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Association of a native predator *Chilocorus* sp. (Coleoptera: Coccinelidae) with a new exotic mango pest, *Aulacaspis tubercularis* Newstead (Hemiptera: Diaspididae) in Ethiopia

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ABSTRACT

White Mango Scale *Aulacaspis tubercularis* Newstead, 1906 was reported for the first time in 2010 from mango orchards belonging to *Green Focus Ethiopia* Ltd in western Ethiopia. It was hypothesized that the pest could enter Ethiopia with mango seedlings imported by the same company. The present study surveyed natural enemies of the pest and their population dynamics in western Ethiopia. Larvae of *Chilocorus* sp. (Coleoptera: Coccinelidae) were found feeding ravenously on live mango scales. There was a statistically significant ($p<0.05$) positive correlation between the *A. tubercularis* and *Chilocorus* sp. populations in both orchards, implying that the predator was not suppressing the pest population. There was no significant difference in the mean numbers of the predatory larva populations between Arjo and Bako orchards ($p>0.05$). Populations of White Mango Scale and its predator showed remarkably similar fluctuations, with their abundancies reaching peaks during same months. It has been concluded that the native predator got associated with the exotic insect pest recently, and its population may gradually build up. It is suggested that implementation of *Chilocorus* sp. as a biocontrol agent would be a sound strategy in the management of White Mango Scale in western Ethiopia, together with other control options.

KEYWORDS: *Aulacaspis tubercularis*, White Mango Scale, *Chilocorus* sp., Coccinellidae, Ethiopia, pest control, population dynamics.

INTRODUCTION

Mango (*Mangifera indica* L.) originated in tropical Asia and is currently distributed across all tropical and subtropical lowland areas throughout the world (Ramcharan 1997; Naturland 2001; Dirou 2004; Okoth *et al*. 2013; Ubwa *et al*. 2014; Crane *et al.* 2017). Mango is one of the most cherished fruits, not only for its flavour and taste, but also for its nutritional value. Mango is a good source of vitamin A and C, and is rich in carbohydrates, potassium and phosphorus (Griesbach 2003; Nabil *et al.* 2012).

More than 47,000 hectares in Ethiopia are under fruit crops production, with mango plantations accounting for 12.6% of the area (Tadesse 2011). Mango is

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traditionally grown in Ethiopia primarily for family consumption and local markets, but some emerging modern farms have started to produce mango for both local and export markets (Chala *et al*. 2014). Ethiopia exports mango to Djibouti, Saudi Arabia, Yemen, Sudan and the United Arab Emirates (Tewodros *et al*. 2009).

Mango production in Ethiopia is constrained by insect pests such as fruit flies, mango seed weevil, mites, thrips, mealybugs and scale insects (Hussen & Yimer 2013; Chala *et al.* 2014). A new pest inflicting damage to mango trees was reported in 2010 in an orchard of the Indian company *Green Focus Ethiopia* in western Ethiopia (Temesgen 2014). The pest was identified in April 2011 by Gillian Watson (California Department of Agriculture, USA) as White Mango Scale, *Aulacaspis tubercularis* Newstead, 1906 (Hemiptera: Diaspididae) (Dawd *et al*. 2012). The pest could have been most likely introduced to Ethiopia accidentally from abroad with mango seedlings imported by the aforementioned company. Following its initial record, infestation was reported in other mango farms in western Ethiopia, as far as 100 km away from the site of the first record within one year (Temesgen 2014). Currently, White Mango Scale has spread to northern and central Ethiopia, with the infested area in the north being about 1500 km away from the place of initial infestation (Gashawbeza *et al*. 2015). The pest has been transported most likely with fruits. When an exotic pest is introduced to a new region, where there are no natural enemies, its population can increase if left untreated, to the level when it becomes invasive to the host plant (Satti 2011).

There have been frequent complaints from mango growing communities in western Ethiopia regarding the damage caused by *A. tubercularis* (Tesfaye *et al*. 2014; Ofgaa, pers. observ.). White Mango Scale is a sucking insect that poses severe threat to mango plantations in various mango growing countries (Labuschagne *et al*. 1995; Pena *et al*. 1998; Nabil *et al*. 2012; Juárez-Hernández *et al*. 2014). The damage caused by White Mango Scale includes yellowing of leaves, appearance of conspicuous pink blemishes on mature and ripe fruits, and dieback of the plant (El-Metwally *et al.* 2011; Abo-Shanab 2012). Mango scale reproduces during both dry and wet seasons (Halteren 1970). However, a low population density of the scale was recorded as of the end of the rainy season in Egypt (Ha *et al*. 2015). A related study in the same country demonstrated that the *A. tubercularis* population had more than two peaks during a year, with temperature and relative humidity having little effect on the population density fluctuations (El-Metwally *et al.* 2011).

Special studies reported that various species of *Chilocorus* preyed on armoured scale insects (Mendel *et al.* 1986; Erkiliç & Uygun 1995; Lambdin 1995). *Chilocorus bipustulatus* (L.), for example, caused mortality among adult females of *Parlatoria blanchardi* (Hemiptera: Diaspididae) and significantly lowered the level of its infestation on date palm in Northern Niger, West Africa (Stansly 1984). Moreover, *Ch. bipustulatus* and *Ch. nigritus* (Fabricius) were found feeding specifically on *A. tubercularis* in South Africa and Egypt, respectively (Labuschagne *et al*. 1995; Abo-Shanab 2012). Product of *Chilocorus nigritus* is used as a biological control agent against armoured scales (Entocare… 2015). Thus, the objective of this study is to survey an association of *Chilocorus* sp. with *A. tubercularis*, and their population dynamics in western Ethiopia.

MATERIALS AND METHODS

This study was conducted at mango orchards in Bako (09°07'N 37°03'E) and Arjo (09°03'N 36°17'E) in western Ethiopia, from June 2013 to May 2014. Both places received unimodal annual rainfall of 1,649 and 1,218 mm, respectively (Ethiomet… 2016). The farmers grew indigenous mango varieties. Insecticides were sprayed prior to the study period in neither Arjo nor Bako orchards.

Five blocks—at the four corners and in the centre—were specified in each orchard using Randomized Complete Block Design. Ten leaves were plucked from upper, middle and lower canopies of each mango tree within every block, monthly for 12 successive months. The leaves from each tree were placed in a separate cloth bag, labelled, kept in a plastic bag and taken to the Insects and Vector Research Laboratory, Science Faculty, Addis Ababa University. The leaves were examined under a stereomicroscope and live male and female white mango scales and their natural enemies were counted. A dissecting needle was used to open up the armour of the female. During each sampling event, ten leaves infested by White Mango Scale were plucked from mango trees and placed in insect rearing cages, kept in the orchards, and checked every five days for emergence of natural enemies. Before placement, the leaves were checked using a hand lens to remove other insects. Predators observed preying on white mango scales were photographed and videotaped with a camera fixed on the eyepiece of the stereomicroscope. These documents were used to support identification of the predator with taxonomic keys (Pope 2012; Chowdhury *et al*. 2015). SAS Software v9 and Microsoft Office Excel were used for the analysis of data on White Mango Scale and the predator. Pearson correlation was run to evaluate the relationship between White Mango Sale and the predator. T-test was used to separate means of the predator population at Arjo and Bako, at 5% significance level. Square root transformation was used to normalize data obtained from the natural enemy count where applicable.

RESULTS

Abundance of natural enemy

A total of 116 predatory larvae of Ladybird beetle (Coccinelidae: Coleoptera) were collected from both sampling sites. The predator was identified to the genus level as *Chilocorus* sp. The larvae were associated with colony of white mango scales in all observations, and they fed on both male and female scales. When feeding, the larvae easily broke the coat of the male pest and reached it, whereas they forcefully pushed their heads inward and partly opened up the cover of the female, captured and chewed it. Adult beetles were not seen on collected leaves. However, a total of 11 adult beetles (7 from Bako and 4 from Arjo sites) emerged

Table 1: Correlations between *Chilocorus* sp. larva and *A. tubercularis* populations in the study area.

		Pearson's Correlation coefficient (r) and p(r)		
		Female	Male	Sum of male & female pests
Arjo	r	0.64	0.74	0.77
	p(r)	0.024	0.006	0.003
Bako	r	0.93	0.90	0.94
	p(r)	<0.0001	<0.0001	<0.0001

in April, March, June and July from the leaves kept in rearing cages, 15 to 23 days after the leaves had been collected.

In both sites, there was statistically significant positive correlation between the populations of White Mango Scale and the predator (Table 1). The correlation was stronger in Bako than in Arjo. However, there was no significant difference (p>0.05) in the recorded numbers of the predator between Arjo (5.34±0.15) and Bako (2.16±0.14) sites. Combined data from both sites showed significant correlation between the two populations in the study area (r=0.80, p(r)=<0.0001).

Population fluctuations of Chilocorus *sp. larvae and* A. tubercularis

Population peaks were recorded for *Chilocorus* larvae in April and May in Arjo and Bako, respectively (Fig. 1). Considerable population sizes persisted in June and July in Arjo with continuous decrease from August to October. *Chilocorus* larvae were recorded at neither site from November to January. Overall, the *Chilocorus* larvae were observed during most of the months in Arjo, while in Bako no larva were detected during most of the months.

Aulacaspis tubercularis population showed two peaks (April and May) in Bako, whereas the population peak in Arjo was in April and was relatively lower compared to that in Bako (Fig. 2). There was a general trend of continuous decline of *A. tubercularis* population from August to January in the study area. There was no records of the insect during September and October in Bako.

DISCUSSION

Chilocorus sp. larvae preying on *A. tubercularis* in Ethiopia were recorded for the first time through this study. Despite some studies that followed the very report of *A. tubercularis* entry in Ethiopia (Dawd *et al*. 2012; Temesgen 2014; Tesfaye *et al*. 2014; Gashawbeza *et al*. 2015) there was no information about any natural enemy from the pest population. The density of the predatory larvae population recorded in the study area was very low, probably due to recent introduction of *A. tubercularis* to Ethiopia and consequently a very recent association of the predator with the pest. Therefore, population of *Chilocorus* sp. may gradually build up in the future.

The abundances of *A. tubercularis* and of *Chilocorus* larvae showed strong linear correlation over the study period. This may indicate that ecofactors of the

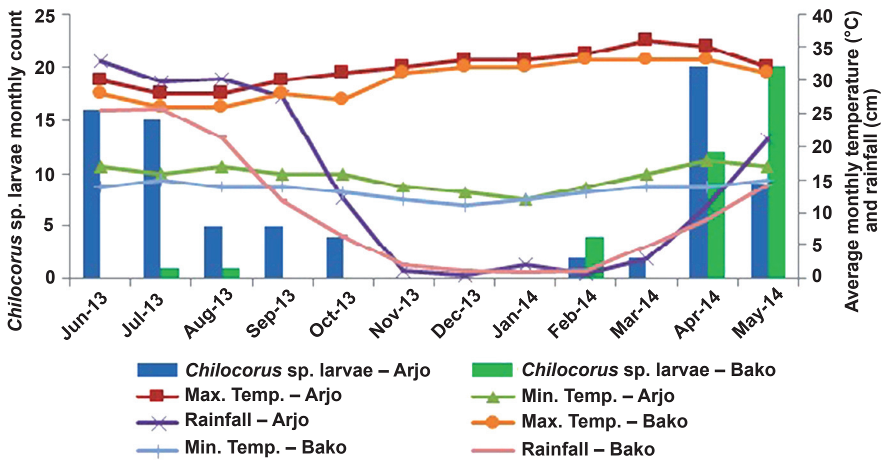

Fig. 1: Population fluctuation of *Chilocorus* sp. larva on mango trees in the study area.

study area affected their populations in a similar manner. Both *A. tubercularis* and *Chilocorus* sp. populations reached their peaks in April and May with a drastic decline from August to February, when precipitation was low or entirely absent. Both populations began to grow from around March and increased to the maximum values in April and May when precipitation started to increase. However, the population size of *A. tubercularis* dropped, mainly in Bako, during heavy rains of June

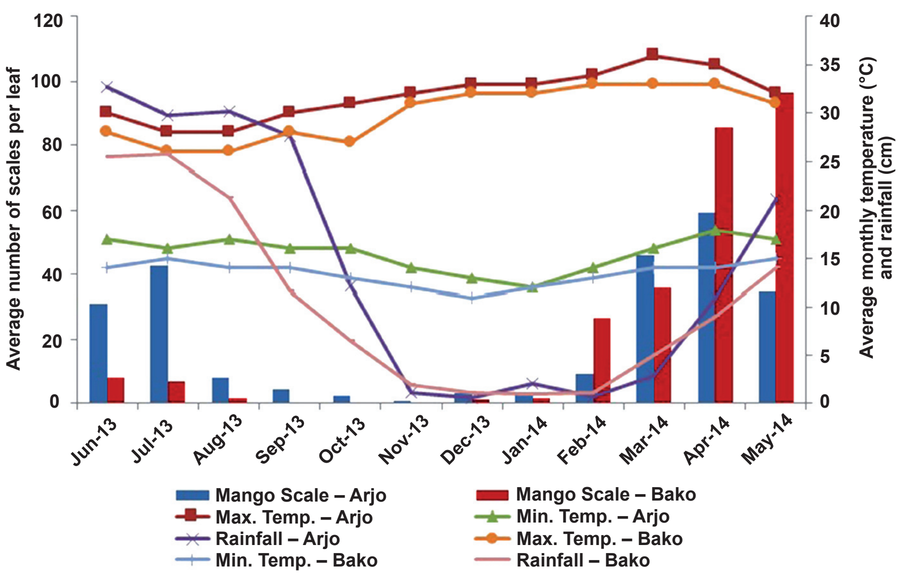

Fig. 2: Population fluctuation of *A. tubercularis* on mango trees in the study area.

and July (Fig. 2) that probably washed out the crawlers. Hence, the growth and decline of *A. tubercularis* and *Chilocorus* sp. population were probably affected mainly by rainfall. The impact of rainfall on *A. tubercularis* may also be indirect. Maturation and ripening of mango fruit, which may encourage population build up of *A. tubercularis*, began in the study area during the first months of the rainy season and continued for some months. Most of those months were characterized by mango fruit maturation and ripening along with significant infestation by *A. tubercularis* in western Ethiopia (Ofgaa, pers. observ.). As a sucking insect, *A. tubercularis* may use the juicy ripe mango as a food source to reproduce to the maximum numbers, which may in turn encourage the simultaneous growth of the *Chilocorus* sp. population.

The current study shows that *Chilocorus* sp. did not control the *A. tubercularis* population. However, the predator may play a vital role in controlling *A. tubercularis* if supported by a conservation biocontrol strategy. It has been demonstrated that some *Chilocorus* spp. are important biological agents for the control of armoured scales (Greathead & Pope 1977; Charles *et al*. 1995; Boothe & Ponsonby 2006; Ponsonby 2009; Entocare… 2015).

CONCLUSIONS

Chilocorus sp. larvae were recorded preying on *A. tubercularis* on mango trees in Ethiopia. *A. tubercularis* was believed to have entered Ethiopia with mango seedling brought from abroad by a company within the past ten years. Therefore, the fact that *Chilocorus* sp. larvae were found preying on *A. tubercularis* within such a short period of time may indicate the beetle's potential for the biocontrol of Mango Scale. The recorded population size of the predator was very small, and it could not yet control the pest. Further study of the predator' ecology and implementation of conservation biocontrol strategy may assist building up its population size.

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