FINAL REPORT

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To examine the potential of *Orius majusculus* to control *Macrolophus caliginosus* in a tomato crop

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Commercial – In Confidence

Project Title:	To examine the potential of *Orius majusculus* to control *Macrolophus caliginosus* in a tomato crop strategies
Project number:	PC 223
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The results and conclusions in this report are based on a series of carefully monitored applied studies in experimental facilities and large-scale commercial glasshouses. The conditions under which the studies were carried out and the results have been reported with detail and accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with the interpretation of the results especially if they are used as the basis for commercial product recommendations.

Authentication

I declare that this work was done under my supervision according to the procedures described herein and that this report represents a true and accurate record of the results obtained.

Signature………………………………………………Date………………………….

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Headlines

- The potential of the predatory bug *Orius majusculus* (Orius) to control *Macrolophus caliginosus* (Macrolophus) in organic tomatoes was assessed.

- In small scale trials, adult Orius were found to reduce the numbers of adult Macrolophus by 47% over a seven day period in the absence of another food source.

- The ability of Orius to remain within a tomato crop was examined. Large numbers (1500) of adult Orius were released into a 110m^2 glasshouse, but only very small numbers were detected (23) on sticky traps throughout a two month period. Adults or nymphs were not located on tomato plants, despite abundant prey (whitefly scales). Orius also failed to be located in flowering pepper plants (known to be attractive to the predator) positioned within the tomato crop. The difficulty in locating this predator can partly be explained by its ability to successfully hide. However the very low numbers that were recorded suggest that the tomato crop is not a preferred habitat for Orius.

- Orius is known to lay its eggs in plant tissue; this experiment demonstrated that Orius caused damage to the tomato fruit by laying its eggs in to the soft tissue of the fruit.

- Overall the results suggest that Orius could reduce numbers of Macrolophus, but it is unlikely to remain within the crop. Additionally the large numbers of Orius that would be required to control Macrolophus may result in damage to the tomato fruit not too dissimilar to that caused by Macrolophus itself.

Background and expected deliverables

Macrolophus was initially introduced for the control of whiteflies (*Trialeurodes vaporiarium*), but was subsequently found to attack a wide range of pest species. It has been released in UK tomato crops under Department of Environment license since 1995. In 1996, however, some tomato growers were concerned that the predator was causing direct damage to their plants resulting in a significant loss of yield. Important damage symptoms included premature flower and fruit drop that could significantly reduce yield particularly in cherry tomatoes, and the loss of whole trusses in vine ripened fruit (Sampson & Jacobson, 1998)

The Tomato Growers' Association list the production of pesticide free tomatoes as one of their main objectives. In order to achieve this, the Tomato Growers' Association list Macrolophus as a one of the main pests to compromise their pesticide usage objective.

Previous research undertaken by staff at Stockbridge Research Foundation (Jacobson, 2001) investigated potential IPM compatible control strategies for Macrolophus in commercial tomato crops. The entomopathogens *Verticillium lecanii* and *Beauveria bassiana* were applied to Macrolophus, but proved unsuccessful. A current control strategy for Macrolophus does not therefore exist for either conventional growers to achieve the objective of pesticide free crops, or for organic tomato growers (8% of the current market).

Research in Denmark (Jakobsen *et al*., 2004) has shown that the predator *Orius majusculus* (Orius) would prey upon Macrolophus, and not the other way round. The aim of this project was therefore to examine the potential of Orius to control Macrolophus when in the absence of prey the latter becomes a pest.

However in the UK, Orius is not applied to tomatoes, as its main application is against thrips, not a pest on tomatoes in this country. To many species of insect the tomato plant presents a hostile environment. The glandular and non-glandular hairs (trichomes) on the surface of leaves and stems give chemical and physical defences to the plant. These defences however not only reduce the numbers of pests but also potentially beneficial insects. The ability of Orius to remain within a tomato crop was not known.

The following project was therefore designed to measure the potential of Orius to control Macrolophus and to establish whether the predator would accept the environment of tomato plants and remain within the crop.

Summary of work to date

Objective 1

The first objective looked at whether Orius would feed on Macrolophus on tomato plants. Orius was found to significantly reduce the numbers of surviving Macrolophus on small tomato plants, in the absence of another food source. Over the seven day period Macrolophus numbers were reduced by 47%.

However the experiment was done in perspex cages to ensure that numbers of Macrolophus could be monitored. This design however was such that natural dispersion of the two predators could not occur. As the defensive trichome structures on tomato plants can be a deterrent to many insects and possibly Orius, it was therefore important to observe Orius within a tomato crop.

Objective 2

Following on from the first objective, the second objective looked at the ability of Orius to remain within a tomato crop.

Early studies had showed that Orius is an extremely difficult species to locate within a crop therefore various methods were used to try and overcome this problem. Preliminary experiments using small numbers of tomato plants within a glasshouse showed that Orius could be located by using flowering pepper plants as bait or trap plants. Therefore in the glasshouse trial flowering pepper plants were incorporated into the tomato crop to act as trap plants to monitor the presence or absence of the predator. Whitefly (*T. vaporiarium*) were also introduced into the tomato crop to provide food for Orius In addition large numbers of Orius were released into the glasshouse section ($110m^2$).

Despite large numbers of whitefly scales throughout the tomato crop and large numbers of released Orius, adults or nymphs of the predator could not be located near or in any of the whitefly colonies during the trial.

Orius failed to be detected in the flowers of the trap pepper plants during the 60 days of observations.

Numbers of Orius could only be monitored through using large numbers of sticky traps hung above the crop canopy to catch incidental movement of the predator (Figure 1). The results show that only during the two week period following their release could adult Orius movement be detected within the crop. However the total numbers detected were low (23) in comparison to the actual numbers of predator released (1500).

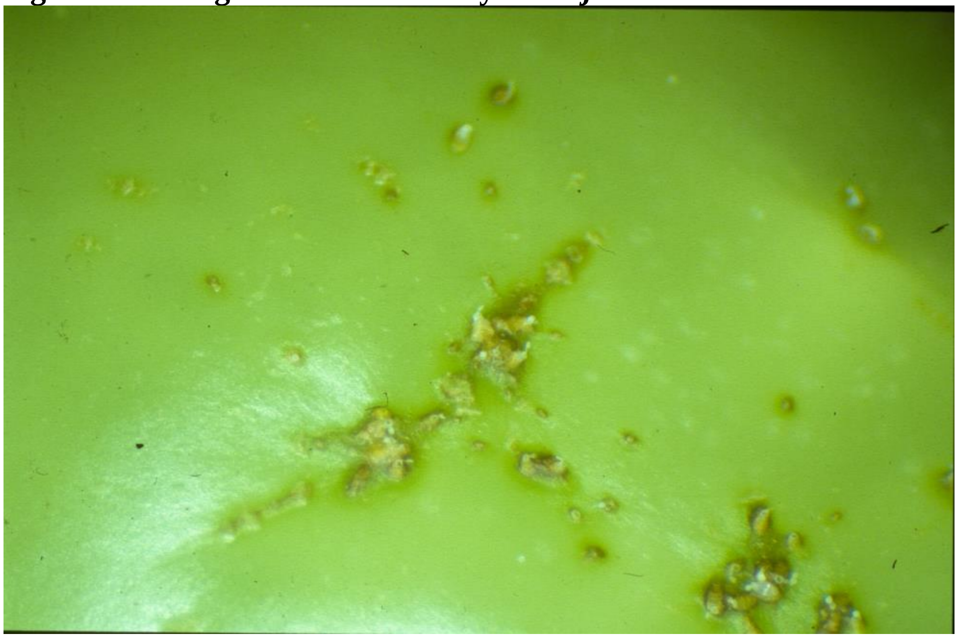
Figure 1. Yellow sticky traps in tomato crop to locate *O. majusculus*

The results suggest that Orius will not remain within a tomato crop. It is difficult to detect the predator and this will partly account for the low observations. However it would be expected that with the combination of the trap plants, the large numbers of predators released and the constant food supply the detection of the predators would have been more successful if the predators had remained within the crop.

Objective 3

The results showed that the fruit from the small enclosures containing Orius suffered some damage; on average one fruit per truss was damaged. Initial examination of the damage to the fruit found it to be similar to that caused by Macrolophus, but closer examination showed that the predator was laying eggs in to the soft tissue of the fruit (Figure 2).

Figure 2. Damage to tomato fruit by *O. majusculus*



The actual fruit that was damaged in all the trusses was the oldest fruit on the truss, and probably at the time of exposure to the predator was the only fruit suitable for egg laying.

Orius did not affect the number of fruit set per truss.

Financial benefits to growers

In the document, Research and Development Priorities for British Tomato Growers, the Tomato Growers' Association (TGA Technical Committee, 2003) lists one of their main objectives as the production of pesticide free tomatoes. The Tomato Growers' Association list Macrolophus as a one of their main pests that compromise their objective of pesticide usage.

Growers have lost as much as £3000/1000m^2 as a direct result of Macrolophus feeding. However the predator is an effective control agent of whitefly and leaf miners on tomato crops. Through managing Macrolophus effectively growers will benefit from the pest reduction that this predator can provide and at the same time prevent the damage that this predator inflicts at certain times during the crop.

Although the project has shown that in small scale trials, Orius can reduce the number of Macrolophus, the results also suggest that Orius is not likely to be effective within a tomato crop and could cause additional damage to the tomato fruit themselves.

SCIENCE SECTION

GENERAL INTRODUCTION

Orius majusculus (Heteroptera: Anthocoridae) and *Macrolophus caliginosus* (Hetereoptera:Miridae) are polyphagous predators that are used against a range of pest species. *M. caliginosus* was first introduced in UK tomato crops in 1995. However in 1996, some tomato growers were concerned that the predator was causing direct damage to their plants. Important damage symptoms included premature flower and fruit drop that could significantly reduce yield particularly in cherry tomatoes, and the loss of whole trusses in vine ripened fruit (Sampson & Jacobson, 1998).

Jakobsen *et al*. (2004) looked at the interaction of the two predators *O. majusculus* and *M. caliginosus* with and without the presence of Western Flower Thrips (*Frankliniella occidentalis*), WFT, as prey, on parts of chrysanthemums (*Dendranthema grandiflorum*). They were able to show that the interaction between the two predators was predominantly unidirectional in that *O. majusculus* adults would feed on *M. caliginosus* nymphs or adults in the absence of the WFT prey. Their work was designed to examine the compatibility of the two predatory species as part of a biological control programme for WFT.

The following project was designed to apply this information and examine the possibility of *O. majusculus* to actually reduce the numbers of *M. caliginosus* within tomato crops. The project looked at three key indicators of this potential.

Objective 1
The first objective looked at the ability of *O. majusculus* to feed on *M. caliginosus* on small tomato plants. This would simply apply a part of the research by Jakobsen *et al*. (2004) but on a different plant species, using tomato instead of chrysanthemums.

Objective 2
The second objective looked at the potential of *O. majusculus* to remain in a tomato crop. The glandular and non-glandular trichomes on the surface of leaves and stems of tomato plants give chemical and physical defences to the plant (Luckwill, 1943) against herbivorous species, but however these defences can also act as a deterrent to potentially beneficial insects.

Objective 3
This final objective was designed to observe any damage symptoms occurring within the crop as a result of oviposition by *O. majusculus* and therefore potentially adding to the damage symptoms resulting from *M. caliginosus*.

Objective 1: *Orius majusculus* predation on *Macrolophus caliginosus*

Introduction

Jakobsen *et al*. (2004) showed that *O. majusculus* adults would feed on *M. caliginosus* nymphs or adults predominantly in the absence of their *Frankliniella. occidentalis* prey. Their work was designed to examine the compatibility of the two predatory species as part of a biological control programme for *F. occidentalis* and was done on parts of chrysanthemum plants. The following experiment looked at the interaction of these two predators on tomato plants.

Monitoring numbers of very mobile insect species such *M. caliginosus* within a glasshouse crop is difficult due to the various environmental factors influencing behaviours such as dispersion. Therefore to establish predation of *M. caliginosus* by *O. majusculus* the first experiment looked at the interaction of these two predators on small whole plants within perspex cages.

Materials and method

Ten adult *O. majusculus* and 20 *M. caliginosus* were placed inside a perspex cage containing a tomato plant (cv'Claree'), in a second cage (the control) 20 adult *M. caliginosus* were released on to the plant with no *O. majusculus*. The cages were then placed in a constant environment room at 22±2^{0}C and 16L:8D. After seven days the numbers of surviving *M. caliginosus* were recorded in all cages. The experiment was also repeated over time (10 replicates).

Results and Discussion

The results in Table 1 verify the findings of Jakobsen *et al*. (2004). *O. majusculus* was found to reduce significantly (p<0.05) the numbers of surviving *M. caliginosus* on small tomato plants in comparison to the control (Table 1). Over a seven day period *M. caliginosus* numbers were reduced by 47%.

Table 1. The mean number (10 replicates) of surviving M. caliginosus

	M. caliginosus	*M. caliginosus* & *O. majusculus*
Mean	11.8	6.3
LSD (18 df)	1.166	

However the experimental design was such that natural dispersion of the two predators could not occur. The defensive trichome structures on tomato plants can be a deterrent to many insects and therefore also possibly to *O. majusculus*. As *O. majusculus* is not released on to tomato crops within this country its behaviour within this crop had still to be determined.

Objective 2: Persistence of *Orius majusculus* in a tomato crop

Introduction

Tomato plants have evolved various lines of chemical and physical defences against invertebrate herbivores. However this defence does not only deter some pests but also potentially beneficial insects. Previous work showed that the predatory mite *Phytoseiulus persimilis* benefited from conditioning to the tomato plant (Croft *et. al*. 2000).

If *O. majusculus* could control *M. caliginosus* then it is important to establish that the predator would remain within a tomato crop. Preliminary studies showed that *O. majusculus* was extremely difficult to locate within a tomato crop and therefore various methods were employed to help locate the predator within crops

Materials and method

Tomatoes (cv'Claree') were grown in glasshouse (110m^2) and at approximately one metre high they were infested with whitefly (*Trialeurodes vaporiarium*) and *M. caliginosus*. When whitefly became established on the crop, large numbers of *O. majusculus* (1500) were released.

Yellow sticky traps (120) where tied at the height of crop canopy to trap any incidental movement by *O. majusculus*, rather than acting as an attractant (Figure 3). Numbers of *O. majusculus* were monitored weekly on the yellow sticky traps.

In addition flowering pepper plants were placed among the crop as trap plants. *O. majusculus* is known to be attracted to the pollen within pepper flowers and therefore by periodically placing the plants within the crop the presence or absence of the predator could be detected.

Results and discussion

Preliminary experiments on small numbers of small whole tomato plants within a glasshouse showed that *O. majusculus* could be located by using flowering pepper plants as traps. However when the experiment moved on to a larger crop scale, *O. majusculus* failed to be detected in the flowers of the trap plants during the 60 days of observations.

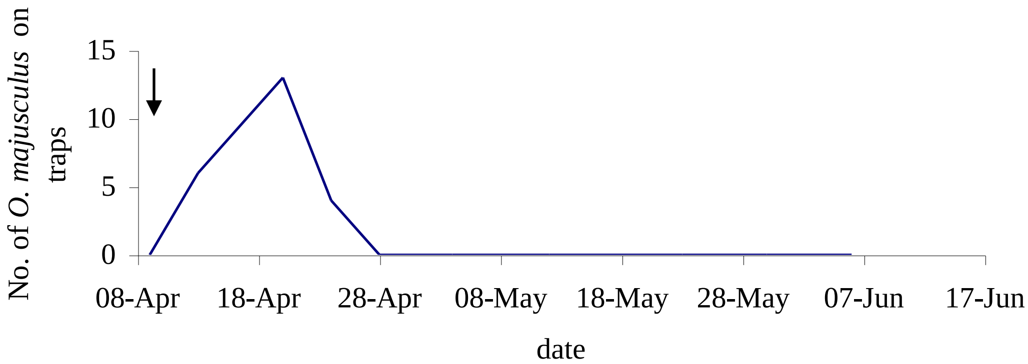
Despite large numbers of whitefly scales throughout the tomato crop and large numbers of released *O. majusculus*, adults or nymphs of the predator could not be located near or in any of the whitefly colonies during the trial.

The actual presence of *O. majusculus* was only monitored on the sticky traps. The results in figure 4 show that only during the two week period following their release adult *O. majusculus* movement could be detected within the crop. However the total numbers detected were low (23) in comparison to the actual numbers released (1500).

The results suggest that *O. majusculus* is not easily maintained within a tomato crop, although detecting the predator is extremely difficult. It would however, be expected that with the combination of the trap plants, the large numbers of predators released and the constant food supply that detection of the predators would have been more successful if the predators had remained in any significant numbers. However it is possible that the large number of released *O. majusculus* created a territorial problem for the adults increasing the dispersal from the plants.

Figure 3. Yellow sticky traps in tomato crop to locate *O. majusculus*

Figure 4. The total number of *O. majusculus* recorded on yellow sticky traps above tomato crop canopy



↓ = *O. majusculus* release

Objective 3. Damage to crop by *O. majusculus*

Introduction

Following its introduction into the UK as a biological control agent in tomato crops, *M. caliginosus* is now also associated with important damage symptoms including premature flower and fruit drop that can significantly reduce yield particularly in cherry tomatoes, and the loss of whole trusses in vine ripened fruit (Sampson & Jacobson, 1998). As *O. majusculus* is known to oviposit into plant tissue it was important to ascertain if this predator could also present a problem in tomato crops. Preliminary work had shown that *O. majusculus* would lay its eggs within tomato stems (see Figure 5). This third objective therefore looked at the potential of *O. majusculus* to cause damage to the tomato fruit.

Figure 5. *O. majusculus* eggs in tomato stems

Materials and method

Five female adult *O. majusculus* were released into a large ventilated plastic bag with a food source (pollen). The bag was then attached to a tomato containing a truss (at the flowering stage) and tomato stem. When the fruit on the truss were fully formed the bag was removed and the fruit examined. Twenty bags were set up, 10 containing *O. majusculus* and 10 bags without *O. majusculus* (control).

Results and Discussion

The results in Figures 6 and 7 show that the fruit from the bags containing *O. majusculus* suffered some damage, on average one fruit per truss was damaged (Table 2). Initially the damage to the fruit is similar to that of *M. caliginosus* (Figure 6). But on closer examination the damage was caused by *O. majusculus* ovipositing into the fruit (Figure 7).

Table 2. The mean number of damaged fruit per truss (n=10)

	Control	*O. majusculus*
Mean	0.00	1.00
Sd	0.00	0.47

The fruit that was damaged in all of the trusses exposed to *O. majusculus* was the most mature fruit. The predators survived only a relatively short period within the bags (approximately four days) and probably at the time of exposure to the predator it was the only fruit that had started developing and was suitable for oviposition.

There was no difference between the control and *O. majusculus* treatments in the number of fruit set per truss.

Figure 6. Damage to tomato fruit by *O. majusculus*

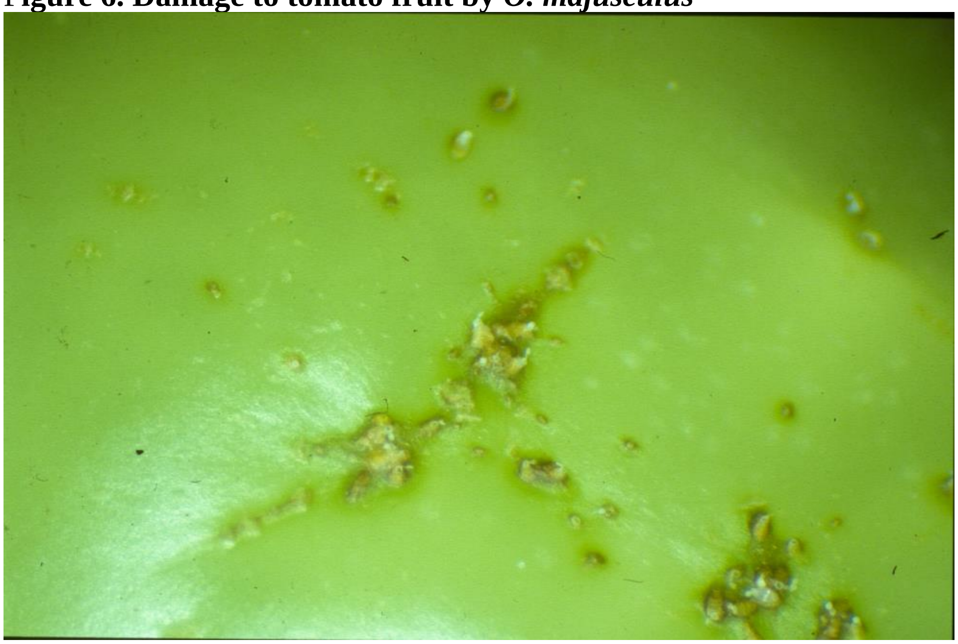
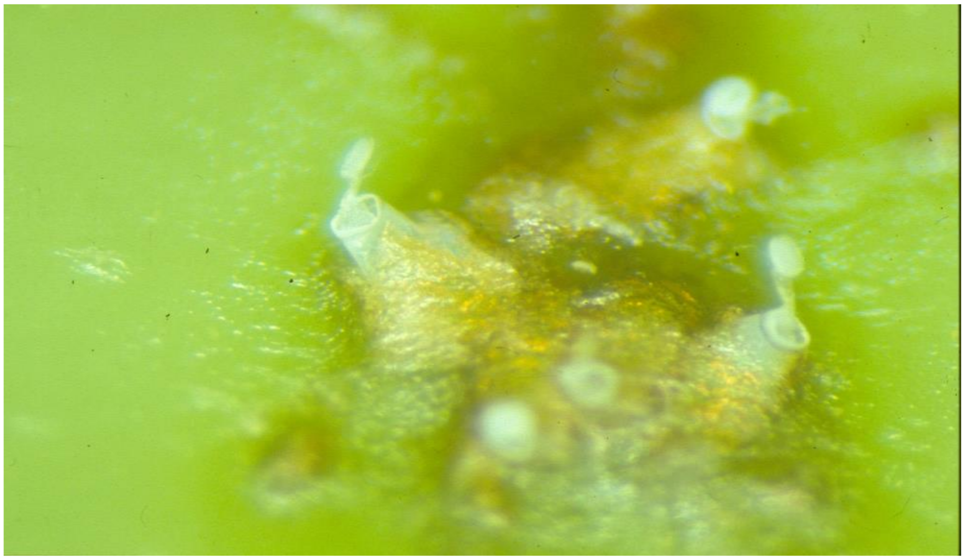
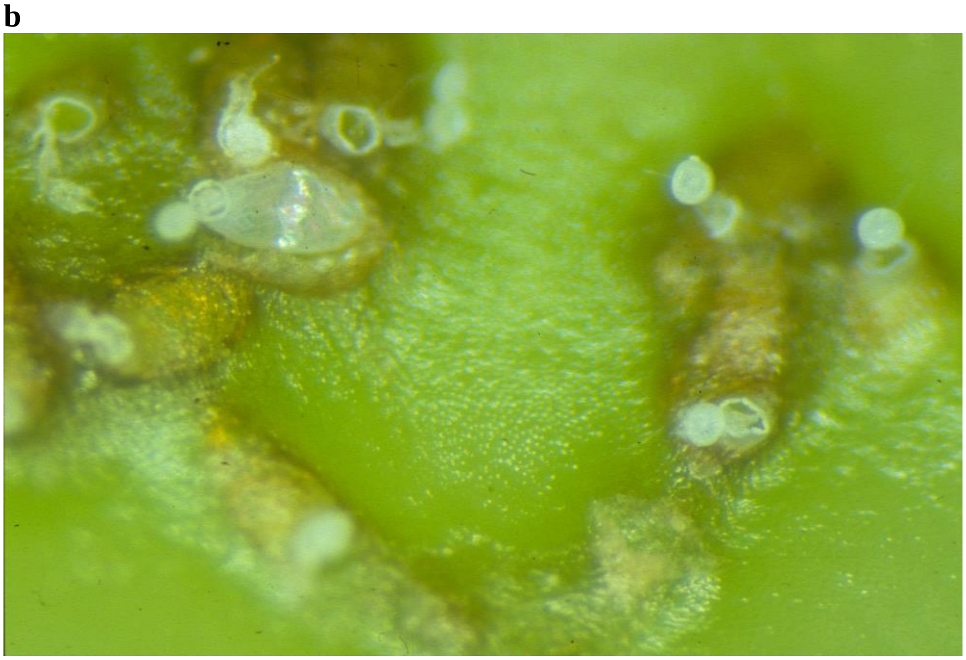


Figure 7a,b. Egg laying in tomato fruit by *O. majusculus*

a



b



Conclusions

- *Objective 1*. In small cages adult *O. majusculus* were found to reduce the numbers of adult *M. caliginosus* by 47% over a seven day period.

- *Objective 2.* Large numbers of adult *O. majusculus* were released but only very small numbers were detected over a two week period on yellow sticky traps. Adult or nymphs were not located on plants near colonies of prey or in flowering pepper plants. Although the difficulty in detecting this predator can be partly due to its ability to successfully hide, the relatively low numbers of adults detected in comparison to the numbers released suggest that the tomato plant is not a preferred habitat.

- *Objective 3. O. majusculus* was observed to oviposit into tomato fruit causing marked damage symptoms.

- Overall the results suggest that *O. majusculus* could reduce numbers of *M. caliginosus*. However the tomato plant itself could be a deterrent to *O. majusculus* remaining within the crop. Additionally the large numbers of *O. majusculus* that would be required to control *M. caliginosus*, may result in damage to the fruit not too dissimilar to that caused by *M. caliginosus* itself.

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