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Research Article A Study on Infestation Factors of Cycas and Zamia Palms with Butterfly, *Chilades pandava* and its Control in Egypt

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Abstract

Background and Objective: *Cycas revoluta* and *Zamia encephalartoides* were commercially ornamental palms. Butterfly, *Chilades pandava* was an important pest of ornamental palms either cycas or zamia. Impact factors on *C. pandava* infestations on cycas and zamia palms were studied. **Materials and Method:** Two field experiments were carried out during the period from 1st January-15th December, 2018 in a private palm nursery at Abu-Ghaleb village, Giza, Egypt to study the infestation of *C. pandava* on cycas and zamia palms and also, provided its control strategies. **Results:** The infested percent of *C. pandava* was recorded the highest values at 1st week of May and September, 2018 with 63.89 % on cycas palms. Whereas, the high value of the infestation percent was 66.67% on zamia palms. A positive effect was reported with maximum and minimum temperatures but a negative effect was recorded with average RH% on *C. pandava* infestations. The increasing of the *C. pandava* infestations decreased these 2 plant enzymes, peroxidase and phenoloxidase. The average reduction percentages of the tested 9 pesticides against *C. pandava* infestations on cycas palms were markedly higher in case of sulfur 70% SC and fipronil 80% WG being 69.88 and 61.30% reductions than other treatments after 3 sequential applications throughout 3 months, respectively. **Conclusion:** *Chilades pandava* infestation was higher on cycas palms than zamia palms. Sulfur and Fipronil were more efficacy pesticides against this pest.

Key word: Chilades pandava, lepidoptera, lycaenidae, cycas, zamia, infestation, control, pesticides

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Cycads are belong Cycadales, including threatened group of plant species on Earth. This gymnosperms order including Cycadaceae, Stangeriaceae and Zamiaceae and contained more than 330 species¹. *Cycas revoluta* (Cycadaceae) and *Zamia encephalartoides* (Zamiaceae) are commercially ornamental palms in Egypt^{2,3}. *Chilades* butterfly was a genus belong family Lycaenidae: Order Lepidoptera. Lycaenidae was contained over 6,000 species worldwide⁴. The invasive lycaenid blue butterfly, *Chilades pandava* (Horsfield⁵) was an important pest of ornamental palms either cycas or zamia^{3,6}.

This pest found in Spain in 1996 on *Cycas revoluta*⁷. This species was originally found in the oriental region from India to Philippines, after that, invaded Kora and Japan⁸. Then it was recorded in Mauritius by Macdonald *et al.*⁹ and also in Sulawesi by Vane-Wright and de Jong¹⁰. Moore *et al.*¹¹ mentioned that *C. pandava* is native to southern Asia invaded Guam. Wu *et al.*¹² mentioned that *C. pandava* butterfly was recorded in Kinmen offshore of Fujian for the first time in 2007.

This Lepidopteran insect was related with native cycas within its indigenous range. It caused numerous damages to cycas populations in its habitats¹³. Blue butterfly, *C. pandava* was firstly found and recorded in September, 2012 from privet garden at Birqash district, Giza, Egypt¹⁴. *Chilades pandava* has ability to produce numerous generations/years under different climatic conditions¹⁵. In Alexandria governorate and the North coast in Egypt, lycaenid butterfly infested *Cycas revoluta*, *C. rumphii* and *C. circinalis* palms².

Highly extent of *C. pandava* damages caused by larvae in the newly emerging leaves due to the palatability to larvae^{6,16}. Among of 85 cycas species was exposed by severe damages which caused by *C. pandava* in Thailand¹³. The caterpillars of butterfly *C. pandava* feed on numerous cycas (Sago palm, *Cycas revoluta*). Larvae bored into young shoots¹⁴. *Chilades pandava* produced several generations/year under weather conditions¹⁵.

Naik *et al.*¹⁶ reported the butterfly, *C. pandava* infestation on Sago palm, *Cycas revoluta* during period from June-August. The infestation of *C. pandava* on cycas micronesica throughout 6 months¹⁷. Moreover, Liu *et al.*¹⁸ found that 2 peaks of *C. pandava* stages was detected in May and October on some cycad gardens. The 5 generations/year of blue butterfly on ornamental plants was recorded by Wei¹⁹. Kunte and Tiple¹⁵ reported that several butterfly species induced seasonal forms known as seasonal polyphenism. Butterfly, *C. pandava* responded to seasonal variation between biotic and abiotic conditions²⁰. *Chilades*

pandava not only infested ornamental plants but also, it attached the flowers of cowpea, *Vigna unguiculate* (L.). The blue butterfly *C. pandava* control based on neem sprays was conducted by Naik *et al.*¹⁶.

Appropriate pest control strategies for this Lepidopteran insect have not been developed because lack data on its infestation in Egypt is insufficient. Therefore, the objective of this study not only flags on the infestation of the invasive blue cycad butterfly, *Chilades pandava* but also provides a clearly information case of its control strategies.

MATERIALS AND METHODS

In field studies, *Chilades pandava* infestations and its control were investigated on 2 ornamental palms, cycas (*Cycas revoluta*) and zamia (*Zamia encephalartoides*), which recently first recorded on Egyptian country¹⁴ since 2012. Initially, numerous visitations to cycas and zamia nurseries was conducted at Abu-Ghaleb village, Giza governorate, Egypt and then the samples of *C. pandava* species and its infested parts were collected from this region. The collected samples were kept in a tightly closed paper bags and transferred to identify at insect identification unit, Taxonomy Research Department, Plant Protection Research Institute at 13th November, 2017.

After that, two field experiments were carried out during the period from 1st January-15th December, 2018 in a private palm nursery at Abu-Ghaleb village.

1st experiment: Experimental area was divided into 6 blocks (3 blocks for cycas palms and 3 blocks for zamia palms, each block contained 12 palms as replicate which cultivated in 3 rows with 1.5 m distance apart). Sample of 5 leaves/palm tree was randomly inspected by 10X magnified lens from each replicate at 15 days interval for determining the mean number of deposited eggs on both 2 host plants. The experimental blocks were laid out in a randomized complete block design. The mean numbers of infested palms was determined by mean numbers of palms with dead heart per replicate (each replicate was 12 palms). Also, the infested percentage was calculated on both tested host plants. All experimental blocks received the normal agricultural practices. For studying the relationship between C. pandava infestations and some phytochemical components, the total protein, nitrogen, total carbohydrate, total phenols and total flavonoids were estimated at Chemical Analysis Constituent, Insect Physiology Department, Plant Protection Research Institute according to the methods of Bradford²¹, Sadasivam and Manickam²², Crompton and Birt²³, Singleton and Rossi²⁴ and Zhishen *et al.*²⁵, respectively. Moreover, the impact of 2 plant enzymes, phenoloxidase and peroxidase activities on *C. pandava* infestations was determined. The sample plant of enzymes was prepared according to Ni *et al.*²⁶ and both 2 plant enzymes were determined by methods of Ishaaya²⁷ and Vetter *et al.*²⁸ at above mentioned constituent, respectively.

2nd experiment: Efficacy of 9 pesticides against *C. pandava* infesting cycas palms was carried out in other private ornamental plants nursery to determine the suitable pesticide for its control during 3 months (April-July, 2018) at Abu-Ghaleb village. An experiment was divided into 30 blocks; each block contained 10 cycas palms as a replicate (6 blocks in length and 5 blocks in width). The 10 treatments were laid out in a randomly block design, each treatment was replicate three times. An untreated check treatment was kept without any pesticides. The rates of nine pesticide applications were used as in Table 1.

To estimate insecticide efficacy of these pesticides against *C. pandava*, mean numbers of infested palms (with dead hearts) per replicate (each replicate was involved 10 palms) for each block were detected after 1st, 2nd and 3rd months after applications by visual inspection in the field. Pre-counts were made for all blocks to determine the initial count of *C. pandava* infestations. Reduction (%) was calculated according to Henderson and Tilton²⁹:

Reduction (%) =
$$\left(\frac{\text{Ta} \times \text{Cb}}{\text{Tb} \times \text{Ca}} - 1\right) \times 100$$

Where:

Ta = Treatment after spray

Cb = Control before spray

Tb = Treatment before spray

Ca = Control after spray

Statistical analysis: The data were analyzed the variance and the values were compared by t-test, f-test ($\alpha = 0.05$),

Table 1: List	of	9	pesticide	applications
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calculated least significant difference (LSD), simple correlation and calculated explained variance (E.V. %) by using SAS program computer³⁰.

RESULTS

Data tabulated in Table 2 showed that the population abundance of *Chilades pandava* eggs/5 leaves/palm tree on cycas and zamia palms throughout extended period from 1st January-15th December, 2018. The mean numbers of *C. pandava* eggs were slight deposited on both cycas and zamia palms. Initially, *C. pandava* laid eggs in firstly inspection at 1st January, 2018 with 14.33 and 6.67 eggs/5 leaves/palm on cycas and zamia palms, respectively. After that, the deposited eggs were gradually increased to 1st August, on cycas and 1st July, 2018 on zamia palms (Table 2).

After that, *C. pandava* deposited eggs were also gradually decreased to the end of experiment on both investigated ornamental palms. *Chilades pandava* female laid eggs about four peaks during the tested period on cycas (21.33, 34.67, 37.67 and 24.67 eggs/5 leaves/palm at 1st February, 1st May, 1st August and 1st November, respectively) and zamia palms (9.67, 17.00, 21.67 and 15.33 eggs/5 leaves/palm at 1st February, 1st May, 1st February, 1st May, 1st July and 1st September, 2018, respectively). The highest peak was observed at 1st August, 2018 (37.67 eggs/5 leaves/palm) on cycas and 1st July, 2018 (21.67 eggs/5 leaves/palm) on zamia palms (Table 2). The overall deposited eggs was 25.03 and 11.53 mean numbers of eggs/5 leaves/palm on cycas and zamia palms with significant differences between them, respectively (t-value = 7.79 and Prob.>|t| = 0.0001, Table 2).

To estimate the infested (%) of *C. pandava*, the mean numbers of dead heart of cycas and zamia palms was detected throughout the investigated period. The mean damages of *C. pandava* were scored the highly intensity based on the observation of dead heart of both two tested ornamental palms through the period from 15th March-1st September, 2018 (Table 2). The overall mean

Trade name	Active ingredient	Concentration (%)	Formula	Application rate/100 L	
Methomyl (Quick)	Methomyl	90	SP	120 cm	
Lufenuron (Match)	Lufenuron	5	EC	80 g	
Lambda-Cyhalothrin (Evect-Power)	Lambda-Cyhalothrin	5	EC	100 cm	
Dimethoate (Cydon-Kemanova)	Dimethoate	40	EC	150 cm	
Dimethoate (Dancothoate)	Dimethoate	40	EC	150 cm	
Thiamethoxam (Actra)	Thiamethoxam	25	WG	20 g	
Fipronil (Firrogen)	Fipronil	80	WG	17.5 g	
Sulfur (Sulfan)	Sulfur	70	SC	200 cm	
Flupyradifurone (Civantoprim)	Flupyradifurone	20	SL	120 cm	
Untreated check (control)					

SP: Water soluble powder, EC: Emulsifiable concentrate, WG: Water dispersible granules, SC: Suspension concentrate, SL: Soluble concentrate

	Mean numb	ers of	Mean numb	ers of	Mean numb	ers of					
	eggs/5 leaves/palm		infested palms/replicate		healthy palms/replicate		Infested (%)		Femperature		
Inspection dates	Cycas	Zamia	Cycas	Zamia	Cycas	Zamia	Cycas	Zamia N	Maximum	Minimum	Average RH
1st January	14.33	6.67	0.33	0.00	11.67	12.00	2.78	0.00	17.67	10.53	53.93
15th January	17.57	7.91	0.07	0.00	11.41	11.74	2.52	0.00	17.67	9.07	53.13
1st February	21.33	9.67	0.33	0.00	11.67	12.00	2.78	0.00	18.81	10.44	60.06
15th February	19.76	8.76	1.92	1.76	9.26	9.42	19.03	17.65	19.53	10.60	58.20
1st March	19.00	8.67	4.33	4.33	7.67	7.67	36.11	36.11	20.46	10.15	61.85
15th March	22.58	5.08	5.25	4.25	5.91	6.91	46.80	38.47	22.80	14.47	53.80
1st April	27.00	2.33	7.00	5.00	5.00	7.00	58.33	41.67	24.75	15.19	50.63
15th April	30.52	9.36	7.02	6.19	4.36	5.19	60.80	53.86	26.00	16.13	55.87
1st May	34.67	17.00	7.67	8.00	4.33	4.00	63.89	66.67	29.73	17.60	41.27
15th May	26.00	15.83	7.00	7.00	5.00	5.00	58.33	58.33	33.20	20.47	44.53
1st June	17.33	14.67	6.33	6.00	5.67	6.00	52.78	50.00	32.63	21.13	44.19
15th June	27.50	11.67	6.67	5.17	5.33	6.83	55.56	43.06	34.67	23.27	46.40
1st July	37.33	21.67	4.67	4.00	7.33	8.00	38.89	33.33	35.60	23.73	51.40
15th July	37.50	15.17	5.83	4.17	6.17	7.83	48.61	34.72	37.13	25.60	52.53
1st August	37.67	8.67	7.00	4.33	5.00	7.67	58.33	36.11	35.63	25.50	56.56
15th August	34.67	12.00	7.45	4.79	4.79	7.45	61.23	39.01	35.87	26.40	60.00
1st September	31.67	15.33	7.67	5.00	4.33	7.00	63.89	41.67	34.81	25.19	56.13
15th September	23.91	14.91	4.75	2.91	6.41	8.25	42.64	27.36	34.33	23.60	58.47
1st October	17.00	15.33	2.67	1.67	9.33	10.33	22.22	13.89	32.40	23.00	57.67
15th October	20.35	13.35	1.69	0.85	9.35	10.19	17.58	10.63	29.93	21.27	52.60
1st November	24.67	12.33	1.67	1.00	10.33	11.00	13.89	8.33	28.63	19.81	52.69
15th November	20.96	10.63	0.63	0.29	10.29	10.63	9.18	6.40	25.80	16.60	55.73
1st December	18.33	10.00	0.67	0.67	11.33	11.33	5.56	5.56	22.87	15.27	63.33
15th December	19.01	9.67	0.01	0.00	10.17	10.34	6.73	5.34	22.07	13.07	65.07
Overall Mean±SE	25.03±1.50	11.53±0.87	4.11±0.59	3.22±0.51	7.59±0.55	8.49±0.48	35.35±4.74	27.84±4.13			
t-value	7.79**		1.14 ^{NS}		-1.24 ^{NS}		1.19 ^{NS}				
Prob.> t	0.0001		0.2609		0.223		0.2387				

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**Highly significant, NS: Non-significant

numbers of infested palms was recorded a non-significant differences between cycas and zamia palms (4.11 and 3.22 palms/replicate, respectively). On the other hand, the 1st and last 3 months were received the lowest infestation with C. pandava on cycas and zamia palms. The mean numbers of healthy palms was ranged from 4.33-11.67 and 4.00-12.00 palms/replicate on cycas and zamia palms, respectively (Table 2). The overall mean numbers of healthy palms was 7.59 and 8.49 mean numbers of heathy palms, respectively.

The present data in Table 2 revealed that the infested percent of *C. pandava* was recorded the highest values at the first inspection of May and September, 2018 with 63.89% and 66.67% on cycas and zamia palms, respectively. The overall mean of infestation percentage was observed non-significant difference between both 2 tested palms (35.35 and 27.84%, respectively, Table 2).

The interaction between certain climatic factors (Maximum and minimum temperatures and average relative humidity RH and C. pandava infestations on 2 palms, cycas and zamia was studied by simple correlation coefficient (r)) and calculated the effect of each factor expressed by explained variance E.V. (%) (Table 3). A positive and highly significant relationship was found between both 2 temperature factors and C. pandava eggs on cycas and zamia palms during the extended tested period from January-December, 2018 (Table 3). Exceeding of 0.60 (correlation coefficient) was reported with temperatures with over 40% of explained variance except in case of minimum temperature and *C. pandava* eggs on zamia palms was 39.55% explained variance. A negative but non-significant relationship between C. pandava eggs on cycas and zamia palms (r = -0.26 and -0.33 and E.V.% = 6.78 and 10.77%, respectively). Similar frequent was reported between the infested (%) of *C. pandava* and the 2 tested temperatures (r-value ranged from 0.43-0.67 and E.V.% ranged from 19.36-44.34%) (Table 3). Contrariwise, a significant effective was established between the average RH% and the infested (%) of *C. pandava* on both 2 palms, cycas and zamia (Table 3). Generally, the 2 tested temperatures were reported a positive effect but the average RH% was a negative effect on the infestation of C. pandava on cycas and zamia palms in the experimental region.

The average amount of 5 phytochemical components in 2 tested palms has been presented in Table 4. The leaves of cycas palms contained the highest level of total protein

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		Correlation par			
Factors	Host plant		Р	E.V. (%)	
T. Max. and <i>C. pandava</i> eggs	Cycas	0.68	0.0002	46.87	
	Zamia	0.69	0.0002	47.19	
T. Min. and <i>C. pandava</i> eggs	Cycas	0.65	0.001	41.71	
	Zamia	0.63	0.001	39.55	
RH% Avg. and <i>C. pandava</i> eggs	Cycas	- 0.26	0.22	6.78	
	Zamia	- 0.33	0.11	10.77	
Infested (%) of <i>C. pandava</i> and T. Max.	Cycas	0.67	0.0004	44.34	
	Zamia	0.54	0.006	29.42	
Infested (%) of <i>C. pandava</i> and T. Min.	Cycas	0.60	0.002	35.03	
	Zamia	0.43	0.03	19.36	
Infested (%) of <i>C. pandava</i> and RH% Avg.	Cycas	- 0.47	0.019	22.27	
	Zamia	- 0.58	0.002	34.03	

Table 3: Interaction between certain weather factors and Chilades pandava infestations on cycas and zamia palms during 2018

r: Correlation coefficient, P: Probability, E.V. (%): Explained variance, T. Max.: Maximum temperature, T. Min.: Minimum temperature, RH% Avg.: Average relative humidity

Table 4: Levels of phytochemical components and plant enzymes in cycas and zamia leaves during 2018

	Host plant		Significant signs		
Elements	Cycas	Zamia	t-value	Р	
Phytochemical components					
Total protein (mg g ⁻¹ DW)	21.65	14.88	-13.59**	0.0002	
Total carbohydrates (mg g ⁻¹ DW)	25.25	11.20	-39.38**	0.0001	
Nitrogen (mg g^{-1} DW)	3.64	2.44	-32.66**	0.0001	
Total phenols (mg GAE g ⁻¹ DW)	6.67	2.05	-9.74**	0.0006	
Total flavonoids (mg CE g ⁻¹ DW)	1.95	1.35	-5.26**	0.006	
Enzymes					
Peroxidase (Δ O.D. min ⁻¹ g ⁻¹ DW)	4.44	3.64	-4.84**	0.01	
Phenoloxidase (O.D. U min ⁻¹ g ⁻¹ DW)	3.48	2.12	-15.79**	0.0001	

**Highly significant, P: Probability

(21.65 mg g⁻¹ DW), total carbohydrates (25.25 mg g⁻¹ DW), nitrogen (3.64 mg g⁻¹ DW), total phenols (6.67 mg GAE g⁻¹ DW) and total flavonoids (1.95 mg CE g⁻¹ DW). However, the leaves of zamia palms contained the least amount of 5 investigated phytochemical components (Table 4).

Through looking into present data in Table 4 elicited that a highly significant difference was scored between all tested phytochemical component and *C. pandava* infestation on cycas and zamia palms. Otherwise, the amount of 2 investigated plant enzymes was recorded also high significant on 2 ornamental palms. The amount of 2 plant enzymes were noted higher significant levels on cycas ($4.44 \Delta O.D. \min^{-1} g^{-1}$ DW of peroxidase and 3.48 O.D. U min⁻¹ g⁻¹ DW of phenoloxidase) than on zamia ($3.64 \Delta O.D. \min^{-1} g^{-1}$ DW of phenoloxidase and 2.12 O.D. U min⁻¹ g⁻¹ DW of phenoloxidase) (Table 4).

In Table 5, the overall deposited eggs of *C. pandava* on both 2 tested palms was negatively high significant correlated with total protein (r = -0.97), total carbohydrates (-0.98), nitrogen (-0.99), total phenols (-0.96), total flavonoids (-0.92), peroxidase |(-0.89) and phenoloxidase (-0.98). The explained variances (E.V.%) were ranged from 80.45-98.09% with last mentioned factors and *C. pandava* eggs on the

2 host palms (Table 5). Contrariwise, a negative but non-significant relationship was noted between the infested percent of *C. pandava* and all tested phytochemical components and plant enzymes except in case of total carbohydrates and nitrogen were significantly affect (r = -0.82and -0.81 and probability = 0.04, respectively, Table 5). Finally, perusal these relationships indicated that the increasing of the *C. pandava* infestation decreased these investigated components.

Perusal of data in Table 6 indicated that fipronil 80% WG and sulfur 70% SC were the most efficiency pesticide for *C. pandava* control throughout 3 sequentially application during 3 months with 73.17 and 79.17% reduction after 2nd month from spraying application, 70.19 and 66.67% reductions after 3rd month from the application and 61.30 and 69.88% of total reductions after 3 sequential sprayings. After spraying, the reduction percentages of all pesticides against *C. pandava* infestations were noted categorized into 2 groups according to statistical analysis of the present data; (a) Group included all pesticide applications except methomyl 90% SP was recorded, (b) Group (8.64% reduction). The sulfur application was more efficacy pesticide after 1 month from application against *C. pandava*

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	Correlation parameter			
Factors	r	Р	E.V. (%)	
Total protein and <i>C. pandava</i> eggs	-0.97	0.001	94.42	
Total carbohydrates and <i>C. pandava</i> eggs	-0.98	0.0001	97.07	
Nitrogen and <i>C. pandava</i> eggs	-0.99	0.0001	98.09	
Total phenols and <i>C. pandava</i> eggs	-0.96	0.002	92.48	
Total flavonoids and <i>C. pandava</i> eggs	-0.92	0.01	84.40	
Peroxidase and <i>C. pandava</i> eggs	-0.89	0.01	80.45	
Phenoloxidase and <i>C. pandava</i> eggs	-0.98	0.001	96.02	
Infested (%) of <i>C. pandava</i> and total protein	-0.77	0.07	59.93	
Infested (%) of <i>C. pandava</i> and total carbohydrates	-0.82	0.04	67.90	
Infested (%) of C. pandava and nitrogen	-0.81	0.04	67.20	
Infested (%) of <i>C. pandava</i> and total phenols	-0.74	0.09	54.66	
Infested (%) of C. pandava and total flavonoids	-0.66	0.15	44.00	
Infested (%) of <i>C. pandava</i> and peroxidase	-0.65	0.16	42.08	
Infested (%) of <i>C. pandava</i> and phenoloxidase	-0.79	0.06	62.63	

Table 5: Relationship between phytochemical components and plant enzymes and Chilades pandava infestations on cycas and zamia palms during 2018

r: Correlation coefficient, P: Probability, E.V. (%): Explained variance

Table 6: Efficiency of some pesticides against	C. pandava	on cycas palms	during sequentia	l applications	throughout 3	months
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	Mean numbers of infested cycas palms				Reduction (%)			
		After	After	After	After	After	After	
Treatments	Pre-count	1st month	2nd month	3rd month	1st spraying	2nd spraying	3rd spraying	Total
Methomyl 90% SP (Quick 90% SP)	3.00	4.67	2.00	0.33	8.64 ^b	67.50 ^{abc}	56.67ª	44.27 ^b
Lufenuron 5% EC (Match 5% EC)	6.67	5.00	3.00	0.67	39.85ª	45.83 ^{abc}	83.33ª	56.34 ^{ab}
Lambda-Cyhalothrin 5% EC (Evect-Power 5% EC)	7.00	5.00	3.67	1.67	40.09ª	32.35 ^{bc}	57.14ª	43.19 ^b
Dimethoate 40% EC(Cydon-Kemanova 40% EC)	6.33	4.67	2.33	1.33	41.17ª	44.94 ^{abc}	48.52ª	44.88 ^b
Dimethoate 40% EC (Dancothoate 40% EC)	7.00	5.00	4.00	1.67	44.66ª	32.02 ^{bc}	57.58ª	44.75 ^b
Thiamethoxam 25% WG (Actra 25% WG)	7.33	5.33	1.33	0.67	43.22ª	71.03 ^{ab}	36.85ª	50.37 ^{ab}
Fipronil 80% WG (Firrogen 80% WG)	7.67	5.67	1.67	0.67	40.54ª	73.17ª	70.19ª	61.30 ^{ab}
Sulfur 70% SC (Sulfan 70% SC)	8.67	4.00	0.67	0.00	63.81ª	79.17ª	66.67ª	69.88ª
Flupyradifurone 20% SL (Civantoprim 20% SL)	7.33	5.33	4.00	2.00	42.22ª	31.03°	56.11ª	43.12 ^b
Control	6.67	8.33	9.00	9.67	-	-	-	-
F-value					3.02	2.14	0.510	1.230
LSD value					24.10	39.962	55.203	24.388

LSD: Least significant difference

infestations (Table 6). On the other hand, the efficacy of the tested 9 pesticides against *C. pandava* infestations on cycas palms was noted 5 groups which signed by letters a, ab, abc, bc and c: the highest efficacy group (a) contained Sulfur 70% SC and Fipronil 80% WG being 79.17 and 73.17% reductions, respectively (Table 6).

A low efficacy was reported after 2nd spraying with flupyradifurone 20% SL application by 31.03% reduction (Table 6). The other tested pesticides were recorded moderately reduction. After 3rd spraying, non-significant difference was detected between all investigated pesticides against *C. pandava* infestations on cycas palms. The reduction percentages of these 9 pesticides against *C. pandava* were extended from 36.85-70.19% after 3rd spraying.

After the 3 sequential applications of investigated 9 pesticides, sulfur 70% SC was showed the best reduction percentage being 69.88% after 3 months against *C. pandava*

infestations, followed by fipronil 80% WG (61.30% reduction), LUFENURON 5% EC (56.34% reduction) and thiamethoxam 25% WG (50.37% reduction) after 3 sequential applications. The total reduction percent values were extended between 43.12 and 44.88% reductions with the remained 5 pesticides against *C. pandava* infestations on cycas palms after three sequential applications (Table 6).

Finally, from the above mentioned results, it is clear that sulfur 70% SC and fipronil 80% WG evinced higher suppression of in *C. pandava* infestations on cycas palms being 69.88 and 61.30% reductions than other treatments after 3 sequential applications throughout 3 months, respectively (Table 6).

DISCUSSION

Throughout the widely distributed of the genus Chilades on a diverse range of ornamental plants but *C. pandava* observed to be restricted to cycas and zamia species in Egypt³ and it causes numerous damage up to 60-90% of cycas plants³¹, including the cycad known as the *Cycas revoluta* (Cycadaceae). The blue butterfly *C. pandava* was the main pest on cycas spp. Similarly results were reported in Egypt^{2,3,14}, in Spain⁷ and in Papua New Guinea³². Moreover, the *C. pandava* mainly covered the tropical regions including Taiwan, China, India, Southeast Asia and Sri Lanka^{33,34}. It is clear from the *C. pandava* is a notable pest on a variety of cycas and zamia species in the present work, as likely as results were reported by Batt *et al.*³.

The warm and humid conditions were preferred to *C. pandava* in the present issue. The 2 tested temperatures were reported a positive effect but the average RH% was recorded a negative effect on the infestation of *C. pandava* on both 2 ornamental palms, cycas and zamia in the experimental region. Similarly frequent, Batt *et al.*³ found that the developing of *C. pandava* stages (egg -adult) was required about 29-34°C and 58-79% RH. Also, temperature combined with humidity to affect the *C. pandava* infestations: At high RH% (>42.87%), less temperatures than 28.47°C might be led to the highest infestations (14.87 average individuals/week), while high RH% combined with high temperature (>28.47°C) was accompanied with intermediate infestation (9.25 average individuals/week)³⁵.

The data was noted 4 peaks for *C. pandava* on cycas and zamia palms as well as, Batt et al.³ and Kunte and Tiple¹⁵ recorded a short life cycle of these pest stages, lead to numerous annual activity periods. Accordingly, we may conclude that C. pandava favors warm and humid conditions of autumn or summer seasons rather than low temperature and heavy rains of winter months. The progressive increase in C. pandava population in the period from May-September, 2018 suggests the need for initiating control of C. pandava before or after this period. As likely, the seasonal variation of C. pandava on cycas species in central India was reported significantly variations in the C. pandava occurrence throughout summer, monsoon and winter seasons, moreover, it was concentrated during the period from May-November³⁵. However, two peaks of *C. pandava* stages in May and October in Guangdong Province in China¹⁸.

Perusal of the present results indicated that the average reduction percentages of the tested nine pesticides against *C. pandava* infestations on cycas palms were markedly higher in case of sulfur 70% SC and fipronil 80% WG being 69.88 and 61.30% reductions than other treatments after three sequential applications throughout 3 months, respectively.

Lack issues were established on *C. pandava* control and insufficient information on its population dynamics of this

pest on the ornamental palms and other host palms range in Egypt is. Therefore, the *C. pandava* management was depended on the conventional applications by using numerous pesticides. Similarly, a preliminary study on the bionomics and control of *Chilades pandava* was conducted by Wei¹⁹. Moreover, Naik *et al.*¹⁶ reported the necessary management of *C. pandava* based on neem as botanical sprays. Lycaenid butterfly, *C. pandava* was higher infestation on cycas than zamia palms and then it's necessary to numerous studies on the management strategies for IPM planning against the blue butterfly *C. pandava* on ornamental plants in Egypt.

CONCLUSION

The invasive lycaenid blue butterfly, *Chilades pandava* (Lepidoptera: Lycaenidae) was higher infestation on cycas than zamia palms and then related with the investigated temperatures and RH%, Also, it was negatively related with tested phytochemical components and plant enzymes in leaves. Sulfur 70% SC and Fipronil 80% WG were more efficacy pesticides against *C. pandava* infestations on cycas palms.

SIGNIFICANT STATEMENT

This study confirmed that high infestation peaks of lycaenid blue butterfly, *Chilades pandava* occurred on cycas and zamia palms throughout May-September during 2018. The *C. pandava* infestation was affected by both maximum and minimum temperatures and RH%. The study revealed that the increasing of the *C. pandava* infestation decreased these investigated 5 phytochemical components and two plant enzymes on cycas and zamia palms. Sulfur 70% SC and fipronil 80% WG were more efficacy pesticides against this pest on cycas palms.

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