move into the central part of the plant in between young leaves where they complete their larval development.

It is generally known that various plant characteristics influence host plant selection in herbivorous insects, but plant chemistry can be especially important. For example, secondary plant metabolites are used by several insects for recognition of their host plants (Chew, 1988; Städler, 1992). The typical pattern of host location among adult *Lepidoptera* is the use of plant odours for longer-range detection and evaluation of potential host plants, followed by contact chemoreception for selection of oviposition sites (Schoonhoven et al., 1998). In the case of CM, it has been found that it mainly selects an oviposition site by odour cue, whereas the search process is, to some extent, influenced by visual cues (Rojas et al., 2000). The choice of egg-laying sites is also influenced by several other factors. The hypothesis that adult females prefer to oviposit on the plant species which had served as their larval food plant is known as the Hopkins host selection principle (Szentesi & Jermy, 1990). However, Rojas and Wyatt (1999<sup>a</sup>) discovered by their experiments that, there is no evidence that the adults of CM base their search of egg-laying sites on the needs of the larvae.

Several aspects of the *M. brassicae* biology have been studied in detail (Johansen, 1997; Rojas and Wyatt, 1999<sup>b</sup>; Rojas et al., 2000, 2001, etc.), but most experiments with the CM selection of host plant has been conducted with adults in wind tunnels in laboratories. Although larvae of CM can feed on many different host plant species, there is currently little knowledge on its feeding preferences and there are almost no data on relevant field observations. It is known that also larvae of highly polyphagous species are selective in their food choice and show preferences for some plants over others (Schoonhoven & Van Loon, 2002). The aim of this experiment was to establish whether CM larvae have feeding preferences for some more important garden culture in Estonia and whether there are any preferences within one plant genus. The criterion for choosing plants was that they all contained glucosinolates.

### Materials and Methods

The experiments were carried out in the experimental garden of the Estonian Agricultural University in the summer of 2003. The experiment included white cabbage (*Brassica oleracea* (L) var. *capitata* f. *alba*), rutabaga (swede) (*B. napus* L. var. *napobrassica* DC. L. Reichenb.), collard (ornamental kale) (*B. oleracea* (L) var. *acephala*), red cabbage (*B. oleracea* (L) var. *capitata* f. *rubra*), and nasturtium (*Tropaeolum majus* L.). All plants were grown from

seed, kept in a glasshouse until they reached the 3 true leaf stage. In mid-May the plants were replanted in the experimental field. Each variant consisted of 9 plants per plot (three rows of three plants spaced at 70-cm intervals). All variants had three replications. To prevent larvae from leaving the experimental plots, a 20 cm wide strip of dill (*Anethum graveolens* L), which is not a food plant of CM larvae, was sown around each plot. Larvae of CM on all the experimental plots were sampled at 7-day intervals from 18 July to 05 September. Larvae were removed by hand picking them from plants to avoid repeated counting. Such repeated experiments enabled discovering, during the experimental period, also those larvae not found in earlier counts.

Data have been presented as mean  $\pm$  standard deviation. Statistical comparisons were performed with paired Student's t-test or repeated-measures ANOVA by Tukey test. All means were considered significantly different at the  $P < 0.05$  level.

## Results and Discussion

### The proportion of larvae of CM on different cultures

Analysing of material gathered during the experimental period showed that 52% of larvae counted during the observation period were gathered from white cabbage. The next choices were collard (ornamental kale), by 32%, and red cabbage, by 14%. On swede (rutabaga) only few larvae of CM were found (2%) (Fig.1). No CM were discovered on nasturtium.

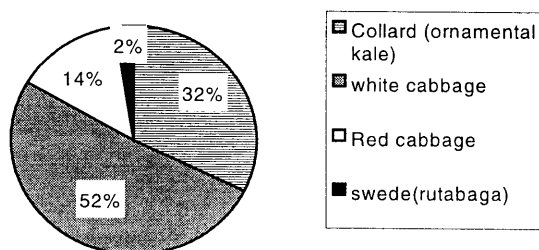
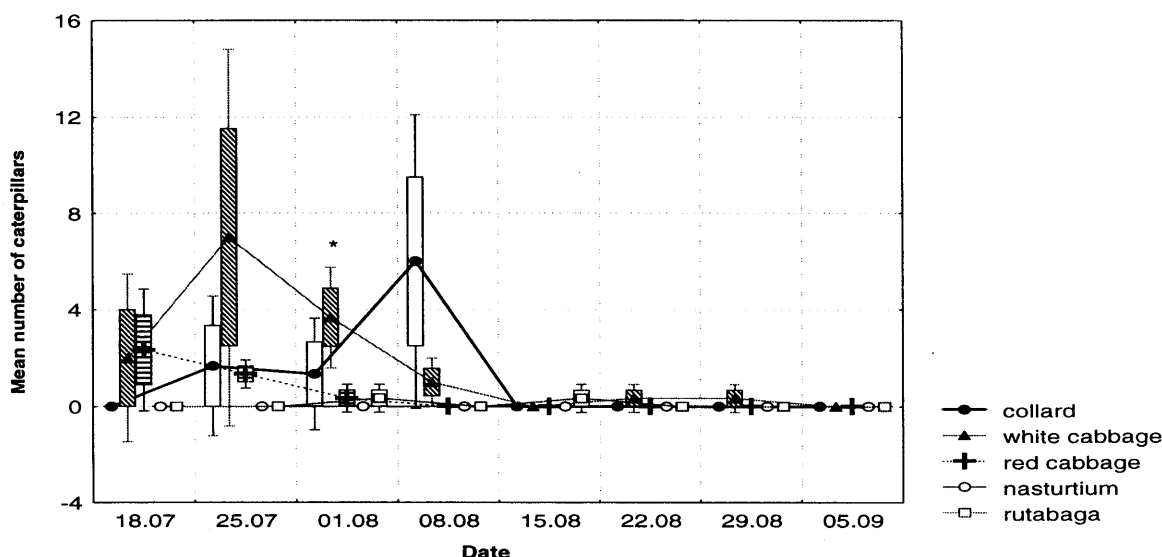


Fig. 1. The proportion of larvae of *Mamestra brassicae* on four different plant species

### The dynamics of the number of CM larvae

During the first observation (18.07), there were few CM larvae and a nearly the same number of them were found both on white cabbage ( $M = 2.0$ ) and red cabbage ( $M = 2.33$ ). There was no statistically significant difference in the mean number of these variants ( $df = 4$ ,  $F = 1.16$ ,  $P = 0.38$ ). There were no larvae on plants of the other variants. During the second observation (25.07), larvae were found again on white cabbage ( $M = 7.0$ ) and, to a lesser extent, on red cabbage ( $M = 1.33$ ), whereas only larvae of older instars were found on red cabbage. During this observation, larvae were first found on collard (ornamental kale), too ( $M = 1.66$ ). On comparing the mean numbers in different variants, there was no statistically significant difference ( $df = 4$ ,  $F = 1.8$ ,  $P = 0.20$ ), however, there were somewhat more larvae on white cabbage than in other variants. The third observation (01.08) revealed again larvae on white cabbage ( $M = 3.66$ ) and ornamental kale ( $M = 1.33$ ) but red cabbage had only few larvae of the last instar ( $M = 0.33$ ). Larvae of the second and third instar were found on rutabaga (swede) ( $M = 0.33$ ). A comparison of the variants showed that white cabbage had statistically reliably ( $df = 4$ ,  $F = 3.27$ ,  $P = 0.05$ ) more larvae than the other variants. At the fourth observation (08.08) there were larvae of mainly the fourth instar on white cabbage. Their number was low ( $M = 1.0$ ). This observation revealed a bigger number of larvae on ornamental kale ( $M = 6.0$ ). As by the time of the observation larvae of the variant had mainly reached last instars, it may be concluded that young larvae had not earlier been found between the thick and wrinkled foliage. Later when larvae reached older instars and moved onto young leaves of ornamental kale, they were easily noticeable. However, the difference in the numbers of larvae on white cabbage and ornamental kale was not statistically reliable ( $df = 4$ ,  $f = 2.68$ ,  $P = 0.09$ ). During the fifth observation (15.08), few larvae were found on rutabaga ( $M = 0.33$ ). Other variants revealed no larvae. At the sixth (22.08) and seventh observation (29.08) only a few grown-up larvae were detected on white cabbage ( $M = 0.33$ ). In September (05.09) no larvae were found on any plant, and the experiment was finished.

In brief, it can be concluded that white cabbage had the biggest number of larvae at the end of July; thereafter their numbers decreased, and in mid-August only single larvae were found there (Fig. 2). The occurrence of larvae on red cabbage showed nearly the same tendency. The red cabbage was more infested with larvae during the first three analyses; in later samples their number decreased constantly. On the basis of the results obtained with white and red cabbage, it can be concluded that there was repeated egg-laying of CM females on white cabbage as larvae of different instars were found within a long period of time. On red cabbage eggs were laid only during one period since each observation revealed larvae of older instars. Collard had a relatively small number of larvae during the first two observations, after that the number started to increase, reaching its peak in the fourth week of the observations. After that the numbers of larvae decreased until by mid-August none remained. Obviously, eggs were laid also on that plant only at the beginning of our observations as later counts revealed no younger instars. It must be added that the number of CM was low in all variants over the entire experimental period.



\* statistical difference ( $P < 0.05$ ).

Fig. 2. Dynamics of larvae of *Mamestra brassicae* on different cultures

Thus, in this experiment, CM larvae fed only on crucifers. According to Rojas and Wyatt (1999<sup>d</sup>), CM may have evolved the ability to recognise characteristic chemicals of this family group. Cruciferas contain a group of sulfur containing secondary metabolites known as the glucosinolates. Glucosinolates are found in all parts of the plant, and concentrations differ according to tissue type, physiological age, plant health, nutrition, etc. It is known that younger plants and plant parts have a higher glucosinolate content than the older ones. CM females always lay their eggs on outer, older cabbage leaves and younger larvae prefer those leaves as well. In an experiment by Boer (1999), young CM larvae chose to feed also on older leaves of the crucifer ragwort (*Senecio jacobaea* L) by constantly moving, when reaching older instars, onto younger parts of the plant. Our observations showed that larvae stayed on older cabbage leaves during their three first instars. Larvae already in the fourth instar started to move onto younger leaves of the plant and, at the end of the fourth and at the beginning of the fifth instar they penetrated inside cabbage head. As collard and rutabaga form no heads, we found older instars between leaves of the core. One reason for such relocation is considered be the fact that the larvae switch from carbohydrate (in older leaves) to protein content (in younger leaves) in their diet when they reach the last instar (Reavey, 1993). The products of hydrolysis may have important roles in the plant defence system against polyphagous insects, however, the defensive secondary metabolites of plants can be utilised by insects adapted to them. It is probably also the case with CM larvae who, by eating older leaves, adapt themselves to the chemistry of the food plant and the lesser amounts of defensive substances there. This enables them later to eat also younger plant parts.

Over the entire experimental period, no larvae were discovered on *T. majus*, despite the glucosinolate content of the plant. However, this species of the family Tropaeolaceae produces only a single glucosinolate — glucotropaeolin. This glucosinolate has long been known for its antimicrobial activity, in addition to which it also contains, for example, chlorogenic acid and isoquercitrin, known to be antifeedant for certain insect species (Duke, 1992; Huang and Renwick, 1995).

Our experiments also revealed that CM larvae had feeding preferences within the same *Brassica* family. Plant species have numerous chemical and physical differences (colour, plant surface waxes, trichome density, secondary chemicals, etc) that may influence preferences. As the largest number of larvae was found on white cabbage, there is a reason to believe that these were the chemical composition and physical properties of white cabbage that suited CM best in the experiment. It must be noted that certain colours are more or less attractive to different insect species. Radcliff and Chapman (1966) detected that a colour-related factor appeared to be important in determining host preferences for *Pieris brassicae* and *P. rapae*, and red cabbage varieties were less susceptible to oviposition than green varieties. Red colour of the plants is mainly caused by anthocyanins. These are members of a class of nearly universal, water-soluble, terrestrial plant pigments that can be classified chemically as both flavonoid and phenolic. There are 15 different anthocyanins in red cabbage (Saupe, 2002). Anthocyanins may inhibit larval growth in insects but also act as insect repellents (Thain et al., 2002). In our experiment red cabbage were less infested (14%) with CM larvae than white cabbage (52%). According to Hommes (1983), red cabbage was less infested with larvae of *P. rapae* than white cabbage. Probably a determinative factor here is the choice by adults who, on some reasons, lay less eggs on red-coloured plants. Our earlier feeding experiments in laboratory have shown that both larvae of *P. rapae* and *P. brassicae* grew and developed equally both on white and red cabbage. Besides, larvae of *P. brassicae* developed on red collard even more successfully than on white head cabbage (Metspalu et al., 2003).

However, to the lesser preference of red cabbage by larvae there were obviously some other reasons than the colour as on red collard there were noticeably more (32%) larvae than on red cabbage (14%). As well known, plant

surface may play an important role in the selection of both oviposition sites of adults and food plants of larvae. The plant cuticle acts as a first chemical and mechanical barrier against herbivorous insects. Characteristic cuticular compounds might act as deterrents against generalistic herbivores, while specialised insects could use them as clues for host-plant recognition. The plants contain a coating of wax on the surface of the cuticle. The wax restricts water loss to the atmosphere but its physiological role is not less important. Obviously both the chemistry of such leaf waxes and their physical attributes act together with some plant characteristics. So far it is not exactly known whether the active factors are the wax coating itself or secondary compounds of the plant, associated with the waxes (Eigenbrode, 1996). It has been found that on leaves with a thicker wax coating larvae waste more time in search of suitable feeding sites than with a thinner wax coating, due to which their feeding time shortens and the amount of food acquired decreases. The consequence here is their decelerated development (Eigenbrode, 1996). In addition, leaf surface may mechanically influence movement of the insect. For example, microscopic structures on the plant surface can reduce the adhesion of insect feet, thereby creating slippery grounds for the animals. In our experiment the wax coating of red cabbage was very thick compared with the wax coating of white cabbage or collard. Wax coating makes it difficult for females of CM to obtain information on the chemical composition of leaves since it prevents the discharge of specific odours from a leaf. The wax coating on rutabaga was noticeably thinner than that of red and white cabbage. There were fewer larvae found on rutabaga (2%). One reason here may have been that rutabaga contains an exceptionally high amount of glucosinolates, even more than other cabbage varieties. Fifteen glucosinolates have been found, whereas gluconasturtin, together with gluconapin, glucobrassicinapin and progoitrin have been reported to be the main glucosinolates from this plant (Kjaer, 1976). It may be that such an amount and composition of glucosinolates and their breakdown products are repellent already to adults of CM, on which reason lesser eggs are laid to rutabaga. Another possibility is that rutabaga leaves probably contain feeding deterrents for the larvae, due to which there were especially few larvae of younger instars on rutabaga leaves. According to our unpublished data, observations carried out in a field of rutabaga in Hiiumaa showed that, when eggs were laid on rutabaga, larvae hatched from egg clutches died in their second and third instar and only a few larvae reached older instars. Hairs, trichomes and thorns on the leaf surface also influence both the choices of oviposition sites of adults and feeding of larvae. Distribution and density of leaf trichomes and chemicals contained in the trichomes may be among the factors influencing the host plant and food plant selection by CM in rutabaga. Usually the youngest leaves have the highest density of trichomes, which certainly was one of the reasons why larvae appeared mainly on older, less hairy leaves of rutabaga. During the year of the experiment, the number of CM was low, and there was almost no competition for adult oviposition site. There could be no competition among larvae for feeding sites as during each observation larvae counted were removed from plants.

It can be concluded that glucosinolates are not the determinative factors in the choice of oviposition and feeding plants by CM, but other secondary compounds, exist in plants, might be responsible for variation in the acceptability of different plant species to cabbage moth. The balance between stimulatory compounds and deterrent ones determined the reaction of CM larvae to different food plants.

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