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Fitness of the parasitoid *Diadegma insulare* is affected by its host's food plants

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Abstract

The diamondback moth, *Plutella xylostella* (L.) is considered a specialist on Brassicaceae, but it is capable of expanding its food range by incorporation of non-brassicaceous plants into its diet. The use of a new food plant may change food availability and vulnerability of *P. xylostella* to its natural enemies, especially specialist parasitoids. In this laboratory study, we evaluated the bottom-up effects of two Brassicaceae viz. *Brassica napus* L. and *Descurainia sophia* (L.) Webb ex Prantl and two non-Brassicaceae viz. *Tropaeolum majus* L. and *Cleome hassleriana* Chodat on several fitness correlates of the specialist parasitoid, *Diadegma insulare* (Cresson) reared on *P. xylostella* larvae. Percentage of parasitism of host larvae by *D. insulare* varied among the plant species and was highest on *T. majus* and lowest on *D. sophia*. Values of several fitness correlates for *D. insulare* differed when the host was feeding on various plant species. Egg to adult development was fastest on *B. napus* followed by *C. hassleriana*, *D. sophia* and *T. majus*. Female wasps reared on *C. hasseleriana* lived the longest in absence of food. The response of *D. insulare* to potential food-plant expansion by its host *P. xylostella* is discussed.

Zusammenfassung

Von der Kohlmotte, *Plutella xylostella* (L.), wird angenommen, dass sie auf Brassicaceen spezialisiert ist. Sie ist jedoch in der Lage ihr Nahrungsspektrum zu erweitern, indem sie Pflanzen aus anderen Familien in ihre Ernährung einbezieht. Die Nutzung einer neuen Nahrungspflanze kann die Nahrungsverfügbarkeit und die Anfälligkeit von *P. xylostella* gegenüber ihren Feinden, vor allem gegenüber spezialisierten Parasitoiden, verändern. In dieser Laboruntersuchung evaluierten wir die „bottom up"-Effekte von zwei Brassicaceen, *Brassica napus* L. und *Descurainia sophia* (L.) Webb ex Prantl, und zwei Nicht-Brassicaeen, *Tropaeolum majus* L. und *Cleome hassleriana* Chodat, auf einige Fitness-Parameter des spezialisierten Parasitoiden *Diadegma insulare* (Cresson), der auf *P. xylostella* gezogen wurde. Der Prozentsatz des Parasitismus der Wirtslarven durch *D. insulare* variierte zwischen den Pflanzenarten und war am höchsten bei *T. majus* und am geringsten bei *D. sophia*. Die Werte einiger Fitness-Parameter von *D. insulare* unterschieden sich, wenn der Wirt auf unterschiedlichen Pflanzenarten fraß. Die Entwicklung vom Ei zum Imago war am schnellsten auf *B. napus* gefolgt von *C. hassleriana*, *D. sophia* und *T. majus*. Die weiblichen Wespen, die auf

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C. hassleriana gezogen wurden, lebten bei Abwesenheit von Nahrung am längsten. Die Reaktion von *D. insulare* auf die potentielle Erweiterung der Futterpflanzen durch ihren Wirt *P. xylostella* wird diskutiert.

Keywords: Brassicaceae; Non-Brassicaceae; Diamondback moth; Biological control; Tritrophic interactions

Introduction

Herbivorous insects routinely encounter two major challenges: feeding on a nutritionally suboptimal or sometimes even toxic resource, and the risk of being eaten. Herbivores can occasionally expand their host ranges by incorporating new food plants into their diets (Bowers, Stamp, & Collinge 1992; Camara 1997; Fraser & Lawton 1994; Löhr & Gathu 2002; Roßbach, Löhr, & Vidal 2006). The use of a new host plant may increase food availability, and change the vulnerability of the opportunist herbivore to its natural enemies. The effects of an expanded host range can cascade up to the higher trophic levels. For instance, plants can negatively affect parasitoid fitness directly when the developing parasitoid encounters the plant allelochemicals inside its host and/or indirectly when the parasitoid is stressed due to compromised host quality from being reared on a suboptimal plant (Campbell & Duffey 1979; Harvey, van Dam, & Gols 2003; Harvey, van Dam, Eitjes, Soler, & Gols 2007; Ode 2006; Price et al. 1980). The relationship between plant chemistry and host location behaviour of parasitoids is well documented (e.g. Gols et al. 2005; Ohara, Takafuji, & Takabayshi 2003; Potting, Poppy, & Schuler 1999; Turlings et al. 1995), but studies elucidating the effects of various food plants of herbivores on parasitoid fitness are relatively uncommon (e.g. Gols et al. 2007; Gols, Bukovinszky et al. 2008; Gols, Wagenaar et al. 2008; Harvey et al. 2003, 2007; Idris & Grafius 1996; Sarfraz, Dosdall, & Keddie 2008a).

The diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae), is a specialist on Brassicaceae (Idris & Grafius 1996; Sarfraz, Dosdall, & Keddie 2006; Talekar & Shelton 1993). Brassicaceae comprise a diverse group of cultivated and wild plants which all biosynthesize glucosinolates, a group of secondary plant compounds (Mithen 1992). *P. xylostella* relies on glucosinolates for host location, oviposition stimulation and feeding initiation (Gupta & Thorsteinson 1960a, 1960b; Renwick, Haribal, Gouinguené, & Städler 2006; Thorsteinson 1953). *Diadegma insulare* (Cresson) (Hymenoptera: Ichneumonidae) is a solitary, host-specific larval endoparasitoid and is an important biological control agent of *P. xylostella* (Harcourt 1960; Sarfraz, Keddie, & Dosdall 2005). It parasitizes all four larval instars of *P. xylostella* and kills and emerges from the pre-pupal stage of its host (Harcourt 1960). *P. xylostella* is one of the most serious pests of brassicaceous crops worldwide (Sarfraz et al. 2006; Talekar & Shelton 1993). In order to reduce reliance on insecticide use for its control, understanding the biology and ecology of biocontrol agents such as *D. insulare* is of crucial importance.

Brassicaceae and close allies such as Capparaceae and Troppaeolaceae commonly occur in many parts of the world. Canola, *Brassica napus* L. (Brassicaceae), is an amphidiploid species derived from crosses between two Palearctic species, *Brassica oleracea* L. and *Brassica rapa* L., and is a widely cultivated oilseed crop in Europe and North America (Rakow 2004). Flixweed, *Descurainia sophia* (L.) Webb ex Prantl, is a winter annual or biennial wild Brassicaceae and is commonly found in canola fields and fallow lands (Mitich 1996). The spider flower, *Cleome hassleriana* Chodat (Capparaceae), is an ornamental herb in North America (Foster 2001) and it readily escapes gardens to invade roadsides and the shores of rivers and lakes (Anonymous 2006). The garden nasturtium, *Tropaeolum majus* L. (Tropaeolaceae), originated in South America but is now grown worldwide as an ornamental plant (Stephens 2003) and often occurs as a weed on roadsides and riverbanks. These four plant species were used in this study as representatives of known food plants and potential food plants for *P. xylostella*.

This study was designed to provide detailed insights into tritrophic interactions focusing on several fitness correlates of both male and female *D. insulare* when its *P. xylostella* host larvae were reared on two brassicaceous (*B. napus* and *D. sophia*) and two non-brassicaceous species (*C. hassleriana* and *T. majus*). *C. hassleriana* and *T. majus* can occur sympatrically with wild Brassicaceae, and so could potentially harbour *P. xylostella* populations, perhaps providing bridge hosts until crop plants are available. Recent research demonstrated that *P. xylostella* performance was equivalent on selected Brassicaceae and non-Brassicaceae (Sarfraz, Dosdall, & Keddie 2008b). We therefore used the same plant germplasm to investigate the effects of experimental host expansion by *P. xylostella* on performance of its parasitoid. Several fitness correlates directly related to parasitoid population dynamics (e.g. parasitism, survival, developmental time, larval herbivory, pupal weight, silk weight, adult body weight, and longevity without food) were investigated.