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Evaluation of predation potential of coccinellids on cassava whiteflies

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Two whitefly species namely *Bemisia tabaci* and *Aleurodicus dispersus* are common cassava pests in Kenya. As direct feeders on the phloem contents and vectors of viruses, whiteflies cause significant damage to the cassava crop in Kenya. This study aimed at evaluating the potential of coccinellidae beetles (*Chelomenes vicina, Diomers flavipes, Diomers Hottentota,* and *Coccinella septempunctata*) as predators of whiteflies. The predation potential of these predators was evaluated using nymphs of *B. tabaci* and *A. dispersus* under 'choice' and 'no choice' feeding conditions. The number of nymphs consumed by each individual predator was recorded after 24 h. Data collected from the 'no choice' and the 'choice' feeding experiments were analyzed using one-way ANOVA and paired-sample T-test, respectively. When the predators were exclusively provided with nymphs of *B. tabaci*, the number of nymphs consumed by the ladybird species was significantly (P<0.05) different. *D.flavipes* consumed the highest number of *B. tabaci* nymphs with a mean number of 79.4±1.1 nymphs. On the other hand, C. *septempunctata* consumed the highest number of *A. dispersus* nymphs with a mean of 2.5±0.2 in an exclusive feeding condition using *A. dispersus* nymphs. Additionally, when the predators were allowed a choice between *B. tabaci* and *A. dispersus* nymphs, all the four species of predators significantly preferred *B. tabaci nymphs.* The findings of this study indicate that the four ladybird species evaluated have potential and can be further evaluated and developed for the management of *B. tabaci.*

Key words: *Bemisia tabaci, Aleurodicus dispersus,* ladybirds, choice feeding, no choice feeding.

INTRODUCTION

Cassava (*Manihot esculenta Crantz*) is an important crop in Kenya, grown for both food and income (FAO, 2007). However, its production is constrained mainly by two whitefly transmitted diseases namely cassava mosaic disease (CMD) caused by cassava mosaic virus which is transmitted by *Bemisia tabaci* and cassava brown streak disease (CBSD) caused by cassava brown streak virus, which is transmitted by both B. *tabaci* and *Aleurodicus dispersus* (Maruthi et al., 2004a; Mware et al., 2009a, b). These whitefly vectors also cause crop damage through direct feeding on the phloem contents and through production of honey dew that facilitates the growth of sooty mould which impairs photosynthesis (Byrne et al., 1990b).

The use of pesticides to control whitefly pests in traditional cassava agro-ecosystems is minimal, primarily due to their high cost and their unavailability to subsistence farmers in sub-Saharan Africa (SSA) (Neuenschwander, 2004). Additionally, the use of pesticides may have unintended effects on the environment. For instance, over 98% of sprayed insecticides reach a destination other than their target species,

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including non-target species, air, water, bottom sedi-ments, and food (Miller, 2004).

Furthermore, con-tinued use of pesticides may lead to development of pest resistance and loss of natural enemies which might result to secondary pest outbreaks (Miller, 2004). Classical biological control, involving the use of natural enemies to control unwanted organisms, has been considered the best solution (Herren and Neuenschwander, 1991).

Predaceous coccinellids are linked to biological control more often than any other taxa of predatory organisms (Hodek and Honek, 1996a; Jervis and Kidd, 1996). Coccinellids are important natural enemies of pest species, especially whiteflies (Gerling, 1990), aphids (Frazer, 1988), mealybugs (Hagen, 1974), scales (Drea and Gordon, 1990), and mites (Chazeau, 1985). Over 50 species of Coccinellidae attack eggs and immature stages of whitefly pests (Gerling, 1990) of which, 13 species prey on *Bemisia* species (Nordlund and Legaspi, 1996; Gerling, 1986), whereas 40 species prey on *A. dispersus* (Ramani, 2000). For instance, *Serangium parcesetosum* feeds on various whitefly species on citrus (Uygun et al., 1997), and *Clitostethus arcuatus* is a predator of several whitefly species in various crops (Booth and Polaszek, 1996). Serangium species were found to prey on whiteflies in cassava throughout the growing period (Asiimwe et al., 2007). Additionally, Coccinellids such as *Anegleis cardoni, A. perrotteti*, *Axinoscymnus puttarudriahi*, *Chelomenes sexmaculata,* three species of *Jauravia* and *Cryptolaemus montrouzieri* were found heavily feeding on the spiraling whitefly (Mani and Krishnamoorthy, 1997b).

In spite of the occurrence of predators of whiteflies on cassava fields in Kenya, there is a gap of information on their predatory potential and preference on the two species of whiteflies infesting cassava in Kenya. In order to understand the predatory efficiency of natural enemies on *B. tabaci* and *A. dispersus,* four species of ladybird beetles belonging to the family *Coccinellidae* were evaluated in a laboratory study.

MATERIALS AND METHODS

Field collection of whiteflies and predators

Four species of arthropods of the family coccinellidae were collected from field cassava at the Kenya Agricultural Research Institute (KARI) Kiboko centre. They included *Chelomenes vicina, Diomers flavipes, Diomers hottentota,* and *Coccinella septempunctata*. The adult ladybird beetles were handpicked from the leaves and placed in Petri plates containing moist filter papers. Pieces of cassava leaves containing whitefly nymphs were placed in the plates to serve as sources of food while on transit. Ten to 15 insects were placed in each plate. Cassava leaves infested with *B. tabaci* or *A. dispersus* nymphs were cut and placed in khaki paper bags. Both the whiteflies and the predators were placed in aerated cartons and transported to the entomology laboratory at the Kenya Agricultural Research Institute's National Agricultural Research Laboratories (KARI -NARL) where the study was performed.

Determination of feeding efficiency of the predators on *B. tabaci* and *A. dispersus* in 'no choice' feeding experiments

To determine the feeding efficiency of the predators, the procedure described by Asiimwe et al. (2007) was used with some modi-fications. Forty adult beetles of each species were used for the study. The beetles were allowed to feed on *B. tabaci* and *A. dispersus* nymphs in separate tests. Individual predators were placed in a Petri-plate containing moistened filter papers and were provided with either nymphs of *B. tabaci* or *A. dispersus* in separate experiments. They were supplied with cassava leaves containing either 100 nymphs of *B. tabaci* or 50 nymphs of *A. dispersus*. The number of nymphs consumed by each beetle was recorded after 24 h.

Determination of prey preference of the predators on *B. tabaci* and *A. dispersus* nymphs in 'choice' experiments

The feeding preference of the predators on *B. tabaci* nymphs or *A. dispersus* nymphs was evaluated using the methodology described by Anila et al. (2005) with modifications. To determine the preference of the ladybird species on *B. tabaci* and *A. dispersus* nymphs, 40 individuals of each lady bird species were evaluated. They were supplied with 100 nymphs of *B. tabaci* and 50 nymphs of *A. dispersus* in the same Petri-plate. In all the experiments, the number of *A. dispersus* nymphs used was half that of *B. tabaci* because the nymphs of *A. dispersus* were double the size of *B. tabaci* ones. The numbers of whitefly nymphs consumed by each individual predator was recorded after 24 h.

Data analysis

Data obtained for the feeding efficiency of the ladybird species in no choice experiment was statistically analyzed using one-way ANOVA and means were separated using LSD at 5% level. For the feeding preference of ladybird species on *B. tabaci* or *A. dispersus* nymphs, the collected data for each species was analyzed using paired-sample T-test.

RESULTS

'No choice' feeding of ladybird species on *B. tabaci* and *A. dispersus* nymphs

Results from this study show the potential of coccinellidae predators for the control of *B. tabaci*. All the four species consumed more *B. tabaci* nymphs than *A. dispersus* nymphs in separate experiments. *Diomers flavipes* consumed the highest (79.4) number of *B. tabaci* nymphs, whereas *Coccinella septempunctata* consumed the highest (*2.5)* number of *A. dispersus* nymphs (Table 1). The mean number of *A. dispersus* consumed by all the four species was quite low.

Feeding preference of the ladybird species on B. tabaci and A. dispersus nymphs

All the ladybird species had a high preference for *B. tabaci* nymphs as indicated by the highly significant differences between the number *B. tabaci* and *A.*

Table 1. Mean number of *B. tabaci* and *A. dispersus* nymphs consumed by the four ladybirds species in no choice conditions.

Ladybird species	Whitefly species	
	B. tabaci	***A. dispersus***
C. vicina	60.8±1.54^{b}	1.60±0.17^{a}
C. septempunctata	55.90±1.44^{a}	2.50±0.21^{b}
D. Flavipes	79.38±1.06^{c}	1.27±0.15^{a}
D. hottentota	60.15±1.38^{b}	1.73±0.19^{a}
LSD	3.82	0.51
P-Value	0.00	0.00

Means along the same column followed by different letters differ significantly at P value ≤ 0.05 levels (one-way ANOVA, Fisher's individual error rate, LSD 5%, P value).

Table 2. Mean number of *B. tabaci and A. dispersus* nymphs consumed by the ladybird species in choice feeding conditions.

Ladybird species	Treatment		T value	P value
	B. tabaci	***A. dispersus***		
C. vicina	39.9±0.68^{a}	1.22±0.18^{b}	43.65	0.00
C. septempunctata	31.73±0.89^{a}	1.43±0.15^{b}	33.72	0.00
D. hottentota	32.15±0.73^{a}	1.85±0.22^{b}	39.93	0.00
D. flavipes	34.15±0.53^{a}	0.45±0.14^{b}	61.07	0.00

Means within the same row followed by different letters are significantly different at 5% level T-Test.

dispersus nymphs consumed (Table 2). All of the species only predated on just a few of *A. dispersus* nymphs regardless of both *B. tabaci* nymphs and *A. dispersus* being in the same Petri plate (Table 2).

DISCUSSION

The management of whiteflies as cassava pests in Kenya has not been considered of major importance. However, yield loss due to whitefly transmitted viruses has necessitated the development of appropriate control measures for whiteflies. Currently, there is limited information on the occurrence, distribution and predation potential of whitefly predators in cassava systems in Kenya. This study investigated the potential of four species of coccinellidae beetles as predators of cassava whiteflies.

In this study, all the four species of the ladybird beetles evaluated under 'no choice' feeding conditions were able to consume large quantities of *B. tabaci* nymphs. *D. flavipes* had the highest predation of 79 nymphs after 24 h. Previous studies demonstrated that various species of ladybirds predate on *B. tabaci* nymphs. For instance, Kapadia and Puri (1992) observed a *Serangium* spp. feeding on *B. tabaci* on cotton. Another study on prey consumption by Legaspi et al. (1996) showed that both larvae and adults of *Serangium parcesetosum* are voracious feeders of immature whiteflies. Furthermore, Asiimwe et al. (2007) demonstrated the potential of a *Serangium* species to control *B. tabaci* populations in cassava. However, when the ladybirds were exclusively fed on *A. dispersus* nymphs in this study, it was revealed that all the species were not efficient in preying on the nymphs. *C. septempunctata* was the most efficient with a mean consumption of three nymphs after 24 h.

Preference is an important factor in the success of a polyphagous predator in a bio-control programme. It is particularly important for the target pests to be among the preferred prey (Waseem et al., 2009). In this study, all the species of the ladybird beetles preferred *B. tabaci* nymphs to *A. dispersus* nymphs as indicated by low efficiency in predating on the nymphs. *C. vicina* highly preferred nymphs of *B. tabaci* to those of *A. dispersus* with a mean consumption of 40 nymphs and 1 nymph *B. tabaci* and *A. dispersus,* respectively. However, this is in contrast with other previous studies where some beetles of the coccinellidae family have been found to be associated with *A. dispersus*. For instance, *Anegleis cardoni*, *A. perrotteti*, *Cryptolaemus montrouzieri, Axinoscymnus puttarudriahi* and *Chelomenes sexmaculata,* were commonly found in the spiraling whitefly colonies (Mani and Krishnamoorthy, 1997b). Moreover, Geetha (2000) observed a higher number of *Chilocorus nigrita* beetles on guava infested by *A. dispersus* at Coimbatore. When the four species of predators were exclusively provided with nymphs of one species of prey, the predation efficiency was higher than when the two prey species were provided together. This indicated that all the four species of ladybirds collected from cassava in Kiboko, were specialized in predating on *B. tabaci*. The inclusion of both *B. tabaci* and *A. dispersus* nymphs in the same plate seemed to interfere with the prey searching efficiency of all the predator species thus resulting in reduced efficiency of predation on *B. tabaci* nymphs in contrast with almost double predation on *B. tabaci* in the ‘no choice’ feeding conditions.

Low predation on *A. dispersus* nymphs, both in choice and no choice feeding conditions, observed in all the four species of the predators under this study indicated their dislike for these nymphs. This may be due to the wax covering the nymphs, which require the predators to have the ability to remove in order to access the body or due to the unpalatability of the nymphs. The findings of this study indicate that the four species of ladybird predators investigated are potential and can be developed for the control of *B. tabaci.* However, they were inferior in predating on *A. dispersus*. The findings further increase knowledge of feeding habits and feeding preference of the predators which is a key factor for successful bio-control using predatory insects.

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