



Functional response of *Chelonus oculator* (Hymenoptera: Braconidae) to temperature, and its consequences to parasitism

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Abstract: The parasitization behaviour of *Chelonus oculator* (F.), egg-larval parasitoid of noctuid lepidopteran species, has been studied under laboratory conditions, using *Ephestia kuehniella* Zeller as host, at four different temperature levels (10, 20, 30 and 40±1 °C) and five densities of host eggs (50, 100, 150, 200 and 250). A significant effect of temperature and parasitism density was observed. At 10 °C, there was no parasitism, whilst at 40 °C it was very low; presenting adequate values at the two other temperatures (20 and 30 °C). With regard to these facts, the functional responses of this parasitoid species were adjusted and we noted that they display Holling type III. Estimating the handling times from the respective mathematical expressions, we obtained 10.944 and 15.250 min, at 20 and 30 °C, respectively. These values are considerably higher than the respective times obtained by direct observation, 0.597 and 0.560 min for these temperatures (this difference is due to the fact that in the first case, unlike the second one, the time used for the search of the host is also included). The results obtained from the parasitization behaviour of *Ch. oculator* are discussed, also considering it as a candidate biological control agent against *Spodoptera exigua* (Hübner), beet armyworm, with a view to its possible use in greenhouse crops in Spain.

Introduction

Spodoptera exigua (Hübner), beet armyworm, is one of the most devastating pest in Spanish greenhouse crops, especially in pepper and water melon (Cabello and Belda 1994, Cabello 2004). The development of biological control methods against noctuid pests in these crops, with the only exception of *Bacillus thuringiensis* Berliner, has hardly been compared with that for outdoor crops; as for example, with species of *Trichogramma* (van Lenteren 2000). To be specific, the allochthonous larval endoparasitoid species *Cotesia marginiventris* (Cresson), has been trialled in greenhouse conditions for the control of *S. exigua* (Messelink 2002, Urbaneja et al. 2002) as well as Baculovirus (SeMNVPV) both allochthonous (Moscardi 1999, Smits and Vlak 1994), and autochthonous (Belda et al. 2000).

The lack of commercially available natural enemies for the control of *S. exigua*, together with the problems of resistance to insecticides of this pest in our area (Smagghe et al. 2003), constitute a restraining factor for the application of biological control programmes or IPM, in greenhouse crops (van der Blom 2002), especially in *S. exigua* (Castañé 2002).

On the other hand, in the outdoor crops of the area, parasitoid and predator species (Cabello 1986, 1988, Caballero et al. 1990, Guimaraes et al. 1995, Torres-Villa et al. 2000) as well as entomopathogens (Caballero et al. 1992) are very abundant and provide very efficient control over the pest populations, with elimination rate of 33 and 100% (Cabello 1988), which does not happen in greenhouse crops (Ca-

bello et al. 1996). In the case of *S. exigua*, the parasitoid egg-larval species that stands out is *Chelonus oculator* (F.) (Pino et al. 2003) which could potentially be a control agent in greenhouse crops if increased. We need to point out that the functional response offers a good basis to understand the action of entomophagous agents in biological control programmes (Waage and Greathead, 1988; Barlow, 1999), albeit with restrictions as described by Mills and Getz (1996); admitting in addition a biological interpretation of the parameters of the functional response (Cabello et al. 2007). Thus, when it comes to "classical" biological control, one intends to introduce an allochthonous natural enemy to a new geographic area, where its prey/host has been previously determined, in order to exert a natural control similar to that they performed in their area of origin. This operation requires a certain stability of the predator-prey (or parasitoid-host) system, which can only be reached with a natural enemy showing type III functional response. The latter is the only type considered adaptive depending on the density of the host and with good potential for regulating the host population (Hassell and May 1973, Oaten and Murdoch 1975a,b, Hassell 1978). Contrary to this, in case of inundative biological control, stability of the system is not important, since our objective then is to get a short-term response, due to the fact that the mortality of the prey/host occurs before a generation is completed. In this case, in principle, a type I response seems to be more adequate, in which there is a linear response between the density of the phytophagous insect and the mortality caused by the entomophagous insect. In this sense,