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Field study of parasitism caused by endemic parasitoids and by the exotic parasitoid *Copidosoma koehleri* on *Phthorimaea operculella* in Central Italy

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Abstract

The Authors refer to experiments and research done in Central Italy on the efficacy and effects of mass releases of the larval parasitoid, *Copidosoma koehleri* Blanchard, on potato tuber moth larvae [*Phthorimaea operculella* (Zeller)]. Furthermore, data were also collected on naturally occurring parasitoids. Data were collected between June and September 1999 with release plots in an open field and one release in a storage facility.

The results showed a modest percentage of parasitized larvae by *C. koehleri* (max. 3%) in the open field plots, whereas, in the storage building this was even less, reaching just 1% parasitism.

Indigenous parasitoids found in the study area were the following: *Diadegma pulchripes* Kokujev (Ichneumonidae), *Pnigalio pectinicornis* L. and *Sympiesis viridula* Thomson (Eulophidae). It is to be noted that *D. pulchripes* were at a higher density when compared to the other two parasitoid species. The latter ones, known as parasitoids of other lepidopteran larvae [e.g. *Phyllonorycter cerasicolella* (Herrich-Schäffer) and *Ostrinia nubilalis* (Hübner)], were new findings for *Ph. operculella*. However, keeping in mind their low incidence, they must be considered as only occasional parasitoids of potato tuber moth. Altogether, indigenous parasitoids reached a maximum of 23% parasitism in the first week of June.

Key words: *Copidosoma koehleri, Phthorimaea operculella, Diadegma pulchripes, Pnigalio pectinicornis, Sympiesis viridula,* biological control.

Introduction

Potato production in Italy covers an area of about 150,000 ha with an average yield of 20 tonnes per hectare.

Italian regions most interested to production of late season potatoes are Veneto, Piemonte and Emilia Romagna in northern Italy, Lazio, Toscana, Abruzzo in central Italy, Campania and Calabria in the South. The early season potato is fairly remarkable just in Campania, Sicilia and Puglia. In Lazio (Central Italy) potato crops occupy about 10,000 ha (late season cultivars) and almost a third of the potato production occurs in the hilly districts around Bolsena Lake in Viterbo province, where yields attain 20-25 tonnes per hectare (Bonari, 1988). For this reason, potato growing is considered to be a good alternative to cereal production (such as barley and wheat).

As far as plant protection is concerned it has to be noted that, in northern Lazio, pesticides are widely used for pest control.

Problems in connection with pests and diseases management are heightened, especially in the places where monocultures of potatoes create a heavy dependence on pesticides which causes serious ecological, toxicological and economic concerns.

With the aim of setting up more rational strategies to control pests, basic research is needed on the key factors regulating population dynamics of major noxious insect pests; numbers of phytophagous are known feeding on potato crop, but in northern Lazio only two pests merit close attention, these are the Colorado potato beetle, *Leptinotarsa decemlineata* (Say) and the Potato tuber moth, *Phthorimaea operculella* (Zeller). The damage caused by Colorado potato beetle is very severe as this pest can completely defoliate the crop.

Recent studies, conducted by the Department of Plant Protection at the University of Tuscia, showed however that the Colorado potato beetle to be easily controlled with 1 or 2 applications with *Bacillus thuringiensis* var. *tenebrionis* (™Novodor), the first spray should be applied when the threshold of 0.5 egg masses per plant is reached (Pucci *et al*., 1991; Pucci, 1992), the next spray should follow one week later.

The worst problem for potato growing in northern districts of Lazio is caused, no doubt, by potato tuber moth infestations. By 1985 the density of moth population has progressively increased with heavy losses in crop production.

This situation has led to an over use of insecticides, more toxic molecules are spread, resulting in less respect for environment and biodiversity.

Crop protection as well has often failed due to wrong time of treatments performed by farmers. By this scenario, planning a biological control based on the use of natural enemies, such as parasitoids, is of primary importance.

This paper documents the mass release of the larval polyembryonic parasitoid *C. koehleri* and its effect on the population dynamics of the potato tuber moth larvae, as well as data on naturally occurring parasitoids. Furthermore, population dynamics of adult male of the tuber moths were estimated by using pheromone traps and larval samples.

C. koehleri is a native parasitoid of South America and is now used in mass releases throughout the world.

Table 1. Releases of *C. koehleri*.

Site	Date	Number of released individuals	Sex ratio females/males
Open field	June 3, 1999	30,000	2:1
Open field	July 5, 1999	30,000	2:1
Open field	August 2, 1999	20,000	2:1
Storage building	September 8, 1999	20,000	2:1

In South Africa, this parasitoid has been shown to be highly susceptible to low relative humidity (Kfir, 1981), tough resulting in low levels of parasitism (20-60%) (Watmough *et al*., 1973).

In Zimbabwe this beneficial insect was so successful in controlling the potato tuber moth that no synthetic insecticides were needed (Mitchell, 1978).

Moderate results were also obtained in different areas of Australia (Callan, 1974).

In Italy, the first use of *C. koehleri* in the biological control of *Ph. operculella* took place in 1940 in Battipaglia, unfortunately with disappointing results, as reported by Silvestri (Entomology and Agricultural Zoology Department of the University of Naples).

Recent studies have recently been undertaken by Guerrieri and Viggiani, 1994, when they received specimens of *C. koehleri* from Prof. Kfir of the Plant Protection Research Institute of Pretoria – South Africa. Then, the specimens were reared until obtaining enough individuals to perform inundative releases in different districts of southern Italy. However, results were very modest.

Materials and Methods

The trials were performed in an area of 4000 m^2 situated in Castelgiorgio – Umbria – Central Italy.

The experimental potato field was surrounded by other crops such as corn, sunflowers and wheat, as well as a cedar forest and a permanent grassland were present. The cultivar "Monalisa" was planted at 70 cm between rows and 30 cm between plants in the same row. During the growing season plants were watered, at the beginning of June and again 10 days later; recording climatic data has concerned temperature, humidity and rainfall.

Potato tuber moth adult males were monitored using pheromone traps, while larvae on potato stems and leaves were observed.

Three inundative releases of *C. koehleri* adults were made in the open field, while only one was performed in the potato storage building.

The releases were carried out from June until September 1999, releasing 30,000 individuals each month, with a sex-ratio of M/F ranging from 2:1 to 3:1 (table1).

Were placed in the field three pheromone traps (™Agrisense Delta Trap) containing 1 mg of the following mixture (in a ratio of 1:1), trans-4,cis-7-tridecadien-1-olacetate and trans-4, cis-10-tridecadien-1-olacetate (Raman, 1982).

Male moths in traps were counted weekly, whereas the pheromone dispensers in the field were replaced monthly. The assessment of infestation levels were made by checking the presence of live, dead and parasitized larvae for 200 potato plants randomly chosen each week. So as to have about the incidence of parasitism, 200 infested leaves were chosen weekly and placed into a lab with a controlled environment. Then number and kind of parasitoids that emerged were recorded.

Results

Climatic trend

From figure 1 can be noted that the season was characterized by a modest rainfall in June, July and August (only 37.2 mm) and that was the reason of watering supplies. Temperature ranged from a minimum of 10°C and a maximum of 30°C (35°C in August). Humidity levels were also very modest and often less than 20%.

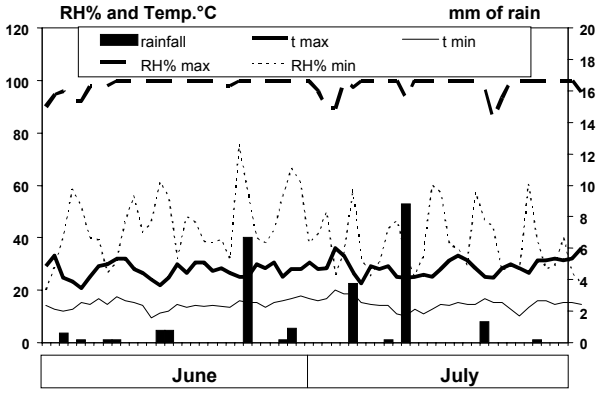

Figure 1. Trend of some climatic parameters in the observation period.

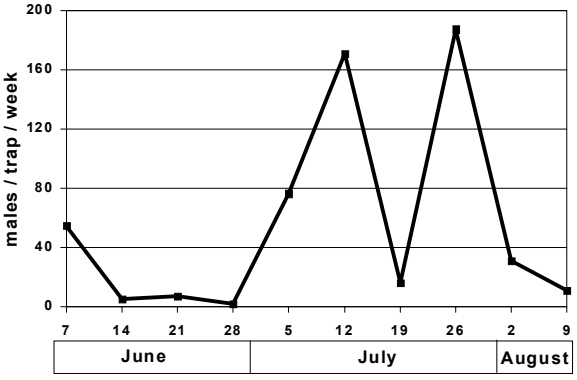

Figure 2. Dynamics of potato tuber moth adult males captured in sex-pheromone traps.

Adult monitoring

The number of males captured in pheromone traps is presented in figure 2. A flights peak took place before beginning of June; followed two flights peaks on July 12 and July 26. After this period of male activity there was a decrease which reached its minimum in August.

Dynamics of epigeous infestation

This Gelechiidae moth thrives at the expense of both spontaneous and cultivated Solanaceae. To the first group belong *Datura stramonium* L. and *Solanum dulcamara*, L. whereas among crops infested by *Ph. operculella* we found potato, tobacco, peppers and eggplants.

Single eggs are laid in the proximity of buds or in crevices of the ground and each female lays about 100 eggs or more, which hatch 3 to 4 days later, if ambient temperature is at 25°C or higher, they will stop ovipositing and their development stops if temperatures drop below 10°C.

In the observation year larval infestation increased progressively through the first 10 days of June, peaking on the third decade of the same month, followed by a second peak one month later with 1.4 larvae per plant (figure 3). Infestation dropped to zero when plants ceased their vegetative growth.

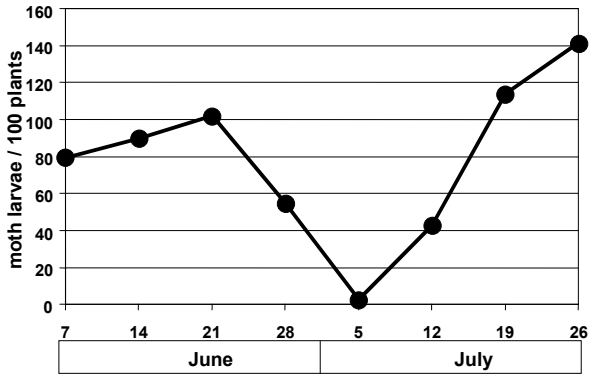

Figure 3. Epigeous infestation detected weekly on 100 potato plants.

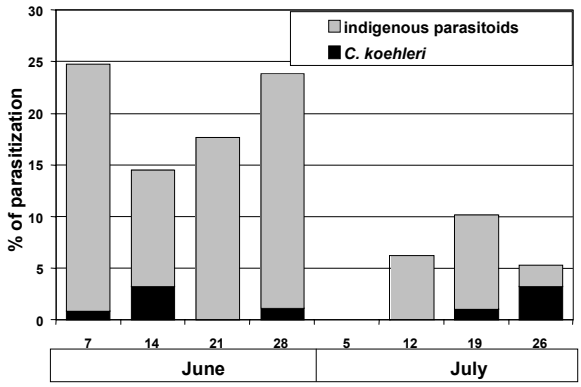

Figure 4. Percentage of parasitism of potato tuber moth larvae caused either by *C. koehleri* or indigenous parasitoids.

Assessment of parasitism levels performed by *C. koehleri* and by indigenous parasitoids

In the figure 4 parasitism percentage referred to *C. koehleri* is shown, where a modest result on concerning parasitized larvae can be noted (max 3%). Same deluding results were found in the storage building where the parasitization effectiveness resulted inferior to 1%. As regards the indigenous parasitoids, those naturally occurred were the following: *Diadegma pulchripes* Kokujev (Ichneumonidae), *Pnigalio pectinicornis* L. and *Sympiesis viridula* Thomson (Eulophidae).

D. pulchripes in particular showed a greater activity in comparison with that of the other two species. The latter are known as larval parasitoids of other Lepidopteran, among which can be mentioned *Phyllonorycter cerasicolella* (Herrich-Schaffer) and *Ostrinia nubilalis* (Hübner) (Frye, 1972; Cravedi, 1992). It has also to be stressed that they are new for *Ph. operculella*, but they should be considered occasional or accidental parasitoids of potato tuber moth.

Dynamics of parasitism show a notable superiority of the indigenous enemies of the moth in comparison with the *C. koehleri* biocontrol effectiveness (figure 4). There is a noteworthy activity of the icneumonid *D. pulchripes* with respect to eulophids *S. viridula* and *P. pectinicornis*.

In the half of June parasitism increased and that one caused by indigenous species reached a maximum of 23%. Then parasitism dropped and increased again gradually until reaching another peak of about 20% at the end of June. Afterwards there is a decline until the end of July.

This low efficiency rate of parasitism activity observed on *C. koehleri* confirms the results obtained in the experiment conducted by Guerrieri and Viggiani, 1994, which took place in Campania and Puglia – southern Italy. The reasons for this low activity could have been due to low humidity of the year and also to the presence of the glandular trichomes present on the potato leaves (Kfir, 1981; Baggen and Gurr, 1995; Gooderham *et al.,* 1998). The indigenous parasitoids, however, showed a reasonable efficiency and therefore will be the subject of forthcoming studies.

Although the percentage of parasitized larvae by indigenous parasitoids was notable (up to 23%), it is still necessary to use insecticides to protect tubers from potato tuber moth direct infestations. It is well known that this pest can make unstopped generations inside storage buildings, indeed a very modest number of infested tubers could provide an active source of infestation, causing a severe damage to the entire harvested crop, also by secondary attack by mites, bacteria and fungi (Tremblay, 1986; Pucci, 1991; Ortu and Floris, 1989).

As far as improvement of growing, conservation and commercialisation of the product is concerned, it is advisable to:

- increase the areas of early and early-medium season potato crops (as they are less susceptible to potato tuber moth attacks)
- increase depth in the soil when seedling, from the actual 12 cm to at least 20 cm, so as to make egg laying more difficult for the moth

- harvest the crop early in the season and quickly
- not weeding between rows after seedling as grass preserve from moth attack to tubers
- perform only one chemical treatment which should coincide with adult monitoring peak. This should be done in the twilight hours when adults are in eggs laying activity
- maintain storage house temperature below 10°C

Conclusions

This experiment, performed in northern Lazio, Central Italy, with the aim of evaluating field efficiency both of the polyembryonic parasitoid *C. koehleri* and other indigenous parasitoids with respect to the Gelechiidae *Ph. operculella* infestation on *S. tuberosum*, which showed the following:

1. three mass releases of *C. koehleri* gave a quite low parasitism of the moth larvae found on green parts of potato plant (max. 3%). That could have been caused by low relative humidity associated with high temperatures during the summer months and also to the length and density of thrichomes of the leaves. However it might not be possible to maintain a stable population of this parasitoid in Italy as it is affected by low winter and spring temperatures, however
2. on the other hand indigenous species seem to survive at reasonable densities of parasitism and will therefore be subject of later studies
3. it is important to remember that, with no chemical intervention, crop loss is total; for this reason improving some agricultural techniques such as rotation, would be desirable in order dto increase the agroecosystem complexity and its sustainability.

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