Mass rearing mullein bug *Campylomma verbasci* (Hemiptera: Miridae)

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Abstract: The mullein bug *Campylomma verbasci* has recently been recognized as a potential pest of apple in the southern Netherlands. An easy method to rear this species on aphid infested potato plants with the addition of eggs of the Mediterranean flour moth (*Ephestia kuehniella*), mixed flower pollen and honey, is described. Females also lay summer eggs in French beans and apple seedlings.

Keywords: apple, orchard pest, diet, aphid predator, pollen, life table.

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Introduction

Until a few years ago, the mullein bug *Campylomma verbasci* (Meyer-Dür) (fig. 1) was thought to be a not too common species in The Netherlands (B. Aukema, personal communication). Moreover, the species was considered to be a beneficial species in European orchards as it feeds on spider mites and aphids (Collyer, 1953a, 1953b; Fauvel, 1974; Niemczyk, 1978). It is only since 1993 that the mullein bug is recognized as a pest of apple in The Netherlands and adjacent regions of Belgium (Blommers, 1994; Stigter, 1995). Like in Canada and the northern United States, where this species is a serious orchard pest since long (Smith, 1991; Reding & Beers, 1995; Thistlewood & Smith, in press), the hatchling's feeding on ovaries of apple flowers causes pit-like craters in the fruits, especially on the variety Golden Delicious (fig. 2).

The newness of this pest was one reason to try a mass rearing, but more important even was the fact that *C. verbasci* is the only mirid species of which the sex pheromone has been determined (Smith et al., 1991; McBrien et al., 1994). As one of us (LB) is involved in an attempt to identify the sex pheromone of the common green capsid *Lygocoris pabulinus* (Linnaeus) (Groot et al., 1996), the possibility to have *C. verbasci* as model for behavioural and physiological studies, was another incentive.

Material and methods

As we were already rearing *L. pabulinus* on potted potato plants, on which mullein bug is also found in nature (Southwood & Leston, 1959), the choice of this host plant was obvious.

Single large, or a few small, potato tubers with about 6, at the start finger-long shoots planted in 0.5 l plastic pots were used as host plants throughout this study. A wooden cage (25 x 25 x 40 cm^3) with 4-6 of these pots was the usual rearing unit. These units were kept in a cabinet at 20 ± 1 °C, 60% relative humidity and 18 h light a day.

General approach

As the general approach was one of trial and error, the initial experiences are described shortly.

A first attempt to rear mullein bug was started with some 100 large nymphs collected from apple cv Golden Delicious in a commer-

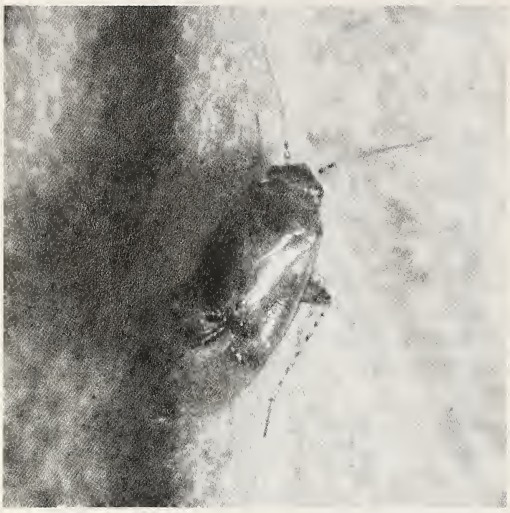

Figure 1. Adult *Campylomma verbasci* (photograph H. Stigter).

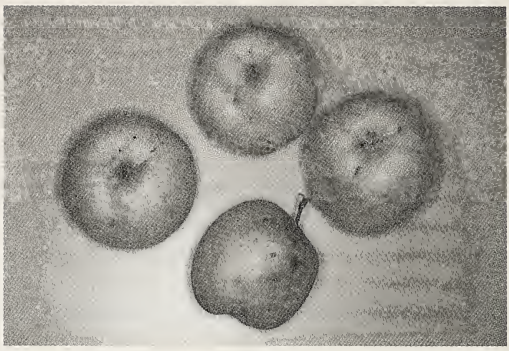

Figure 2. Fruit damage by *Campylomma verbasci* at harvest (cv Golden Delicious) (photograph M. Kers, DLV-fruitteelt).

cial orchard at Velden (province of Limburg) on 6 June 1994. These were offered potted potato plants (*Solanum tuberosum* L., mainly cvs Prelude or Surprise) with aphids *Macrosiphum euphorbiae* (Thomas). The first adults appeared after one day. Some of these adults, put for 24 or 48 h on fresh plants in early July, produced eggs which developed into adults in about 18 days.

Four groups of 5 ♀♀, plus 5 ♂♂, put onto new plants on 26 July and once again on 2 August produced respectively 63.8 ± 12.0 and 71.5 ± 37.8 young, mainly first instar, nymphs on average per week, or almost two per female per day. Whereas these numbers were sufficiently high to consider continuous rearing, survival of the nymphs in the rearing units appeared to be more problematic.

Most young nymphs disappeared when they were left on the plants where they had emerged. Survival could be improved, but only to about 50%, by transferring the first instar nymphs to fresh host plants. However, collecting these nymphs appeared cumbersome and time consuming. They are small and fragile, and not easily found and collected, as they often hide deeply among unfolding leaves or debris, like dead leaves. When detached by tapping from the plants onto a sheet of paper, the nymphs, unlike those of *L. pabulinus*, seldomly walk up into a glass tube put over them. When alarmed, the tiny animals defecate and so get often glued to the glass of a tube or exhauster. Though this rearing could be continued for some months, the net production of progeny remained low throughout.

A new attempt to rear mullein bug was started with nymphs collected from apple in Horst (province Limburg) on 24 May 1995. Alternate aphid species were tried as prey, but neither tinier *Myzus persicae* (Sulzer) nor *Aulacorthum solani* (Kaltenbach) brought appreciable improvement. While the various aphids were preyed upon, though some were seen to kick away a young mullein bug, they soon became so numerous as to debilitate the potato plants.

At last, it transpired that adding other food substances should be tried. This, indeed, brought the solution. Simultaneous addition of eggs of Mediterranean flour moth *Ephestia kuehniella* Zeller, a pollen mixture and honey to some rearing units produced a spectacular increase of production of older nymphs. Table 1, extracted from the mass rearing diary, shows this increase in numbers of older nymphs harvested, once the additional food substances had been given to their parents: groups of ♀♀, plus similar numbers of ♂♂, kept for successive periods of 3-4 days on plants with *M. persicae*.

To see whether the development of nymphs was also affected by the enrichment of diet, 20

Table 1. Average numbers of (mainly) 5th stage nymphs per ♀ per day, produced by groupes of ♀♀ *Campylomma verbasci* on potted potato plants with *Myzus persicae* before and after the addition of eggs of *Ephestia kuehniella*, mixed pollen and honey, at 20 °C. Numbers of females between brackets.

With aphids only		Plus eggs, pollen and honey	
Age ♀♀ (days)	Number of progeny	Age ♀♀ (days)	Number of progeny
6	0.05 (15)	4	0.73 (27)
6	0.08 (10)	10	1.46 (20)
10	0.74 (7)	13	3.15 (20)
13	0.10 (10)	13	4.43 (19)
16	1.20 (16)	17	5.20 (37)
16	0.21 (17)		

first and another 20 third instar nymphs were individually reared on various combinations of food substances (table 2). This was done in cotton stoppered glass tubes containing a potato leaf. The development of the animals was checked daily.

Though some nymphs were lost as they drowned in the condensation, the results indicate that young nymphs develop faster on flour moth eggs, with or without other food substances, than with aphids or pollen plus honey. For the older nymphs, no differences were found. The nymphs were also seen to feed on the various food substances.

Rearing procedure

With aphids plus the other three food substances, a flourishing rearing of mullein bugs could be established. The following basic procedure was developed and employed for several months:

Day 0 About 40 ♀♀, plus some ♂♂, are put into a cage to lay eggs on (4) potted young potato plants, freshly infested with a few aphids plus the other food substances.

Day 3-4 The adult bugs are removed. They may be transferred to a new cage.

Day 12 Some fresh food is added, for egg hatch starts on day 13-14. This may be repeated weekly.

Day 25-30 Fifth instar nymphs may be collected

Day 30 First adults appear and may be collected.

Day 35-40 The adults have mated and females start egg laying. These young mated females are preferably used the next round.

Depending on the age of the forty parent females, between 250 and 500 young adults are produced, females and males in approximately equal numbers.

Additional observations

The possibility to slow down production in periods of less demand was also considered: it appeared possible to permanently keep mullein bugs, of all stages and ages, on aphid-infested potato plants in a single larger cage for 5 months and longer. Only, some honey (water) is smeared on the gauze top of the cage twice a week, and dead and dying potato plants are replaced by fresh ones with flour moth eggs and pollen once every month.

Table 2. Average development time, ± standard deviation, and percentage survival till adulthood of 1st and 3rd instar nymphs *Campylomma verbasci* provided with different food substances on a detached potato leaf in a cotton stoppered glass tube, at 20 °C. (N = Initial numbers). Development times per series are normally distributed (Kolmogorov-Smirnov test: p = 0.35). Means followed by a different letter are significantly different from each other (ANOVA, p<0.01)

	N1 to adult			N3 to adult		
	duration (days)	(N)	survival (%)	duration (days)	(N)	survival (%)
aphids + eggs + pollen + honey	18.9±1.07 a	(13)	68	12.4±0.83 a	(9)	90
eggs	17.9±0.70 a	(10)	83			
pollen + honey	20.4±1.68 b	(12)	65	12.1±0.99 a	(8)	90
aphids alone	22.8±0.88 c	(7)	70	12.3±1.39 a	(8)	80

Eggs of the mullein bug are deeply inserted into plant tissue. Counting those laid in stems of apple or potato is impossible without peeling the epidermis. French beans were tried as possibly better egg laying substrate in that respect. Twenty single 6-day old mullein bug females, each with one male, were offered French beans *Phaseolus vulgaris* L., bought in a greengrocery. Each couple was kept in a small aerated plastic pot; 10 received honey and pollen as food, the other also *Ephestia*-eggs. One fresh bean was provided daily during 10 days. Afterwards, these were stored in a cotton stoppered glass tube, till the hatchling nymphs could be scored 14 + 3 days later. Six females in each group, several of which died before the experiment was over, produced less than 10 progeny. Only four produced more: 11 and 18 in the group without moth eggs, and 18 and 38 in the group with these eggs. Maximum daily productions in the groups amounted to 5 and 4, and 9 and 7 eggs, respectively. In all, it is clear that French beans are accepted as egg laying substrate, but manipulation of them should be improved so as to prevent them from tumbling onto the adult bugs and hatchlings. Unfortunately, most eggs were also invisible in this substrate.

Finally, it was tried how mullein bugs could be maintained on small apple trees. For this we used about 25 cm high potted apple rootstocks cv Malling M9 that had stayed outdoors since previous summer (1995). When these apple plants were placed aside of the potato plants in the standard rearing units, oviposition occurred on them, too. The eggs hatched within two weeks like those on potato, indicating that summer eggs are also laid on apple.

In another trial, 30 hatchling nymphs were put onto two apple plants in a cage with naturally attracted, incipient colonies of rosy apple aphid *Dysaphis plantaginea* (Passerini), plus some extra pollen. Twenty seven of these could be recollected as adult.

Discussion

Niemczyk (1978) reports an average total of 10 eggs laid by female mullein bugs kept on apple twigs with eggs of grain moth *Sitotroga cerealella* (Oliver) as prey. Smith & Borden (1991) succeeded in rearing the species on twospotted spider mite *Tetranychus urticae* Koch on potted eggplant *Solanum melongena* L., but new mite-infested seedlings had to be added almost weekly to prevent starvation of neonates. Initially, we encountered similar problems. With aphids on potted potato plants, females produce many eggs, but the young nymphs clearly have great difficulty to survive. At least, very few stay on the plants and often quite a number was found elsewhere in the cage, even beneath the flower pots (J. Prinsen, personal observation). This contrasts with the sometimes hugh numbers of nymphs crowding on host plants in nature (Smith, 1991; L. Blommers, personal observation).

Adding honey, pollen and *Ephestia*-eggs to the aphid infested plants solved the problem of loosing nymphs. The nymphs remain on the plants, many of them sharing one shoot. With so many bugs around, the aphids in these cages remain low in number and therefore have less effect on food plant quality. As the bugs themselves cause no visible damage to the plants, 100 and more can stay on a single plant for one life cycle. Only reproducing adults have to be transferred. Under these conditions, juvenile development takes about 18 days at 20 °C. A similar figure is reported by Smith & Borden (1991) for mullein bugs on eggplant with twospotted spider mite.

Juvenile development is slower when the flour moth eggs are withheld from the diet of the youngest nymphs. Apparently, the moth eggs can fully replace prey like spider mites, psyllids and aphids employed by mullein bug in nature. For the youngest instars, these eggs evidently are much easier to handle. On the other hand, previous suggestions that the first and second instar nymphs can not develop without animal food (Smith, 1991; Niemczyk, 1978; McMullen & Jong,1970) are incorrect. Juvenile development is possible with only pollen, honey and plant juice available. This suggests that the coincidence between egg hatch and apple flowering is functional to the

species because it provides essential food substances.

Potting eight larger potatoes, transfer of 40 egg laying females twice weekly, and the provision of some flour moth eggs, pollen and honey to their juvenile progeny is almost all that is to be done for a steady weekly production of 500-1000 adult mullein bugs. This production compares well with the 6.7 ± 0.6 nymphs/female produced during 48 h at 25 °C reported by Smith & Borden (1991).

Additional observations showed that female mullein bugs are not very choosy about egg laying substrate. French beans and tiny apple trees are also accepted, the latter also in the presence of potato plants.

In all, these observations support the notion that the whereabouts of the mullein bugs are not very fixed. Egg hatch coincides with blossom time in orchards; pollen and honey will be available to the nymphs, often also aphids and honeydew. The species may become even more abundant there later in summer when spider mites or pear suckers (*Psylla* spp.) are around (Collyer, 1953b). Other populations apparently move to herbs, as it seems mainly to species that flower in summer; mullein, *Solanum*, *Stachys*, and *Nepeta* spp. (Thistlewood & Smith, in press). On some of these, like mullein or potato, there may also be quite some prey present.

Samenvatting

De toortswants *Campylomma verbasci* werd tot voor kort weinig in Nederlandse boomgaarden gezien. Zuidelijker in Europa zou de soort vooral nuttig zijn, omdat hij leeft van spintmijten en bladluizen. Sinds enkele jaren echter is de toortswants, vooral in Limburg en Oost-Brabant, plaatselijk soms zo talrijk dat hij schade veroorzaakt aan appels. Dit is nieuw voor Nederland, maar al jaren een groot probleem in delen van Canada en de Verenigde Staten, waar de soort lang geleden per ongeluk binnengebracht is. Om die reden is daarginds veel onderzoek aan deze soort gedaan, maar een vlotte manier om grote aantallen te kweken was nog niet gevonden. Deze wordt hier beschreven.

Volwassen ♀♀, plus een aantal ♂♂, worden op aardappelplanten in een kooi gezet waar ze voor 3-4 dagen eieren kunnen leggen. Behalve bladluizen, bijvoorbeeld *Myzus persicae*, worden als voedsel ook meelmoteieren, gemengd stuifmeel en honing aangeboden. Een en ander gebeurde bij 20 °C en 18 uur licht per etmaal. De eieren komen dan na ongeveer 14 dagen uit. Wanneer alleen bladluizen als voer aangeboden werden, bleken veel jonge nimfen te verdwijnen. Vooral met meelmoteieren, maar ook met het andere extra voedsel, groeien die wel voorspoedig op. De ontwikkeling van de vijf nimfestadia neemt circa 18 dagen. Veertig dagen na het inzetten van de oudergeneratie, kunnen weer jonge eileggende ♀♀ op nieuwe planten gezet worden.

Vier à vijf nakomelingen per vrouwtje per dag kunnen verwacht worden; vrouwtjes en mannetjes in gelijke aantallen. Voor een wekelijkse productie van 500-1000 wantsen is het voldoende 40 ♀♀ halfwekelijks op een viertal aardappelplanten over te zetten. Tussentijds behoeven de planten niet vervangen te worden, want de toortswants doet geen schade en voorkomt ook, wanneer voldoende talrijk, dat bladluizen de planten afbreken.

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