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Population Fluctuation of Diamondback Moth, *Plutella xylostella* (L.) and its Natural Enemies in Cabbage Plantations as Influenced by Climatic Factors, Chemical and Biocide Compounds

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ABSTRACT

Experiments were carried out at El-Riad district, Kafr El-Sheikh Governorate, seasons 2008/09 and 2009/10 to study the population fluctuation of *Plutella xylostella* (L.) and its natural enemies in cabbage plantations, as influenced by some weather factors, biopesticids and insecticides. Population density of *P. xylostella* peaked in January, February, March and April. Surveyed spider species were found belong to nine families; Araneidae, Dictynidae, Lycosidae, Linyphiidae, Miturigidae, Philodromidae, Salticidae, Theridiidae and Thomisidae. Maximum number of insect predators (*Paederus alfierii, Chrysoperla carnea* and coccinellids) + spiders occurred in April. Six primary parasitoid species; *Trichogramma* sp., *Trichogrammatoidea* sp., *Cotesia plutellae* Kurdjumov, *Diadegma semiclausum* (Hellén). *Brachymeria* sp. and *Oomyzus sokolowskii* (Kurdjumov) and three hyperparasitoids; *Tetrastichus* sp., *Gelis agilis* (Fabricius) and *Trichomalopsis* sp., were also recovered from *P. xylostella*. Spiders in 2008/09 and temperature in 2009/10 had highly significant negative effect on *P. xylostella* population. In the laboratory, Neomyl was the most toxic compound to *P. xylostella* 2nd instar larvae, followed by Bermectine, while Bermectine was the most toxic compound to 4th instar larvae, followed by Neomyl. The results showed that BioGuard was highly toxic, while Biofly was moderate. Also, Neomyl and Bermectine were effective on egg hatchability, followed by Biofly (moderate), while BioGuard had slight effect. All tested compounds under field conditions caused reduction in infestation of *P. xylostella* larvae. Regarding the side effect of the tested compounds on predators, Neomyl was the highest while biopesticides were slightly harmful.

Key words: Population fluctuation, *Plutella xylostella*, parasitoids, predators, cabbage plantation, climatic factors, chemical compounds.

INTRODUCTION

The diamondback moth (DBM), *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) is a cosmopolitan pest and is considered the most destructive insect pest on crucifers worldwide (Vandenberg *et al.*, 1998 and Goh *et al.*, 2005). In Indonesia, this pest has been reported as a primary factor in limiting the production of cabbage (*Brassica oleracea* L.) (Ahmed *et al.*, 1998). It causes a considerable damage to cabbage plants, resulting in many losses particularly leaf quality.

Parasitoids are of great importance to regulate the population density of many of their hosts (Monnerat *et al.*, 2002 and Kassem *et al.*, 2008). The hymenopterans parasitoids can play an important role in the population regulation of *P. xylostella* (Talakar and Shelton 1993). The parasitoid species; *Cotesia plutellae*, *Diadegma insulare* and *Trichogramma* spp. are important factors in controlling diamondback moth populations (Fitton and Walker, 1992 and Azidah *et al.*, 2000). The solitary larval endoparasitoid, *C. plutellae* (Kurdjumov) was found as one of the major parasitoid of *P. xylostella* (Schuler *et al.*, 2004). In brassica growing areas of Southeast Asia, where the strategy of parasitoid release is likely to be most successful, two species of hymenopteran endo-larval parasitods, the ichneumonid, *Diadegma semiclausum* and the braconid *C. plutellae*, have established (Azidah *et al.*, 2000).

Disadvantages of chemical insecticides serve as a strong impetus for the development of alternative insect control measures. Particular attention, in recent years has been focused on biological control agents; including certain fungi and bacteria (Salem *et al.*, 2007 and Oke *et al.*, 2010).

The present work aimed to study seasonal abundance of diamondback moth attacking cabbage plants and its associated natural enemies under certain climatic factors, and the efficiency of some compounds on eggs and larvae of *P. xylostella* under laboratory conditions.

MATERIALS AND METHODS

The present study was conducted at El-Riad district, Kafr El-Sheikh Governorate, Egypt for two seasons 2008/09 and 2009/10.

Population fluctuation of diamondback moth and natural enemies in cabbage

Cabbage seedlings (*Berassica oleracea* var. *capitata* Linneu) were transplanted in three plantation dates; on 15th August, 20th November and 26th February in both seasons. An area of about a half feddan was divided into four equal plots and considered as four replicates. The cabbage plants were weekly examined, one month after transplanting, till the end of the crop season. At each inspection, 40 cabbage plants were inspected and number of *P. xylostella* (eggs, larvae and pupae) and associated natural enemies were counted on ten plants/ replicate in the field. Samples from diamondback moth larvae and pupae were collected, counted, kept and reared in the laboratory.

Spider catches were transferred to the laboratory. Individuals of spiders were classified for identification and counting.

The collected larvae were introduced individually into Petri dishes and provided with sections of cabbage leaves for feeding. The leaves were replaced every other day, until *P. xylostella* pupae or parasitoid cocoons formed. Also, the diamondback moth pupae were introduced into glass tubes. Egg, larvae and pupae of the pest were daily observed till the emergence of parasitoids, or diamondback moth adults. Emerged parasitoids were identified and their seasonal abundance was monitored. The pest larvae that escaped or died for unknown reasons and pupae that failed to emerge were excluded from the calculation of parasitism.

Climatic factors

Daily mean temperature and relative humidity were obtained from the Meteorological Station at Rice Research and Training Center at Sakha Agricultural Rèsearch Station. Sakha, Egypt.

Efficacy of the tested compounds against diamondback moth and predators

Tested chemicals and biocontrol agents

A- Pesticide: methomyl (neomyl) 90% Sp at 150 g /100L water.

B- Biopesticides: 1- abamectin (Bermectine) 1.8% EC at 40 ml /100L water.

C- Biofly (*Beauveria bessiana*) (Balsamo) (fungus) 3 X10^7 conidia/ml, at 150 ml/100 L water.

D- BioGuard (*Bacillus thuringiensis*) (bacteria) 30 million IU/g) at 250g/100L water.

Laboratory assessments

Toxicity tests of compounds were estimated by leaf disc dip technique, according to Siegler (1947). Formulated compounds were diluted to certain concentrations (ppm) and Biofly (conidia/ ml). Four discs from cabbage leaves were dipped in each concentration for 5 seconds and left to dry. Then, 10 larvae of diamondback moth were transferred to each disc. In case of eggs of diamondback moth, the discs containing the eggs were dipped in different concentrations of each treatment for 5 seconds. The discs were placed on moist filter paper, rested on moist cotton wool pad mounted in Petri dishes. Mortality counts were estimated 24, 48 and 72 hours after application. Mortality was corrected according to Abbott's Formula (1925).

Field assessments

Toxicological studies were carried out at a private field of cabbage (a half feddan) at El-Riad district, Kafr El-Sheikh Governorate during 2008/09 and 2009/10 seasons. The tested compounds were applied at recommended doses using a knapsack sprayer with one nozzle. Each treatment was replicated four times, in addition to an untreated area (check). The compounds were sprayed on 26th and 5th March in both seasons, respectively. The experiment was designed in a complete randomized block design.

Counts of *P. xylostella* larvae, eggs and predators were recorded before spraying on 40 cabbage plants/ treatment. Counts were also recorded 1, 3, 5, 7, 10 and 14 days after application for *P. xylostella* larvae. Laid *P. xylostella* eggs were marked and counted on cabbage leaves. Again, these eggs were counted to calculate their hatchability, when the hatchability of eggs in control treatments reached 95%. Percentage of reduction was calculated according to Henderson and Tilton (1955) equation.

RESULTS AND DISCUSSION

Population fluctuation of *Plutella xylostella*

Data illustrated in figs. (1&2) show the population density of *P. xylostella* eggs, larvae and pupae on cabbage plants in 2008 /09 and 2009 /10 seasons. In both seasons, infestation reached its peak on 11th December, 5th , 26th March and 9th April, for eggs, 25th December, 5th February, 26th March and 9th April for larvae and 29th January and 9th April for pupae in 2008/ 09 (Fig. 1). It peaked on 5th March and 16th April for eggs, 25th December, 5th February, 19th March and 2nd April for larvae and 29th January, 19th February and 2nd April for pupae, respectively in 2009/10 (Fig. 2). Mitchell *et al.,* (1997) found that numbers of DBM larvae per collared were inconsequential until mid-March and then increased rapidly to peak in late April. Densities of DBM larvae on collared plants in each collection date were greater than that on cabbage plants in the field. Maxwell and Fadamiro (2006) showed that infestation levels of the DBM varied with growing season. Generally, relatively higher population of the *P. xylostella* was recorded in spring season compared to the fall season.

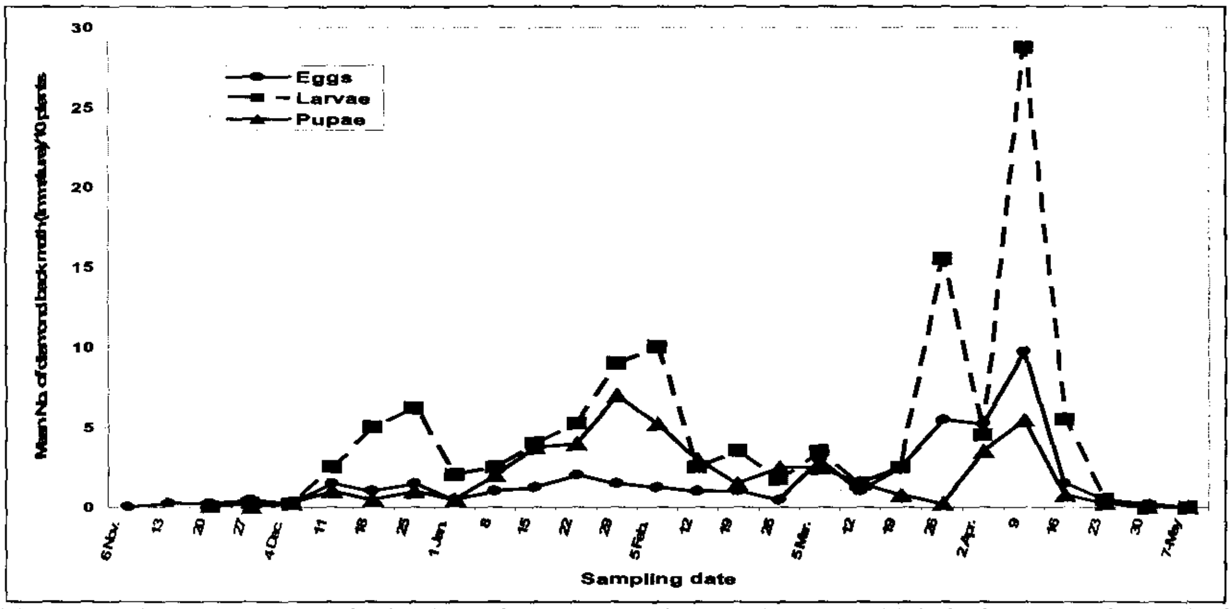

Fig. (1): Population fluctuation of *Plutella xylostella* on cabbage plants at El-Riad district, Kafr El-Sheikh Governorate in 2008/09 season.

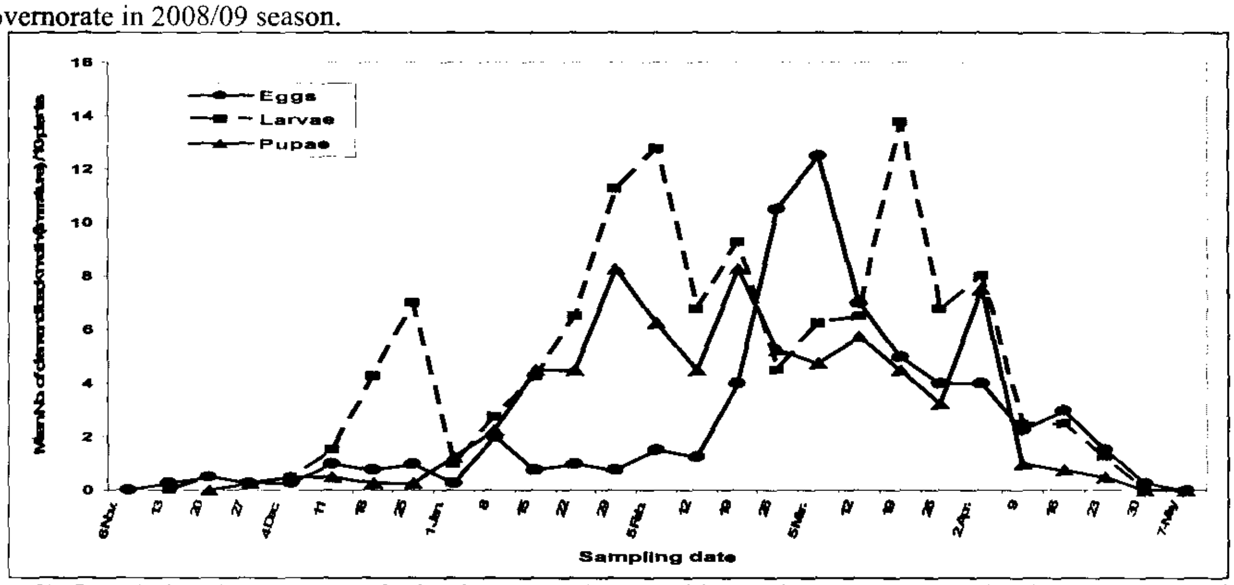

Fig. (2): Population fluctuations of *Plutella xylostella* on cabbage plants at El-Riad district, Kafr El-Sheikh Governorate in 2009/10 season.

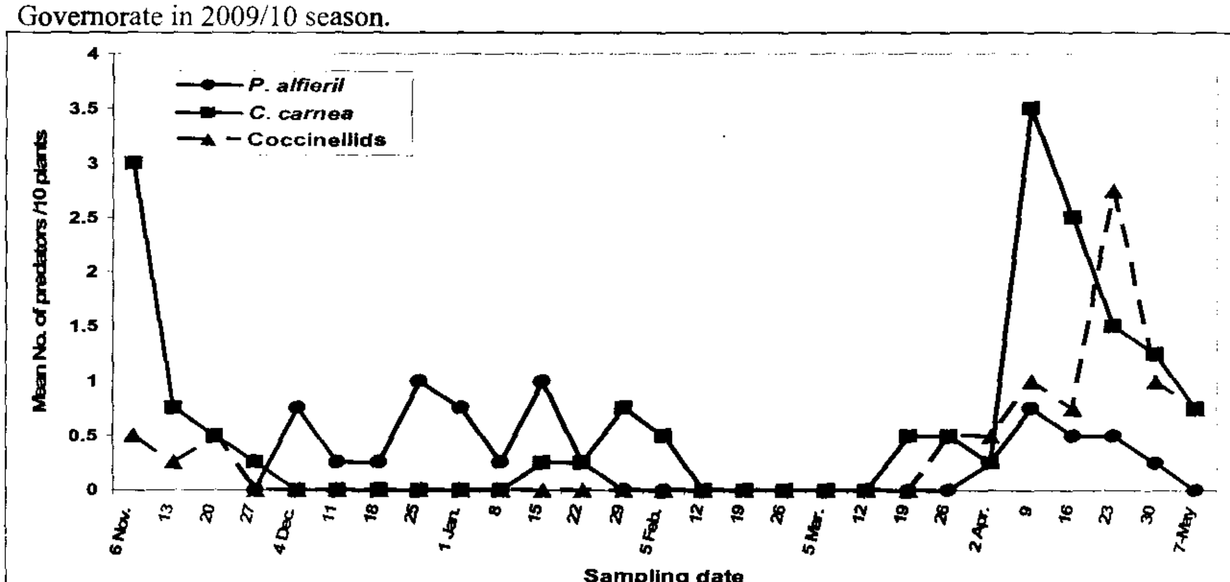

Fig. (3): Population fluctuations of predators on cabbage plants at El-Riad district, Kafr El-Sheikh Governorate in 2008/09 season.

Survey of parasitoids and hyperparasitoids

The survey of parasitoid species revealed the presence of two egg-parasitoid species: *Trichogrammatoidea* sp. and *Trichogramma* sp. (Fam.: Trichogrammatidae) recovered from the collected eggs of *P. xylostella*, two larval parasitoid species; *Cotesia plutellae* Kurdjumov (Fam.: Braconidae) and *Diadegma semiclausum* (Hellén) (Fam.: Ichneumonidae) emerged from the larvae and *Brachymeria* sp. (Fam.: Chacididae emerged from the pupae. In addition, *Oomyzus sokolowskii* (Kurdjumov) (Fam.: Eulophidae) attacked the pest larvae, but emerged from the pupal stage. Three hyperparasitoid species; *Tetrastichus* sp. (Fam.: Eulophidae), *Gelis agilis* (Fabricius) (Fam.: Ichneumonidae) and *Trichomalopsis* sp. (Fam.: Pteromalidae) recovered from the primary parasitoid; *C. plutellae.*

Abbas and El-Dakroury (1985) reported two larval parasitoids on *P. xylostella*, they were *Diadegma semiclausum* Hellen and *Apanteles* sp., and one larval-pupal parasitoid; *Tetrastichus sokolowskii* Kur. Also, Hassanein (1958) recorded *Microplitis plutellae, Apanteles* sp., *Meteorus* sp. and *Brachymeria femorata* as parasitoids of diamondback moth larvae or pupae in Egypt.

3- Survey and population fluctuation of predators

The study revealed the occurrence of *Paederus alfierii* and *Chrysoperla carnea* as well as the Coccinellids; *Coccinella. undecimpunctata* and *Scymnus* spp. Also, nine families of spiders were surveyed; Araneidae, Dictynidae, Lycosidae, Linyphiidae, Miturigidae, Philodromidae, Salticidae, Theridiidae and Thomisidae.

Population densities of the predators are presented in figs. (3 and 4). In 2008/09 and 2009/10 seasons, *C. carnea* was the most dominant predator and *P. alfierii* population was the least one. The highest population density of *P. alfierii* was recorded on 4th and 25th December, 15th January and 9th April in 2008/09 and 4th December, 5th March and 23rd April in 2009/10 (Fig. 3 and 4). Highest population of *C. carnea* was recorded on 6th November, 29th January and 9th April in the first season, and on 18th December, 15th January, 5th, 19th March and 16th April in the second season (Figs. 3 and 4). Coccinellids were recorded on 9th and 23rd April in the first season and on 19th March and 23rd April. Highest population of spiders was recorded on 6th November, 11th December, 8th January and 30th April in 2008/ 09 and 4th December, 15th January, 5th March and 30th April in 2009/10, respectively (Fig. 5).

Effect of climatic factors and predators on diamondback moth

Data in table (1) show that the temperature induced significant negative effect in 2008/09 and highly significant negative effect in 2009/10 on the population of DBM. Relative humidity had insignificant positive effect in 2008/09 and insignificant negative effect in 2009/10. The predators; *P. alfierii, C. carnea* and coccinellids had significant positive effects in 2008/09 and insignificant positive effects in 2009/10. Wakisaka *et al.*, (1992) found that temperature higher than 30°c delayed the development of diamondback moth and reduced the survival of immature stages and fecundity of females.

Spiders had highly significant negative effect in 2008/09 and insignificant positive effect in 2009/10. Henry (2008) reported that spiders feed on DBM eggs, larvae and pupae and further contribute to their mortality. Cordero (2009) found that a high percentage of DBM are killed during periods of heavy precipitation from disease and dislodging from the plants. Predators, entomopathogens and parasitoids attack all stage of DBM.

Combined effect of temperature, relative humidity and predators on *Plutella xylostella*

In general, combined effect (percentage of explained variance, Table 1) of the three factors on DBM was higher in the first season than in the second one. These interactions induced the greatest effect against the pest (50.80 and 40.20 %) in 2008/09 and 2009/10 seasons, respectively.

Laboratory studies

Toxicity of tested compounds to diamondback moth larvae and eggs

Results in table (2) indicated that Neomyl was the most toxic compound to *P. xylostella* 2nd instar larvae, followed by Bermectine, with LC_{50} values of 1.35 and 22.34 ppm after 24 hours, respectively. Bermectine was the most toxic compound to *P. xylostella* 4th instar larvae, followed by Neomyl, with LC_{50} values of 33.24 and 183.78 ppm after 24 hours, respectively.

Neomyl and Bermectine, with the recommended rate, half or quarter dose, are the most effective compounds on *P. xylostella* eggs. Biofly was moderate at the recommended rate, except half and quarter doses, which were less effective. BioGuard had slight effects on *P. xylostella* eggs at recommended rate (Table, 3).

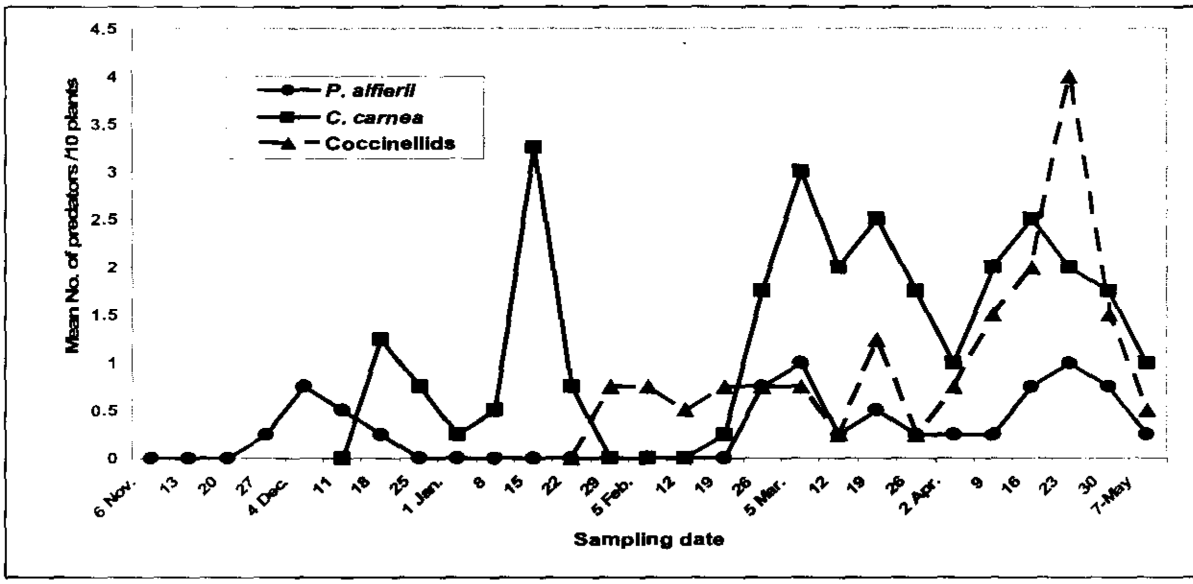

Fig. (4): Population fluctuations of predators on cabbage plants at El-Riad district, Kafr El-Sheikh Governorate in 2009/10 season.

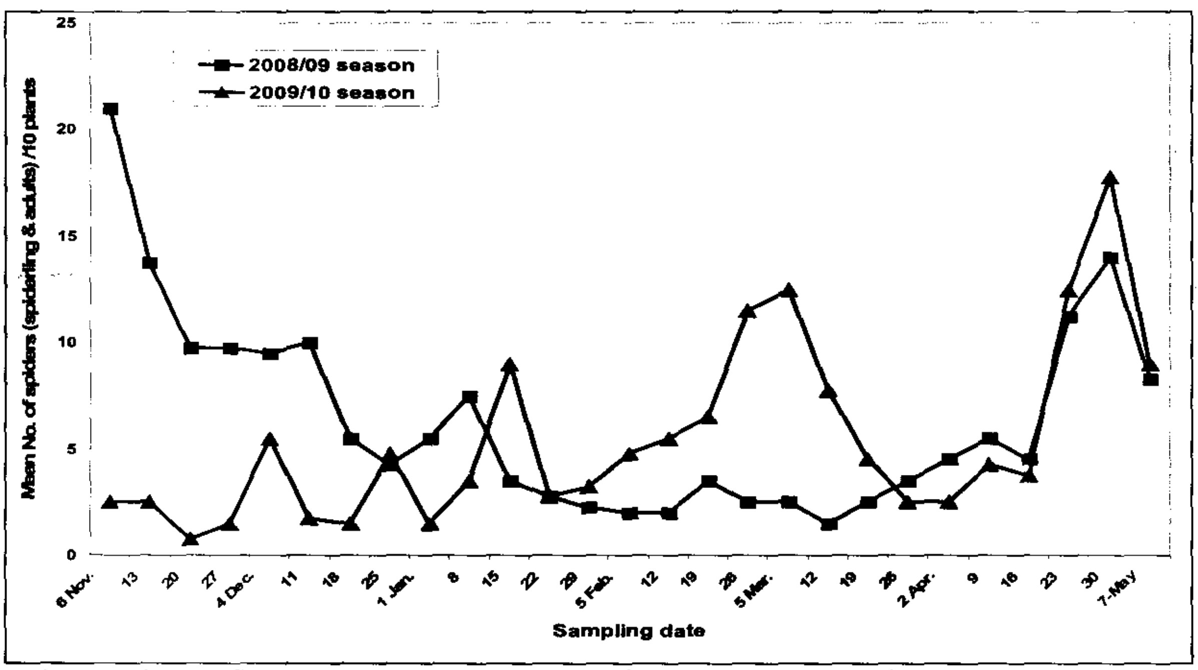

Fig. (5): Population fluctuations of spiders on cabbage plants at El-Riad district, Kafr El-Sheikh Governorate.

Table (1): Partial correlation (r) and regression coefficient (B) between each of climatic factors, predators and the population of *Plutella xylostella* on cabbage at El-Riad district, Kafr El-Sheikh Governorate seasons 2008/0 and 2009/10

Season	Variables	*Plutella xylostella*		
		r	B	E.V%
	Mean temperature (c°)	-0.3501*	-0.741*	
2008/09	Mean R.H (%)	0.1196	0.216	50.80
	Predators	0.6130*	3.871*	
	Spiders	-0.5746**	-0.635**	
	Mean temperature (c°)	-0.6053**	-1.414**	
2009/10	Mean R.H (%)	-0.2552	-0.412	40.20
	Predators	0.1145	0.361	
	Spiders	0.2254	0.363	

Table (2): Efficacy of tested compounds against *Plutella xylostella* larvae under laboratory conditions

Compound	Unit	LC_{50}	Confidence limits for LC_{50} Lower	Confidence limits for LC_{50} Upper	Slope	LC_{90}	Confidence limits for LC_{90} Lower	Confidence limits for LC_{90} Upper
	Second instar							
Neomyl	ppm	1.35	0.071	3.51	0.56	266.37	184.71	82934.99
Bermectine	ppm	22.34	18.39	26.39	1.46	169.82	117.71	288.11
Biofly	conidia/ml	36861.83	31894.79	42322.02	2.23	138840.00	107920	200640
BioGuard	ppm	47.70	39.10	58.01	1.40	395.00	265.60	706.64
	Fourth instar							
Neomyl	ppm	183.78	153.00	217.55	1.65	1104.31	824.66	1653.45
Bermectine	ppm	33.24	27.73	40.52	1.51	235.47	159.16	414.06
Biofly	conidia/ml	30341.90	25617.81	35153.37	2.09	124790.00	96663.73	182350.00
BioGuard	ppm	36.14	28.96	44.05	1.37	313.66	214.62	548.20

Table (3): Potency of tested compounds in reducing *Plutella xylostella* eggs hatchability under laboratory conditions

Compound	Rate /100 liter of water	No. of treated eggs Hatchability	No. of treated eggs Unhatchability	% hatched eggs
Pesticide				
	150 g	00.00	40.00	00.00
Neomyl	75 g	00.00	40.00	00.00
	37.5 g	1.00	39.00	2.50
Biopesticides				
	40 ml	00.00	40.00	00.00
Bermectine	20 ml	00.00	40.00	00.00
	10 ml	2.00	38.00	5.00
	150 ml	20.00	20.00	50.00
Biofly	75 ml	34.00	6.00	85.00
	37.5 ml	38.00	2.00	95.00
BioGuard	250 g	34.00	6.00	85.00
	125 g	40.00	00.00	100.00
	62.5 g	40.00	00.00	100.00
Untreated*	-	40.00	00.00	100.00

Table (4): Potency of tested compounds in reducing *Plutella xylostella* larvae populations on cabbage plants at El- Riad district, Kafr El-Sheikh Governorate, seasons 2008/09 and 2009/10

Compound	Rate/ 100 liter of water	season	Number pre-treatment /10 plants	Initial effect %	Residual effect after 3 days	5	7	10	14	Residual effect average	Grand average
Pesticide		2008/09									
Neomyl	150 g		52.25	99.13	98.34	98.06	96.54	94.77	86.12	94.77	95.49
Biopesticides											
Bermectine	40 ml		47.50	97.11	96.76	96.93	95.51	88.88	75.89	90.79	91.85
Biofly	150 ml		42.75	54.08	90.98	95.43	94.63	81.43	71.35	86.76	81.32
BioGuard	250 g		40.00	73.78	86.10	65.33	62.38	40.88	35.67	58.07	60.69
Untreated*	-		56.25	58.75	61.00	64.25	67.50	71.25	75.50	-	-
Pesticide		2009/10									
Neomyl	150 g		52.75	100.00	99.62	99.33	98.67	95.75	85.56	95.79	96.49
Biopesticides											
Bermectine	40 ml		43.00	98.89	99.56	98.80	97.61	93.55	73.58	92.62	93.67
Biofly	150 ml		46.50	55.47	91.96	96.98	96.81	84.55	74.56	88.97	83.39
BioGuard	250 g		43.50	72.49	86.74	65.28	63.44	38.97	33.97	57.68	60.15
Untreated*	-		58.75	60.00	66.50	76.00	80.25	74.25	78.75	-	-

* Numbers

Table (5): Potency of tested compounds in reducing *Plutella xylostella* egg hatchability on cabbage plants at El-Riad district, Kafr El-Sheikh Governorate seasons 2008/09 and 2009/10

Compound	Rate /100 liter of water	season	Av. Number of eggs pre- treatment	Av. Of hatched eggs	% Reduction in egg hatchability
Pesticide					
Neomyl	150 g		48.50	1.25	97.42
Biopesticides					
Bermectine	40 ml	2008/	40.25	1.25	97.22
Biofly	150 ml	09	31.00	18.75	39.33
BioGuard	250 g		31.50	30.50	3.26
Untreated*	-		46.00	45.00	-
Pesticide					
Neomyl	150 g		47.75	2.00	96.19
Biopesticides					
Bermectine	40 ml	2009/10	43.25	2.00	95.82
Biofly	150 ml		34.25	24.50	28.49
BioGuard	250 g		35.25	33.50	4.84
Untreated*	-		43.75	43.75	-

* Numbers

Table (6): Potency of tested compounds in reducing predator[¤] populations on cabbage plants at El-Riad district, Kafr El-Sheikh Governorate seasons 2008/09 and 2009/10

Compound	Rate/ liter of water	season	Number pre-treatment /10 plants	% Reduction							
				Initial effect %	Residual effect after indicated days					Residual effect average	Grand average
					3	5	7	10	14		
Pesticide											
Neomyl	150 g	2008/09	26.25	37.09	31.78	24.05	17.55	10.24	3.80	17.48	20.75
Biopesticides											
Bermectine	40 ml		25.75	5.73	2.25	00.00	00.00	00.00	00.00	0.45	1.33
Biofly	150 ml		25.25	5.27	2.01	00.00	00.00	00.00	00.00	0.40	1.21
BioGuard	250 g		27.00	0.70	0.09	00.00	00.00	00.00	00.00	0.02	0.13
Untreated*	-		28.50	30.50	32.00	33.75	35.00	36.50	38.25	-	-
Pesticide											
Neomyl	150 g	2009/10	26.75	33.19	27.47	22.31	15.23	7.45	2.12	14.92	17.96
Biopesticides											
Bermectine	40 ml		25.75	4.51	1.71	00.00	00.00	00.00	00.00	0.34	1.04
Biofly	150 ml		25.50	4.87	1.40	00.00	00.00	00.00	00.00	0.28	1.05
BioGuard	250 g		28.50	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00
Untreated*	-		29.00	30.75	32.25	35.50	37.00	39.25	40.00	-	-

* Numbers

Toxicity of Biofly and BioGuard are presented in table (2). Results showed that the LC_{50} to *P. xylostella* 2^{nd} and 4^{th} instar larvae after 72 hours were 36861.83 and 30341.90 conidia/ ml for Biofly and 47.70 and 36.14 ppm for BioGuard, respectively. Success and Kryocide generally maintained larger-sized DBM larval numbers below or similar to the untreated check at most rating dates. The current data agree with those of Ahmad (1999) and Goh *et al.* (2005).

Follow–up the potency of compounds

Effect of the tested compounds on *P. xylostella* larvae is presented in table (4). Data revealed that Neomyl was the most potent compound in reducing the population density of DBM in 2008/09 and 2009/10 seasons, with reduction rate of 95.49 and 96.49 %, respectively. Neomyl was followed by Bermectine and Biofly. Biofly showed suitable residual effect, since it reduced the population with > 80 %. BioGuard was the least effective compound.

Chalfant (1992) showed that the pyrethroid insecticides tested including permethrin and esfenvalerate were generally incapable of controlling the DBM, although the high rates produced more than 95% marketable heads in some tests. Microbial pesticide (*B. thuringiensis* Berlliner) products; Dipel, Javelin, Cutlass and MVP were moderately effective against the pest. Soares and Quick (1992) showed that *B. thuringiensis* variety ***kurstaki*** was highly active against DBM. Yasudomi *et al.*, (1992) found that benfuracarb was effective up to 28 day after application against DBM. Over 90 % control was observed up to 28 days after application. Umeda *et al.* (1997) stated that cabbage treated by Xentari, Alert, Confirm and Proclaim exhibited larger–sized DBM larvae as compared to the check. Maxwell and Fadamiro (2006), Salem *et al.*, (2007) and Oke *et al.*, (2010) reported that microbial pesticides gave satisfactory results against diamondback moth.

Of the three tested insecticides to control DBM *P. xylostella* in cabbage, Teflubenzuron was found to be the most effective, followed by Lufenuron, while the least effective insecticide was *B. thuringiensis* (Oke, 2008).

Neomyl and Bermectine were the most effective compounds in reducing DBM eggs. While Biofly was the least effective compound. BioGuard had slight effects in this in respect (Table, 5).

Predators

Side toxic effects of tested compounds on the predators are summarized in table (6). Data revealed that Neomyl was the highest harmful compound against predators. The other tested compounds had slight affects. Yasudomi *et al.*, (1992) studied the effect of benfuracarb 5G arthropods was investigated when 2g of the granules were applied to broccoli in the field, no adverse effect was observed on the population of spiders, important predators of diamondback moth. Maxwell and Fadamiro (2006) recorded that no significant effects of bioinsecticide treatments on numbers of spiders and lady beetles found per plant in cole crop in Alabama.

In conclusion, *P. xylostella* population peak was in January, February, March and April. Spiders were the most dominant predators. Natural enemies, especially predatory spiders and parasitoids, can be important against the pest on cabbage plants. A combined effect of predators and weather factors on the population density of *P. xylostella* was higher in the first season than in the second one. Neomyl was the most toxic compounds on *P. xylostella* (eggs and larvae) and predators. The biopesticides proved to be promising and could be used as alternative insecticides in the future for controlling *P. xylostella* and be safe at the same time for natural enemies.

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REFERENCES

Abbas, M.S.T. and M.S.I El–Dakroury 1985. Some natural enemies of the diamondback moth, *Plutella xylostella* L.Minia J. Agric. & Dev.7, (2): 671-679.

Abbott, W. W. (1925). A method of computing the effectiveness of an insecticide. J. Econ. Entomol., 18 : 265 – 267.

Ahamd, I. 1999. Dosage mortality studies with *Bacillus thuringiensis* and Neem extract on diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae). Indonesian J. Plant Protect., 5 (2): 67– 71.

Ahamd, I.; A. D. Permana; R. Rahadian and S. A. Wibowo 1998. Developing a Neem-based pest management product: laboratory evaluations of Neem extracts on insect pests resistance to synthetic pesticides. P. 21-28 In: Riyanto, B. (ed.), Seminar on Research Findings Assisted by the Asahi Glass Foundation 1998. Proceedings, ITB. Supplement Vol. 30, No. 2.

Azidah, A.A., M.G. Fitton and D.L.J. Quicke 2000. Identification of the *Diadegma* species (Hymenoptera: Ichneumonidae, Campopleginae) attacking the diamondback moth, *Plutella xylostella* (Lepidoptera: Plutellidae) Bull Entomol. Res.; 90(5): 375-89.

Chalfant, R. B. 1992. Microbial and other insecticides to control lepidopterous pests of cole crops in Georgia. P. 139–146. In: N. S. Talekar (ed.). Diamondback moth and other crucifer pests. Proceedings of the second International Workshop, Tainan, Taiwan: 10 – 14 December, 1990.

Cordero, R. J. 2009. Diamondback moth in Virginia. Communications and Marketing, College of Agriculture and Life Sciences, Virginia Polytechnic Institute and State University Cooperative Extension, Publication 444-007: 1-3.

Fitton, M.G. and A. K. Walker 1992. Hymenopterous parasitoids associated with diamondback moth: the taxonomic dilemma. P. 225–232. In: Talekar N. S. (Ed.). Diamondback moth and other crucifer pests. Proceedings of the Second International Workshop, Tainan, Taiwan.

Goh, H. G.; D. B. Gelman; P. A. W. Martin; A. D. S. Shropshire; D. L. Rowley; M. B. Blackburn; I. Y. Choi and R. R. Farrar 2005. Insecticidal effect of new strains of *Bacillus thuringiensis* on the diamondback moth *Plutella xylostella*. 6th Pacific Rim Conference on the Biotechnology of *Bacillus thuringiensis* and its Environmental Impact, Victoria BC, 94-96.

Hassanein, S. M. H., 1958. Biological studies on the diamondback moth *Plutella maculipennis* Curtis. Bull ent. Soc. Egypte, 42: 325-337.

Henderson, C. F. and E. W. Tilton 1955. Test with acaricides against the brown wheat mite. J. Econ. Entomol., 48 : 157-161.

Henry, K. 2008. Diamondback moth in canola. ISSN 1323- 0409 August FS 03/08.

Kassem, S. A.; A. S. Hendawy; S. A. Azab and W. A. Shahawy 2008. Diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) in cabbage and associated parasitoids at Kafr El-Sheikh and Gharbia regions. Egypt, J. Agric. Res., 86 (3): 981-988.

Maxwell, E. M. and H. Y. Fadamiro 2006. Evaluation of several reduced-risk insecticides in combination with an action threshold for managing lepidopteran of cole crops in Alabama. Florida Entomologist, 89(2): 117 – 126.

Mitchell, E. R.; G. Y. Hu and J. S. Okine 1997. Diamondback moth (Lepidoptera: Plutellidae) infestation and parasitism by *Diadegma insulare* (Hymenoptera: Ichneumonidae) in collards and adjacent cabbage fields. Florida Entomologist, 80 (1) : 54 – 62.

Monnerat, R. G.; A. A. Kirk and E. D. Bordat 2002. Biology of *Diadegma* sp. (Hymenoptera: Ichneumonidae), a parasitoid of *Plutella xylostella* (L.) (Lepidoptera: Yponomeutidae), from reunion Island. Neotropical Entomology, 3 (2): 271– 274.

Oke, O. A. 2008. Evaluation of the effectiveness of three insecticides to control diamondback moth (*Plutella xylostella*) in cabbage (*Brassica oleracea* var. *Capitata* L.). European J. Sci. Res., ISSN 1450-216X 22 (3): 391-395.

Oke, O. A.; N. C.; C. Ismael and D. Lesperance 2010. Efficacy of a botanical and biological method to control the daimondback moth (*Plutella xylostella* L.) in cabbage (*Brassica oleracea* var. *capitata* L.) under open field conditions at anse boileau, seychelles. J. Agric. Ext. Rural Dev., 2 (7): 141-143.

Salem, S. A.; H. A. Abdel-Rahman; C. P. Zebitz; M. M. Saleh; I. F. Ali and M. Y. El-Kholy 2007. Evaluation of entomopathogenic nematodes in controlling some cabbage pests. J. Appl. Sci. Res., 3 (4): 323 - 328.

Schuler, T. H., I. Denholm, S. J. Clark, C.N. Stewart, G.M. Poppy 2004. Effects of *Bt* plants on the development and survival of the Parasitoid *Cotesia plutellae* (Hymenoptera: Braconidae) in Susceptible and *Bt*-resistant larvae of the diamondback moth, *Plutella xylostella* (Lepidoptera: Plutellidae). J. Insect Physiol. 50: 435–443

Siegler, E. H. 1947. Leaf- disc technique for laboratory tests of acaricides. J. Econ. Entomol., 40 : 341- 442.

Soares, G. G. and T. C. Quick 1992. MVP, a novel bioinsecticide for the control of diamondback moth. P. 129–137. In: N. S. Talekar (ed.). Diamondback moth and other crucifer pests. Proceedings of the Second International Workshop, Tainan, Taiwan: 10–14 December, 1990.

Talekar, N. S. and A. S. Shelton 1993. Biology, ecology and management of diamondback moth. Annu. Res. Entomol., 38: 275-301.

Vandenberg, J. D.; A. M. Shelton; W. T. Wilsey and M. Ramos 1998. Assessment of *Brevicoryne brassicae* spray for control of diamondback moth (Lepidoptera: Plutellidae) on crucifers. J. Econ. Entomol., 91 (3) : 624 - 630.

Wakisaka, S.; R. Tsukuda and F. Nakasuji 1992. Effects of natural enemies, rainfall, temperature and host plants on survival and reproduction of the diamondback moth. P. 15–26. In: N. S. Talekar (ed.). Diamondback moth and other crucifer pests. Proceedings of the Second International Workshop, Tainan, Taiwan: 10 – 14 December, 1990.

Yasudomi, N.; T. Miyata; K. Murai and N. Umetsu 1992. Use of benfuracarb in the integrated management of diamondback moth. P. 333–340. In: N. S. Talekar (ed.). Diamondback moth and other crucifer pests. Proceedings of the Second International Workshop, Tainan, Taiwan: 10 – 14 December, 1990.

الملخص العربى

التذبذب العددى للفراشة ذات الظهر الماسى *Plutella xylostella* (L.) وأعدائها الحيوية فى حقول الكرنب وتأثير العوامل المناخية و المركبات الكيماوية والبيولوجيه عليها

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تم إجراء البحث بمركز الرياض محافظة كفرالشيخ – مصر عامى2008 /09 ،2009 /10 لدراسة الكثافة العددية لحشرة الفراشة ذات الظهر الماسى *Plutella xylostella* (L.) واعدائها الحيوية فى زراعات الكرنب تحت بعض الظروف الجوية. كما تمت دراسة فاعلية بعض المركبات على بيض ويرقات الفراشة فى المعمل و الحقل. وكذلك دراسة الأثر الجانبى للمركبات المختبرة على المفترسات. أظهرت النتائج تذبذب تعداد الفراشة خلال فترات الفحص و كان أعلى كثافة عددية لها فى أشهر يناير وفبراير ومارس وابريل فى كلا الموسمين. بينما كان أعلى تعداد فى شهر ابريل للمفترسات (الرواغة، أسد المن، أبى العيدات العناكب). كان للأعداء الحيوية خاصة العناكب دورا هاما فى مكافحة الآفة فى حقول الكرنب. تم تسجيل تسعة طفيليات منها ستة طفيليات أولية و ثلاثة طفيليات ثانوية. دلت النتائج أن هناك تأثير للظروف الجوية و المفترسات على تعداد الآفة، حيث كانت العناكب ذات معنوية سالبة فى الموسم الأول و درجات الحرارة ذات معنوية سالبة فى الموسم الثانى. كما كان التأثير المشترك للعوامل الجوية والمفترسات على الفراشة واضحاً. أظهرت النتائج فى المعمل أن مركب النيوميل كان أكثر المركبات فاعلية يليه البرمكتين على العمر اليرقى الثانى بينما كان البرمكتين أكثر المركبات فاعلية يليه النيوميل على العمر اليرقى الرابع للفراشة. كان البايوجارد ذو فاعلية عالية بينماالبيوفلاى كان متوسط الفاعلية على يرقات الآفة. كانت مركبات النيوميل و البرمكتين أكثر المركبات فاعلية ضد فقس البيض وتلا هذه المركبات البيوفلاى (متوسط) بينما أعطى البايوجارد أقل تأثير فى خفض معدل فقس البيض. أظهرت النتائج تحت الظروف الحقلية أن كل المركبات المختبرة قد أدت إلى خفض تعداد الفراشة على نباتات الكرنب مع تفاوت نسب الخفض فى الإصابة. كانت مركبات النيوميل و البرمكتين أكثر المركبات سمية ضد بيض ويرقات الفراشة، وتلا ذلك البيوفلاى والبايوجارد على اليرقات. أعطى البيوفلاى سمية قليلة على فقس البيض والبايوجارد سمية طفيفة. عند دراسة الأثر الجانبى للمركبات المختبرة على المفترسات المصاحبة للآفة ظهر أن النيوميل كان أعلاها سمية أما المركبات الميكروبية فلم يكن لها تأثير ضار على المفترسات.

كلمات مفتاحية: التذبذب العددى، الفراشة ذات الظهر الماسى، *Plutella xylostella* (L.) ، الأعداء الحيوية، حقول الكرنب العوامل المناخية، مركبات كيماوية، مصر.