



Effect of common wild crucifer species of Kenya on fitness of two exotic diamondback moth parasitoids, *Cotesia plutellae* and *Diadegma semiclausum*

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ABSTRACT

Plutella xylostella is the most abundant and damaging pest of cruciferous crops in Kenya and has gained economic importance over the years. During a survey conducted in the major crucifer areas of Kenya a number of wild crucifers recorded in the region were found infested with diamondback moth. As a result, research was conducted in the laboratory and greenhouse to investigate whether exotic parasitoids recently introduced would develop and survive on the wild crucifers. Experiments were conducted on development, survival, reproductive potential and parasitism of *Cotesia plutellae* and *Diadegma semiclausum* on cultivated Brassica (*Brassica oleracea* var. *capitata* and *B. oleracea* var. *acephala*) and wild crucifers (*Erucastrum arabicum*, *Raphanus raphanistrum*, *Rorippa micrantha*, *Rorippa nudiuscula* and *Brassica juncea*). Both diamondback moth and parasitoids survived and developed on the wild crucifers. Egg-larval period of *C. plutellae* was shortest on *E. arabicum* (7.4 days) and longest on *R. raphanistrum* (9.3 days) while that of *D. semiclausum* was shortest on *B. juncea* (6.7 days). *Ro. micrantha* and *R. raphanistrum* recorded the lowest cocoon weight of 1.67 mg and 7.1 mg from *C. plutellae* and *D. semiclausum*, respectively. Longest pupal period was recorded on *C. plutellae* and *D. semiclausum* reared on *B. oleracea* var. *acephala* and *Ro. micrantha*, respectively. Egg-adult development time of *C. plutellae* was significantly longer on *R. raphanistrum* (15.2 days) and shortest on *B. juncea* and *E. arabicum* (12.2 days) while that of *D. semiclausum* was longest on *Ro. micrantha* (16.1 days) and shortest on *E. arabicum* (12.4 days). Mortality was higher on wild crucifers than on the cultivated Brassica species. In free choice tests, parasitism and parasitoid emergence were significantly higher on cultivated cultivars. Relatively higher percentage of larvae exposed to *C. plutellae* was not re-collected.

The results suggest that wild crucifers can support development of the exotic parasitoids and thus provide refugia, thereby lowering the risk of local parasitoid extinction after pesticide application or harvesting. However, they might also be a source for diamondback moth and their presence near cultivated crucifer fields could lead to early population build-up.

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1. Introduction

The diamondback moth (DBM) *Plutella xylostella* Linnaeus (Lepidoptera: Plutellidae) is the most important pest of cultivated crucifers (Talekar and Shelton, 1993). The pest has become the most abundant and damaging pest of cruciferous crops in Kenya and has gained economic importance over the years (Kibata, 1996; Ayalew, 2006; Löhr et al., 2007). Its exceptional pest status is due to the diversity and abundance of the host plants, high reproductive potential and genetic elasticity (Mohan and Gujar, 2003). The pest

has developed resistance to most chemical (Kibata, 1996) and bacterial insecticides (Tabashnik et al., 2003; Sarfraz and Keddie, 2005). Misuse and overuse of broad-spectrum pesticides have disrupted its natural enemies' communities.

Parasitoids are very important natural enemies of Brassica pests in general (Billqvist and Ekblom, 2001) and play a key role in management of diamondback moth (Talekar and Shelton, 1993; Löhr et al., 2007). Their ability to establish stable populations in short-term, disturbed habitats, such as cabbage production fields is of primary importance for their long-term efficacy. In this context, the role of non-crop plants in the surroundings of cultivated fields may be of major importance to ensure early arrival of parasitoids in the field thereby maximising their pest control potential. Parasitoids survival and fitness are intrinsically linked to the quality and fate of their host (Godfray, 1994; Quicke, 1997). Variation in

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host plant quality is known to affect the body size of herbivorous insects (Bjorkman, 2000; de Bruyn et al., 2002). The quality of the first trophic level influences development, survival, fecundity, size as well as sex ratio of parasitoids (Kester and Barbosa, 1991; Teder and Tammaru, 2002; Harvey et al., 2003; Ode et al., 2004). The effects of food plant on host quality, and subsequently on development of parasitoids, may be directly due to the presence via sequestration of allelochemicals in host tissues, or allelochemicals in the diet of the herbivore may reduce its consumption efficiency leading to indirect reduction of developmental conditions for the parasitoid on smaller hosts. On the other hand compensation of the host may occur in spending more time feeding, thereby extending the temporal exposure to their natural enemies ('slow-growth-high-mortality hypothesis', *sensu* Clancy and Prince, 1987; Awmack and Leather, 2002), a secondary function of reduced herbivore performance on more toxic host species.

Apparent levels of parasitism by the same parasitoids have frequently been observed to differ between plants species or cultivars (Price et al., 1980; Verkerk and Wright, 1996; Billqvist and Ekblom, 2001) and plants with different morphological traits (Fujiwara et al., 2001). In addition, the developmental status (size, age) of a host plant can also affect the size and performance of natural enemies (Neveu et al., 2000). Furthermore plant attributes like the provision of host finding cues or shelter mediate the efficiency of natural enemies (Cortesero et al., 2000). For example, *Diadegma semiclausum* (Hellén) (Hymenoptera: Ichneumonidae), a specialist parasitoid of DBM, relies on plant related cues to locate its host (Ohara et al., 2003; Rossbach et al., 2005).

Crucifers are very diverse family and contain a long list of secondary metabolites, some of which are highly toxic (Agrawal and Kurashige, 2003; Wittstock et al., 2003). They are known to affect host plant interactions up to the fourth trophic level (Harvey et al., 2003; Soler et al., 2005). Several species of cultivated and wild crucifers produce different concentrations of glucosinolates (Nayar and Thornsteinson, 1963; Simmonds, 1979). Harvey and Wagenaar (2006) reported that work in progress by Gols et al. (unpublished data) have shown that glucosinolate profiles in the feral populations of *Brassica oleracea* are qualitatively and quantitatively similar to those in cultivars but much lower than in wild species. Herbivores that specialize on glucosinolate-containing plants have developed some mechanisms of overcoming toxicity of their host. Diamondback moth (DBM) *P. xylostella* L. (Lepidoptera: Plutellidae) avoid the formation of isothiocyanate hydrolysis products in their digestive tract, which are deleterious for larval growth and survival (Agrawal and Kurashige, 2003; Wittstock et al., 2004). Several studies have reported the negative effects of allelochemicals in the host's diet on performance of parasitoids (Gunaseena et al., 1990; Harvey et al., 2005; Ode et al., 2004) and the effects are more apparent in koinobiont endoparasitoids (Harvey et al., 1994).

The objective of our study was to examine the effect of six common wild crucifer species on development, survival and reproductive potential of two exotic larval parasitoids *Cotesia plutellae* (Kurdjumov) (Hymenoptera: Braconidae) and *D. semiclausum* and their suitability as refugia for the parasitoids. In one of the recent classical biological control efforts, *D. semiclausum* was imported from Taiwan and released in the highland areas of Kenya in 2002 while *C. plutellae* from South Africa was released in the mid-altitude semi-arid areas in 2004. *D. semiclausum* has successfully established and it is providing good control of DBM (Löhr et al., 2007). This has resulted in farmers reducing pesticide application while others have stopped spraying against DBM altogether in the highland areas where *D. semiclausum* was released (Löhr et al., 2007).

2. Materials and methods

2.1. Host plants

Two cultivated Brassica cultivars (head cabbage *B. oleracea* var. *capitata* and kale *B. oleracea* var. *acephala*) and five wild crucifers (*Erucastrum arabicum* Fisch. & Mey., *Raphanus raphanistrum* L., *Rorippa micrantha* (Roth.) Jonsell, *Rorippa nudiusscula* (Sond.) Thell., and *Brassica juncea* Czern., were used in laboratory trials at the International Center of Insect Physiology and Ecology (ICIPE), Nairobi, Kenya. The selection of wild crucifer species was based on their common occurrence in highland and mid-altitude semi-arid areas and presence of DBM on the host plant during surveys conducted earlier. During the surveys, seeds were collected from the wild species found in Athi River (01°25'46"S, 036°59'50"E) and Kinangop 00°52'12"S, 036°33'43"E) and used for raising plants in the greenhouse at 22–26 °C at 60–80%RH. Seedlings were transplanted into 15 cm diameter plastic pots three weeks after germination. Plants were raised as described in Kahuthia-Gathu et al. (2008).

2.2. Diamondback moth culture

A colony of DBM was established and maintained in the insectary on cabbage *B. oleracea* var. *capitata* L., cultivar Gloria. The DBM larvae and pupae were originally collected from cabbage grown in Werugha Location, Taveta District, Coastal Region of Kenya at 03°26'16"S, 38°20'24"E and 1650 m above sea level. The moths were reared as described by Löhr and Gathu (2002). Sub-colonies were established on all test plant cultivars/wild species and maintained in the insectary at 23 ± 2 °C. They were maintained on the respective host plants for two generations before the trials.

2.3. Cotesia plutellae culture

Ten potted cabbage plants with 100 second instar DBM larvae each was placed in a screenhouse measuring 4 × 3 × 2 m. Twenty pairs of one-day-old *C. plutellae* adults were released into the screenhouse and allowed to parasitise freely. The wasps were fed on 10% honey solution soaked in cotton wool. Host larvae were allowed to complete their development on the cabbage in the screenhouse until pupation or parasitoid cocoon formation. Cabbage plants were added where necessary. The parasitoid cocoons were harvested using a pair of soft forceps, put in a clean ventilated plastic container and kept in the laboratory at 23 ± 2 °C for adult emergence.

2.4. Diadegma semiclausum culture

A potted cabbage plant with one cohort of 200 early third instar DBM larvae was placed in a perspex cage (20 × 20 × 40 cm) with muslin sleeve on one side of the cage. Ten pairs of three-day-old mated *D. semiclausum* were introduced into the cage through the sleeve to oviposit freely. The wasps were provided with a diet of 10% honey solution soaked in cotton wool. After 24 h the exposed larvae were removed and placed in ventilated plastic containers (20 × 10 × 5 cm) lined with tissue at the bottom to absorb excess moisture. Fresh cabbage leaves were added as required until the larvae pupated. The parasitised pupae were harvested and put in clean plastic containers for adult emergence. The *D. semiclausum* culture was established and maintained in the laboratory at 23 ± 2 °C.

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