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**Yeboah OE**

Department of Biological Sciences  
Education, Akenten Appiah-  
Menka University of Skills  
Training and Entrepreneurial  
Development, P.O. Box M40,  
Mampong, Ashanti, Ghana

**Amissah-Reynolds PK**

Department of Biological Sciences  
Education, Akenten Appiah-  
Menka University of Skills  
Training and Entrepreneurial  
Development, P.O. Box M40,  
Mampong, Ashanti, Ghana

**Ofori AS**

Department of Biological Sciences  
Education, Akenten Appiah-  
Menka University of Skills  
Training and Entrepreneurial  
Development, P.O. Box M40,  
Mampong, Ashanti, Ghana

**Kwakye DO**

Department of Biological Sciences  
Education, Akenten Appiah-  
Menka University of Skills  
Training and Entrepreneurial  
Development, P.O. Box M40,  
Mampong, Ashanti, Ghana

**Amoabeng BW**

Entomology Section, CSIR-Crops  
Research Institute, P. O. Box 3785,  
Kumasi, Ghana

**Asante C**

Department of Biological Sciences  
Education, Akenten Appiah-  
Menka University of Skills  
Training and Entrepreneurial  
Development, P.O. Box M40,  
Mampong, Ashanti, Ghana

**Corresponding Author:****Yeboah OE**

Department of Biological Sciences  
Education, Akenten Appiah-  
Menka University of Skills  
Training and Entrepreneurial  
Development, P.O. Box M40,  
Mampong, Ashanti, Ghana

## Preliminary studies on the parasitism rate of larval parasitoids of the diamondback moth (*Plutella xylostella*) L. (Lepidoptera: Plutellidae) in the Ashanti region of Ghana

**Yeboah OE, Amissah-Reynolds PK, Ofori AS, Kwakye DO, Amoabeng BW and Asante C**

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**Abstract**

The diamondback moth, *Plutella xylostella* L. (Lepidoptera: Plutellidae) is the most important pest of the brassicas worldwide. Over the years, management of this pest has largely relied on conventional insecticides, with well-documented negative impacts. Biological control using indigenous natural enemies is a promising way to manage the pest while reducing the use of synthetic insecticides. However, due to the negative impact of synthetic insecticides on beneficial insects, the number of natural enemies in the agroecosystem is often below the levels that may have significant pest reduction. Here, we assessed the range and parasitism rates of the larval parasitoids of *P. xylostella* in the Ashanti Region of Ghana. On the whole, one hymenopteran endo-parasitoid species, *Cotesia plutellae*, was identified in the *P. xylostella* larval samples. In all, the percentage of field parasitism of *P. xylostella* larvae ranged between 11% and 23%. Given the percentage of parasitism in this preliminary study, we are of the view that there is potential in relying on endemic parasitoids to biologically manage *P. xylostella* if conditions in agroecology are improved to encourage the survival of these beneficial insects.

**Keywords:** *Plutella xylostella*, biological control, parasitoid, cabbage, percentage parasitism

**Introduction**

The diamondback moth, *Plutella xylostella* (Lepidoptera: Plutellidae), is the crucifers' most important global pest. Damage is caused by larval feeding on the leaves of cruciferous crops that produce glucosinolates (Talekar & Shelton, 1993) [48] and, are limiting factors for productivity in brassica crops farming, resulting in a deficit in food supply (Verkerk & Wright, 1996 [50]; Sarfraz *et al.*, 2005 [43], Liu *et al.*, 2021) [31]. *Plutella xylostella* has benefited from a lack of natural enemies or a low parasitism rate of indigenous natural enemy species, especially parasitoids, in regions where it was accidentally introduced (Miall *et al.*, 2021) [37]. In the tropics and subtropics where weather conditions are highly favorable for its development, the pest gains a higher ground of worsening and causing more than the anticipated damage (Christopher, 2020) [11]. *Plutella xylostella* is considered the most widely distributed Lepidopteran pests found everywhere suitable host plants are present (Shelton, 2014 [41]; Zalucki *et al.* 2012) [55], and for a long-time has been managed using synthetic insecticides (Munir, S. 2019) [39]. Nonetheless, it currently shows resistance against a wide range of insecticides. (Furlong *et al.*, 2012; Zalucki *et al.*, 2012) [55]. The use of these insecticides also negatively affects biodiversity, contributing to the reduction of natural enemy-mediated pest control and killing non-target organisms (Furlong *et al.*, 2012 [55], Abraham *et al.*, 2018) [2], in addition to the residual and compounding effects of these chemicals on of human and animal health (Abraham *et al.*, 2018) [2].

Due to the development of resistance and negative effects of synthetic insecticides in the ecosystem, alternative control strategies, such as integrated pest management (IPM) have become important. IPM aims to keep pesticide applications to a minimum and to actively introduce a more environmentally friendly and sustaining way of controlling the pest (Ehler, 2006 [17]; Furlong *et al.*, 2012 [55], Mayanglambam *et al.*, 2021) [36]. Biological control with a wide range of natural enemies, including parasitoids, arthropod predators, viruses,

microsporidia, pathogenic fungi, and bacteria, is a promising way of reducing synthetic insecticides in agricultural systems. Among the biological control agents, parasitic insects are the most efficient and therefore frequently used (Lim, 1992, Hajek *et al.*, 2018) [20]. They can regulate their host population without negatively impacting the environment (Shi *et al.*, 2019) [46].

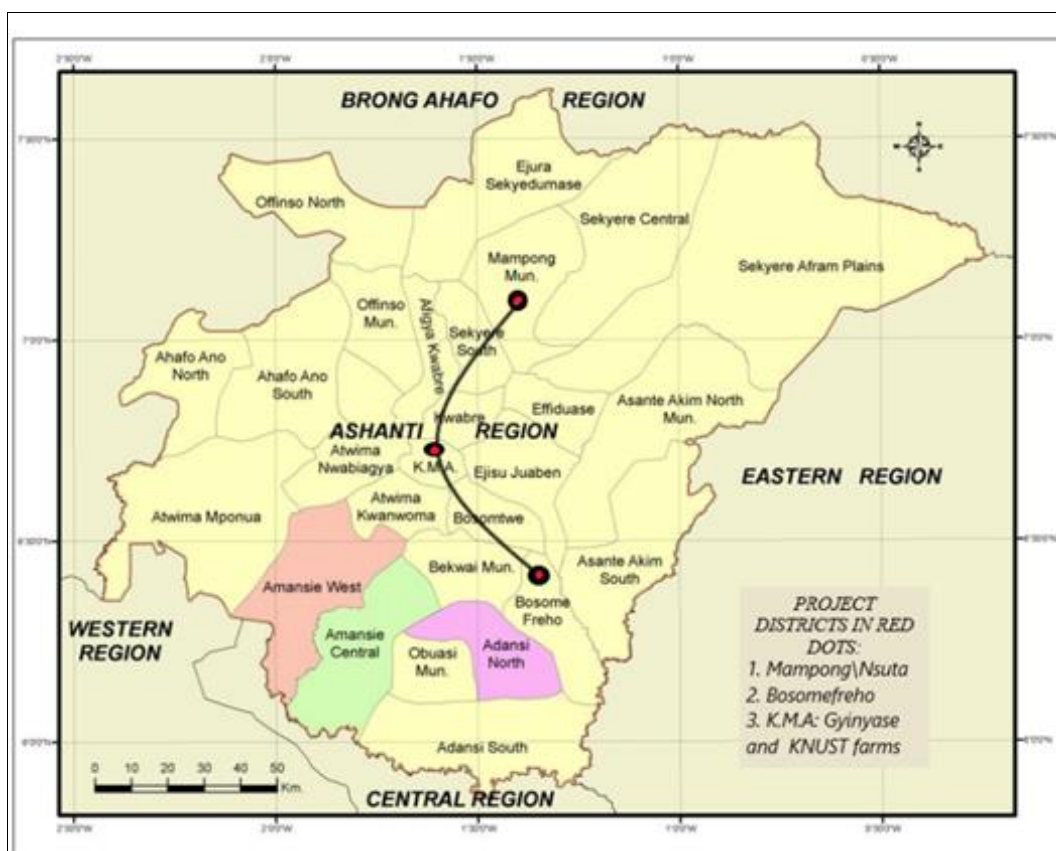
Several parasitoids are associated with *P. xylostella* and have the potential of being used for biological control of the pest (Shelton *et al.* 2002 [45], Dancau *et al.* 2020) [13], as outlined some years back in Indonesia, United States, New Zealand, Zambia and Australia (Lim, G. S., 1986) [29]. However, little is known in Ghana about the parasitoid species that attack *P. xylostella*. Good knowledge about the parasitoid taxa of *P. xylostella* would therefore help in preserving these species through sustainable farm practices such as judicious use of synthetic insecticides, and habitat manipulation with plant species that will reward parasitoids with floral resources to encourage the build-up of these natural enemies. This study

therefore aimed at identifying the endemic larval parasitoid taxa associated with the diamondback moth, *P. xylostella*, and their parasitism rate in field-collected larvae.

## Materials and Methods

### Study location

The study was conducted at the Entomology lab of CSIR-Crops Research Institute, Kumasi. Collection of *P. xylostella* larvae was done at the Bosome-Freho district, Mampong Municipal, and Kumasi Metropolitan Assembly of the Ashanti Region, Ghana. The Ashanti region is located in the middle belt of Ghana. It lies between longitudes 0.15W and 2.25W, and latitudes 5.50N and 7.46N. The Ashanti Region is in the tropical rainforest belt. (Bour *et al.*, 2019) [8], the mean annual rainfall is between 1100 mm and 1800mm. Similarly, the mean annual temperature ranges between 25.5<sup>0</sup>c in the southern districts and 32<sup>0</sup>c in the northern parts of the region (Bessah *et al.*, 2021) [7]. Cabbage production is an important activity in the region.



**Fig 1:** Map of the Ashanti Region of Ghana showing cabbage-producing sites visited.

### Sample size and collection

Larvae of *P. xylostella* were collected from infested but unsprayed cabbage farms in the districts as shown in Fig. 1. In Bosome-Freho and Mampong, three farms were selected such that farms were at least 2km apart. For Kumasi Metro, two communities; KNUST and Gyinyase were selected and three farms from each community were sampled. Larvae were brought to the lab for rearing. Potted cabbage plants at three weeks old were put in cages to serve as feed for the larvae.

*Plutella xylostella* larvae were monitored daily for the emergence of parasitoids or adult *P. xylostella*. The parasitoids that emerged from the larvae were recorded. Newly emerged adults *P. xylostella* were maintained in the cages, while newly emerged parasitoid species were removed

from the cage and kept in glass vials for identification. Parasitoids in glass vials were sustained on a sugar solution.

### Data Analysis

The analyses were done with the IBM Statistical Program for the Social Sciences (SPSS) version25 software. Mean values were taken for every community sampled. The significant difference and mean separation between the various means per community were analyzed using ANOVA as presented in table 1. All analyses were done at a 0.05 confidence level. The rate of parasitism (percentage parasitism) was calculated by the formula: Parasitism rate = the number of individuals (larvae + pupae) parasitized x 100 / total number of individuals (larvae + pupae) of *P. xylostella*.

## Results and Discussion

*Cotesia plutellae* was the parasitoid species identified on the larvae and pupae of *P. xylostella*. This larval endo-parasitoid was the only species found among the samples collected in all locations. The percentage of parasitism ranged between 13.9 – and 23%, with significant differences between locations (Table 1).

**Table 1:** Percentage parasitism of *P. xylostella* by *Cotesia plutellae* in the Ashanti region of Ghana

Location	Total number of larvae	Percentage parasitism
Bosomefreho	100	22.807 <sup>a</sup>
Gyinyase.	100	19.231 <sup>a</sup>
Nsuta.	100	12.903 <sup>b</sup>
K.N.U.S.T. farmland	100	13.235 <sup>b</sup>

## Discussion.

The results of this study revealed that *Cotesia plutellae* is prevalent in all the locations surveyed in the region. This parasitoid has been previously reported in the Accra plains of Ghana as the most abundant parasitoid species (Cobblah *et al.*, 2012) [12]. According to that study, *C. plutellae* accounted for about 92% of the parasitoids present.

While the same parasitoid species were present in all locations in the present study, the percentage of parasitism varied markedly between the locations. It could be realized that locations where cabbage is cultivated all year round and in larger acreages had higher parasitism percentages compared to locations with relatively smaller cabbage farms. Bosome-Freho is known to be the district with the highest cabbage production in the Ashanti region with severe *P. xylostella* infestation reported each year. Several farmers often abandon their cabbage crop due to overwhelmingly higher numbers of *P. xylostella* that become unmanageable (B. Amoabeng, Pers. Com). Natural enemies tend to be higher where there are higher numbers of prey and show aggregative numerical response (Goodwin, 1979 [56]; Cock, 1985 [57]; Alam, 1992 & Sow *et al.*, 2013a) as was observed by, and.

The 23% parasitism observed in the present study is an indication that *C. plutellae* can contribute significantly toward natural enemy-mediated *P. xylostella* management in the cabbage agro-ecosystem in the Ashanti region of Ghana if the application of synthetic insecticides can be regulated. Cabbage growers in the study locations especially the Bosome-Freho district often apply synthetic insecticides three times a week resulting in not less than 30 applications in one cabbage production cycle. Given the percentage of parasitism by *C. plutellae* amid high insecticides application, a greater percentage of parasitism would be realized if conditions in agroecology are improved to enhance parasite numbers and fitness.

In parts of Asia and Central America, *C. plutellae* has been reared and introduced in combination with other ecologically friendly methods to manage *P. xylostella* (Bennett *et al.* 1972 [6]; Sarfraz *et al.* 2005 [43]; Cobblah *et al.* 2012) [12]. Thus, relying on endemic parasitoids to manage *P. xylostella* could be a sustainable alternative to synthetic insecticides. Ooi (1992) noted that, until the extensive use of synthetic insecticides to manage pest insects of cabbage in the Cameroon highlands of Malaysia, *P. xylostella* was not a problem. This could be because there were adequate numbers of natural enemies in the agroecosystem but the introduction of insecticides eliminated these natural enemies. Similarly, in

their study in Jamaica, Alam & M. M (1990) [3] introduced *Cotesia plutellae* into the eastern Caribbean islands, and as a tropical region, it became readily established, along with *Oomyzus Sokolowski*, providing significant control of *P. xylostella*. From Mason *et al.*, (2022), introductions of *Cotesia vestalis*, *O. Sokolowski*, *Diadegma semiclausum Hellén* (Hymenoptera: Ichneumonidae), and *Diadromous collaris* enhanced suppression of diamondback moth by native parasitoids in other regions of the world.

Many countries still have serious problems with *P. xylostella* on brassica crops and this is due to the lack of crucially important parasites (parasitoids). These issues are likely to endure unless these important parasitoids are integrated into the host-parasite complex (Way 1976); additionally, completely ignoring them will condemn crucifer farming to ongoing dousing in ever-increasing volumes of insecticides.

While it is easier to understand a single parasitoid's biology and ecological requirements, the presence of only one parasitoid species in the study area presents a worrying situation. This is because any harmful condition in the ecosystem that negatively affects the survival and effectiveness of *C. plutellae* will cause significant ecosystem imbalance and cause the pest to rapidly multiply without any significant natural check of the pests' population.

The parasitoids of *P. xylostella* do constitute a valuable control component and resource if properly managed. However, effective utilization is generally not simple. Knowing the relative potential of the individual species and how they should be utilized is particularly important and could prove crucial in determining the outcome (Taleker and Shelton, 1993) [48].

*C. plutellae* as an established population in the Ashanti Region of Ghana is limited in terms of population size, but it is hoped that the parasitoid species once bred as a control measure will increase its populations, as in other Caribbean islands, and along with other indigenous natural enemies, to provide better control of *P. xylostella*. (Alam 1982 and 1986). Consideration should also be given to the introduction of other potential parasitoids, which have been tremendously successful in controlling diamondback moth populations, and could provide a model for the basics of a successful IPM program (Taleker and Shelton, 1993; Mason *et al.* 2020) [48, 13].

## Conclusion

*C. plutellae* was the parasitoid species identified on the larvae of *P. xylostella* population samples. Based on the current results, this can be explored as a potential biological control agent for *P. xylostella*. In addition, studies to determine parasitoids associated with other life stages including egg and pupae of *P. xylostella* would be vital.

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## Conflict of interest

The authors declare none.

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