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Do non-diapausing insects respond to different photoperiods: *Spodoptera littoralis?*

Esmat M. Hegazi[1*], Wedad E. Khafagi[2] and Essam Agamy[3]

[1]Department of Applied Entomology, Faculty of Agriculture, Alexandria University, Alexandria, Egypt.
[2]Plant Protection Research Institute, Alexandria, Egypt.
[3]Department of Applied Entomology, Faculty of Agriculture, Cairo University, Giza, Egypt.

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Photoperiod is a great factor in determining the developmental pattern (continued development vs. suspended development, this is, diapause) of many insect pests. The cotton leaf worm, *Spodoptera littoralis* (Boisd.) is non-diapaused insect. Knowledge about how developmental pathway of *S. littoralis* responds to photoperiod is necessary for mass rearing of the pest and its parasitoids and may suggest new control management. The present work was to investigate the effects of a range of photoperiods under different temperatures on the speed of development and the number of larval instars of *S. littoralis* in the laboratory conditions. The photoperiods (Light: Dark) 0L: 24D; 6L: 18D; 12L: 12D; 18L: 6D and 24L: 0D) of a constant temperature (15, 20, 25, or 30°C) affected the developmental speed, live fresh weight and number of instars of *S. littoralis* larvae. The day length demonstrated its greatest impact at 20°C, compared to lower (15°C) or higher temperatures (25 and 30°C). At 20°C, short photoperiod significantly accelerated the developmental pattern of both larval (by 14 days) and pupal stages (by 9 days), but long photoperiod slowed down the development. There was significant effect of photoperiod on the developmental time at 20°C, which decreased as the temperature, increased to 25, or 30°C. The occurrence of extra molt differed significantly among ranges of day lengths at constant rearing temperature. There was also an increased frequency of extra instars at low temperatures of different photoperiods. Extra instars were less common at high temperature (30°C). In summary, photoperiod had significant effects on the developmental durations of *S. littoralis* larvae, fresh pupal weight and number of larval instars.

Key words: *Spodoptera littoralis*, non-diapaused insect, photoperiodism, development time, number of larval instars.

INTRODUCTION

The cotton leafworm, *Spodoptera littoralis* (Boisd.), is a serious economic pest due to the damages it causes, and being difficult to control. The host range of *S. littoralis* includes over 40 families, containing at least 87 economic species (Salama et al., 1970; Gerling, 1971). Among the most important host plants attacked by this insect in

*Corresponding author. E-mail: eshegazi@hotmail.com.

Egypt are cotton and truck crops. It has been shown to reduce cotton yields by as much as 75% (Hosny and Issha, 1967). Damage on many crops arises from feeding by larvae, leading to complete stripping of the plants (Bishara, 1934). It occurs throughout Africa (e.g. Egypt, Algeria, Angola), Turkey, Spain, southern France, Southern Greece and northern Italy. It has been recorded many times in the UK (Campion et al., 1977). In, France and Greece, *S. littoralis* pupae have been seen in the soil after November. It is not established in the northern parts of Europe due to cooler temperatures and its quarantined pest status. The pest develops throughout the year, without undergoing diapaus (Sidibe and Lauge, 1977). Low winter temperatures are therefore an important limiting factor affecting the northerly distribution of this pest (Miller, 1976).

The minimum constant temperature for normal development in all stages is 13-14°C. Resistance to low temperatures, generally increases through the larval stages and is greatest in the pupal stage (Miller, 1977; Dahi, 2005). Sidibe and Lauge (1977), Baker and Miller (1974) and Ocete (1984) provided data on survival and development of *S. littoralis* at different temperatures. At 18°C, egg, larval and pupal stages last 9, 34 and 27 days, respectively. At 36°C, egg, larval and pupal stages decreased to 2, 10 and 8 days, respectively. Information on development on different host plants is given by Dimetry (1972), Harakly and Bishara (1974), Zoebelein (1977) and Badr et al. (1983). In Egypt, field studies carried out by Dimetry (1972), El-Shafei et al. (1981), Khalifa et al. (1982) indicated that six larval instars exist and there are six to seven overlapping generations of *S. littoralis* when feeding on cotton, and that there are three peak infestation periods. In the Middle East the leaf worm produces 7-10 annual generations (Gerling, 1971; Sidibe and Lauge, 1977).

Photoperiod is an importance greater factor in determining the developmental line (continued development vs. suspended development, that is, diapause) of many insect pests (Eizaguirre et al., 1994; Fantinou et al., 1995 López and Eizaguirre, 2019). Moreover, the effect of photoperiod on other developmental characteristics has also been determined (Lopez et al., 1995; Fantinou et al., 1996). However, data in the literature on the influence of photoperiod on life history parameters of non-diapaused insects, such as, *S. littiralis* or about other adaptations by which they synchronize their development with seasonal changes are little. The purpose of the present investigation was to study the effects of a range of photoperiods under different temperatures on the speed of development and the number of larval instars of *S. littoralis* larvae in the laboratory conditions. The obtained data may lead to more appropriate phenological models for evaluation of pest management methods and for population dynamics analysis. It can also contribute to an understanding of the effects of weather conditions on *S. littoralis* phenology.

MATERIALS AND METHODS

The experiment was carried out in the biological control laboratory of Alexandria University, Egypt. The cotton leafworm *S. littoralis* was reared in mass culture on semi-artificial diet. The components of the diet were prepared and used as described by Hegazi (1976). To minimize genetic differences in developmental traits among test insects, regularly, fresh field-collected insects were made to eliminate the bad effects of inbreeding for the culture. For each trial, four cultures were established from a large egg mass, reared at 4 constant temperatures of 15, 20, 25 and 30 ± 1°C. Each temperature was combined with “L:D” 0:24, 6:18, 12:12, 18:6 or 24:0 and Relative Humidity of 65 ± 5%. Also, each treatment was carried out in three different rearing chambers. The hatched larvae were reared individually in petri-dishes (3.5 cm in diameter) (n = 30-35 larvae/rearing chamber x 4 trials/ day length). Larval instars were determined according to methods followed by Stavridis et al. (2004), Mironidis and Savopoulou-Soultani (2008).

The caterpillars were fed daily, with fresh diet available at all times *(ad libidum)*. The daily procedures were food exchange, cleanings, record of deaths, and collection of cephalic capsules. The duration and number of instars were daily recorded. The pupae obtained were sexed using the Butt and Cantu (1962) technique and weighed with a precision scale with an approximation of 0.001 g. The development of the cotton leafworm was assessed by observing time for larval growth to pupation, larval weight, pupal developmental period, pupal weight.

The experiments were conducted in incubators (type Hann, Munden, Germany, Hegazi et al., 2017), equipped with six fluorescent 30-Watt cool white flurescent tube per cabinet. In all experiments, the light onset started at 5 am. The light intensity during photophase was approximately at 1270 foot candles. Light was measured with a Weston light meter (Model) (Weston Electrical Instrument Company, Newark, NJ). Some fans were used for cooling electronic equipment, operated during the light cycle to remove heat produced by lights. Variation of temperatures in rearing chambers was ± 1°C. All incubators were located in a controlled rearing room. The results reported here only include those individuals that pass through six instars and successfully survived to eclosion.

Statistical analysis

Statistical analyses were conducted using SPSS 17.0. Differences in the durations of immature development between different treatments were compared using one way analysis of variance (ANOVA) followed by multiple comparisons analysis using Student’s t-test.

RESULTS

The interactions between photoperiod and temperature in larval and pupal development on non-diapausing insect "*S. littoralis*", is shown in Tables 1 and 2. Table 1 shows the development time patterns in *S. littoralis* at low constant temperature (15 and 20 °C) under different photoperiods. The developmental period of males was less than that of females irrespective of temperature and photoperiodic conditions. Figure 1 shows that at 15°C, only short (6L:

Table 1. Development time patterns in *S. littoralis* at low constant temperature and different photoperiods.

Stage	Photoperiod (L : D, h)				
	0:24	6:18	12:12	18:6	24:0
A: Temperature 15℃					
Egg	-	**8.10 ± 0.02**	-	**8.20 ± 0.01**	-
First instar	-	9.28 ± 0.09	-	9.24 ± 0.20	-
Second instar	-	8.36 ± 0.12	-	7.44 ± 0.18	-
Third instar	-	8.50 ± 0.14	-	7.16 ± 0.17	-
Fourth instar	-	7.84 ± 0.12	-	7.80 ± 0.40	-
Fifth instar	-	10.12 ± 0.46	-	8.30 ± 0.40	-
Sixth instar	-	12.60 ± 0.56	-	12.16 ± 0.64	-
Larvae	-	56.70 ± 0.50[a]	-	51.84 ± 0.13[b]	-
Pupa ♂	-	48.50 ± 1.90[a]	-	39.7 ± 0.49[b]	-
Pupa ♀	-	42.90 ± 0.18[a]	-	32.5 ± 0.37[b]	-
B: Temperature 20℃					
Egg	5.0 ± 0.01	4.50 ± 0.01	6.00 ± 0.10	6.00 ± 0.10	5.8 ± 0.20
First instar	4.80 ± 0.14	3.48 ± 0.16	5.16 ± 0.07	5.12 ± 0.12	4.08 ± 0.08
Second instar	3.20 ± 0.10	3.72 ± 0.12	4.28 ± 0.12	5.48 ± 0.20	3.48 ± 0.10
Third instar	3.00 ± 0.10	2.52 ± 0.18	4.64 ± 0.15	4.44 ± 0.14	3.76 ± 0.18
Fourth instar	3.30 ± 0.10	2.92 ± 0.17	5.00 ± 0.10	5.08 ± 0.14	4.00 ± 0.19
Fifth instar	3.80 ± 0.10	3.36 ± 0.09	5.36 ±0.16	5.72 ± 0.23	4.36 ± 0.14
Sixth instar	5.84 ± 0.10	5.12 ± 0.20	6.96 ± 0.30	8.24 ± 0.34	6.32 ± 0.19
Larvae	24.00 ± 0.22 d	20.30 ± 0.50[e]	31.30 ± 0.50[b]	34.1 ± 0.40[a]	26.0 ± 0.34[c]
Pupa ♂	15.40 ± 0.20 b	15.10 ± 0.39[b]	24.60 ± 0.20[a]	24.80 ± 0.34[a]	15.8 ± 0.30[b]
♀	13.00 ± 0.21 c	13.10 ± 0.22[c]	20.60 ± 0.52[b]	22.00 ± 0.47[a]	12.7 ± 0.15[c]

Means within a row followed by the same letter are not significantly different, ($P < 0.01$).

18D) and long (18L: 6D) photoperiods were tested. The developmental time for both larval and pupal stages was significantly longer ($t_{0.05} = 2.24$ for larvae; $t_{0.05} = 4.6$ for male pupae, $t_{0.05} = 2.1$ for female pupae) at short photoperiod compared to long photoperiodThe larval stage lasted 56.7 days at short photoperiod vs. 51.8 days at long photoperiod. At short photoperiod (6L: 18D) the developmental time of pupal stage lasted 48.5 days for male and 42.9 days for females vs 39.7 and 32.5 days for male and female at long day length(18L: 6D), respectively.

At 20°C, the results showed that photoperiods had significant effects on the developmental durations of the larval ($F = 194.5$; df = 4, 45; $P < 0.05$) and pupal (for male, $F = 210.0$; df = 4, 45; for female, $F = 171.2$; df = 4, 45; $P < 0.05$) stages of *S. littoralis* (Table 1). The short day length of 6L: 18D significantly accelerated the development of both the larval and pupal stages, while the long photoperiod (18L: 6D) slowed down the development, compared with other photo schedules. For instance the larval stage lasted 20.3 days at short photoperiod (6L: 18D), slowed down to 34.1 days at long photoperiod (18L: 6D).

At 25°C, the scenario was different at higher temperatures, the continuous darkness (0L: 24D) significantly accelerated the development of both the larval ($F = 13.05$; df = 4, 45; $P < 0.05$) and pupal (for male, $F = 10.1$; df = 4, 45; for female, $F = 13.39$; df = 4, 45; $P < 0.05$) stages, while photoperiod of 12L: 12D significantly slowed down the development. The fastest development of the larvae lasted 16.5 vs 19.8 days, under continuous darkness and photoperiod of 12L: 12D, respectively (Table 2).

At 30°C, the developmental speed of the larval stage was significantly increased ($F = 40.6$; df = 4, 45; $P < 0.05$) at short photoperiod (11.4 days) compared to those of longest development at continuous photoperiod (14.2 days) (Table 2). Table 4 shows mean live weights of prepupal and pupal stages of *S. littoralis* at different photoperiods of different temperatures. The day length induced drastic changes in live weights of prepupal and pupal stages and it was temperature dependent. At 15°C, although short photoperiod (6L: 18D) slowed down the development of *S. littoralis* larvae, no significant differences in pupal weights were obtained at the long photoperiod (18L: 6D) or short photoperiod. At 20°C, there were significant differences (for male prepupae, $F = 54.63$; df = 4, 45; $P < 0.05$; for female pupae, $F = 59.87$;

Table 2. Development time patterns in *S. littoralis* at high constant temperature of different photoperiods.

Stage	Photoperiod (L : D, h)				
	0:24	6:18	12:12	18:6	24:0
A: Temperature 25℃					
Egg	3.00 ± 0.04	3.0 0 ± 0.04	3.50 ± 0.03	3.60 ± 0.04	3.1 ± 0.20
First instar	3.00 ± 0.00	3.80 ± 0.08	3.50 ± 0.10	3.2 ± 0.20	3.0 ± 0.00
Second instar	2.08 ± 0.08	2.50 ± 0.11	2.80 ± 0.10	3.10 ± 0.20	2.12 ± 0.07
Third instar	2.28 ± 0.10	2.28 ± 0.09	2.80 ± 0.13	2.36 ± 0.10	2.12 ± 0.07
Fourth instar	2.20 ± 0.11	2.36 ± 0.09	2.90 ± 0.14	2.20 ± 0.10	2.2 ± 0.10
Fifth instar	2.70 ± 0.13	3.12 ± 0.12	3.08 ± 0.13	2.60 ± 0.10	2.7 ± 0.12
Sixth instar	4.20 ± 0.18	4.32 ± 0.09 b	4.70 ± 0.17	4.44 ± 0.02	4.76 ± 0.17
Larvae	16.50 ± 0.30^{c}	17.70 ± 0.21^{a}	19.80 ± 0.29^{a}	17.90 ± 0.36 ^{b}	17.00 ± 0.20^{c}
Pupa ♂	10.00 ± 0.10^{c}	11.70 ± 0.15^{b}	12.20 ± 0.24^{a}	11.80 ± 0.13^{ab}	11.2 ± 0.13^{c}
Pupa ♀	9.40 ± 0.16^{d}	10.30 ± 0.15^{b}	10.90 ± 0.10^{a}	9.90 ± 0.18^{c}	10.3 ± 0.15^{b}
B: Temperature 30 ℃					
Egg	3.00 ± 0.10	3.00 ± 0.02	3.50 ± 0.20	3.60 ± 0.10	3.00 ± 0.10
First instar	2.04 ± 0.04	2.04 ± 0.04	2.04 ± 0.04	2.12 ± 0.07	2.04 ± 0.04
Second instar	1.76 ± 0.09	1.92 ± 0.08	1.84 ± 0.07	2.00 ± 0.08	2.36 ± 0.20
Third instar	1.72 ± 0.09	1.80 ± 0.11	1.56 ± 0.10	1.64 ± 0.13	2.52 ± 0.17
Fourth instar	1.64 ± 0.09	1.48 ± 0.11	1.56 ± 0.10	1.68 ± 0.14	1.64 ± 0.10
Fifth instar	1.92 ± 0.08	1.88 ± 0.07	1.88 ± 0.07	2.04 ± 0.07	1.84 ± 0.09
Sixth instar	3.60 ± 0.11	2.64 ± 0.13	2.92 ± 0.12	3.80 ± 0.20	3.88 ± 0.13
Larvae	12.64 ± 0.17^{c}	11.76 ± 0.17^{e}	11.96 ± 0.14^{d}	13.36 ± 0.39^{b}	14.24 ± 0.35^{a}
Pupa ♂	7.70 ± 0.15^{a}	7.20 ± 0.13^{b}	7.20 ± 0.13^{b}	7.70 ± 0.20^{a}	7.1 ± 0.10^{b}
Pupa ♀	6.50 ± 0.16^{bc}	6.30 ± 0.30^{c}	6.30 ± 0.15^{c}	7.10 ± 0.23^{a}	6.80 ± 0.20^{ab}

Means within a row followed by the same letter are not significantly different, ($P < 0.01$).

df = 4, 45; $P < 0.05$) among live prepupal and pupal weights of S. littoralis developed from larvae reared under different photoperiods. The heaviest weights were for those reared under photo-schedules of (12L: 12D) and (18L: 6D).

Typically, S. littoralis has six larval instars, with developmental commitment to metamorphosis occurring in the 6th (late) instar. The results showed that S. littoralis larvae had substantial intraspecific variation in the number of larval instars when reared at different photoperiods of a constant temperature on a modified artificial diet. The occurrence of extra molt differed significantly among photoperiods under constant rearing temperature. Table 3 shows that 15°C, 56.4 and 30.0% of *S. littoralis* larvae developed extra instar (seventh) before pupation under short (6L: 18D) and long (18L: 6D) photoperiods ($t_{0.05}$ = 21.17), respectively. At 20°C, the larvae reared under (6L: 18D) and long (12L: 2D) photoperiods, showed the highest values (23 and 22%, in respect) of additional molts ($F = 335.5$; df = 4, 20; $P < 0.05$) compared to those reared under continuous darkness (0L: 24D) (0.0%), long (18L: 6D) (10.0%) and continuous photoperiod (24L: 0D) (8.1%). At 25°C, the larvae had significant ($F = 246.7$; df = 4, 20; $P < 0.05$) number of additional extra molt among different photoperiods. At 30°C, the frequency of individuals with extra instars significantly ($F = 932.8$; df = 4, 20; $P < 0.05$) decreased with increased rearing day length.

Figure 2 summarizes the effect of photoperiods (L: D, h) and constant temperature (°C) that accelerated (A, shortest duration) and slowed down (S, longest duration) the development larvae and pupae of *S. littoralis*. The photoperiod had significant effects on the developmental durations of *S. littoralis* larvae. The day length demonstrated its greatest impact at 20°C. At 20°C, short photoperiod significantly accelerated the developmental pattern of both larval (by 14 days) and pupal stages (by 9 days), but long photoperiod slowed down the development. The effect of photoperiod at 20°C decreased as the temperature increased to 25, or 30°C.

DISCUSSION

Detailed information of the insect life cycle and how it responds to environmental factors is the necessary for future events, and for developing successful control programs (Nylin, 2001; Bansode et al., 2016; Montezano

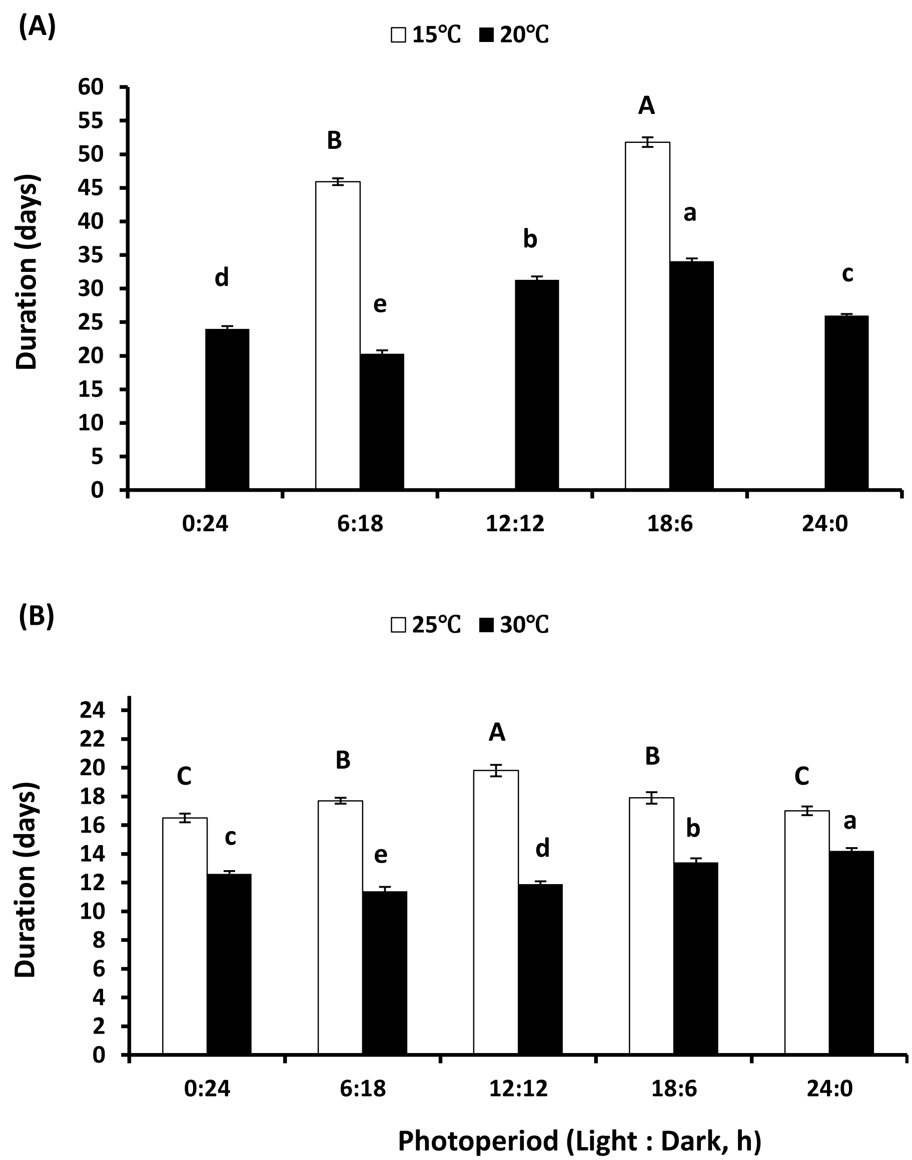

Figure 1. Mean durations (±SE) of larval stage (1^{st} – 6^{th}) of *S. littoralis* under different photoperiods of constant low 15 or 20℃ (A); or high temperature 25 or 30℃ (B). Bars with the same uppercase or lowercase letter are not significantly different (P > 0.05).

Table 3. Effect of photoperiod on percentage (mean ± SE) of *S. littoralis* larvae developed an extra instar before pupation.

Photoperiod	Temperature (℃)			
(L : D, h)	15	20	25	30
0 : 24	No data	00.00 ± 0.00^{D}	8.30 ± 0.00^{C}	14.70 ± 0.90^{A}
6 : 18	56.40 ± 2.30^{A}	23.00 ± 1.50^{A}	5.6 0± 1.20^{D}	6.73 ± 1.30^{B}
12 : 12	No data	22.50 ± 0.90^{A}	9.30 ± 1.30^{C}	0.00 ± 0.00^{C}
18 : 6	30.00 ± 1.20^{B}	10.00 ± 1.20^{B}	17.8 0± 1.20^{B}	0.00 ± 0.00^{C}
24 : 0	No data	8.10 ± 2.20^{C}	19.10 ± 0.90^{A}	0.00 ± 0.00^{C}

For each temperature, means followed by different letters are significantly different from each other at P < 0.05.

Table 4. Mean live weights of prepupal and pupal stages of *S. littoralis* at different photoperiods of constant temperature.

Temp (℃)	Stage	Photoperiod (L : D, H)				
		0:24	6:18	12:12	18:6	24:0
15	Prepupa ♂	-	439.70±9.10[a]	-	439.2±7.70[a]	-
	Prepupa ♀	-	488.60±2.80[a]	-	492.80±3.80[a]	-
	Pupa ♂	-	394.99±7.80[a]	-	401.70±7.60[a]	-
	Pupa ♀	-	437.20±11.90[a]	-	436.3±11.20[a]	-
20	Prepupa ♂	385.90±4.30[b]	340.30±1.60[d]	399.40±3.10[a]	388.20±2.70[b]	360.20±3.90[c]
	Prepupa ♀	426.30±3.50[b]	376.50±3.70[d]	440.10±2.80[a]	438.70±4.50[a]	402.3±2.60[c]
	Pupa ♂	339.60±7.30[c]	337.60±6.50[c]	378.10±4.10[b]	391.97±5.50[a]	341.3±6.90[c]
	Pupa ♀	353.60±5.50[d]	397.40±4.40[b]	425.40±2.40[a]	414.90±4.60[a]	376.5±4.80[d]
25	Prepupa ♂	310.87±2.50[c]	322.90±6.10[b]	350.70±3.20[a]	300.10±2.90[d]	300.8±1.40[cd]
	Prepupa ♀	366.80±3.00[d]	415.40±3.10[a]	390.20±3.40[b]	299.70±3.20[e]	336.1±7.70[c]
	Pupa ♂	289.03±4.80[c]	305.20±4.03[b]	328.50±6.10[a]	294.90±4.50[c]	284.8±6.50[c]
	Pupa ♀	336.30±7.80[b]	363.50±4.20[a]	370.30±7.20[a]	303.20±3.10[d]	314.90±3.80[c]
30	Prepupa ♂	275.99±3.60[c]	263.30±3.60[d]	284.10±3.30[b]	282.20±3.90[bc]	292.10±4.40[a]
	Prepupa ♀	305.10±2.98[b]	299.98±4.10[b]	310.50±2.99[b]	300.90±3.50[b]	352.96±4.80[a]
	Pupa ♂	253.40±0.80[b]	246.50±1.40[c]	265.40±0.93[b]	265.40±1.00[a]	262.6±1.40[a]
	Pupa ♀	282.60±2.60[c]	291.10±2.50[b]	283.70±1.80[bc]	274.70±3.10[d]	349.60±3.20[a]

Means within a row followed by the same letter are not significantly different, (P < 0.01).

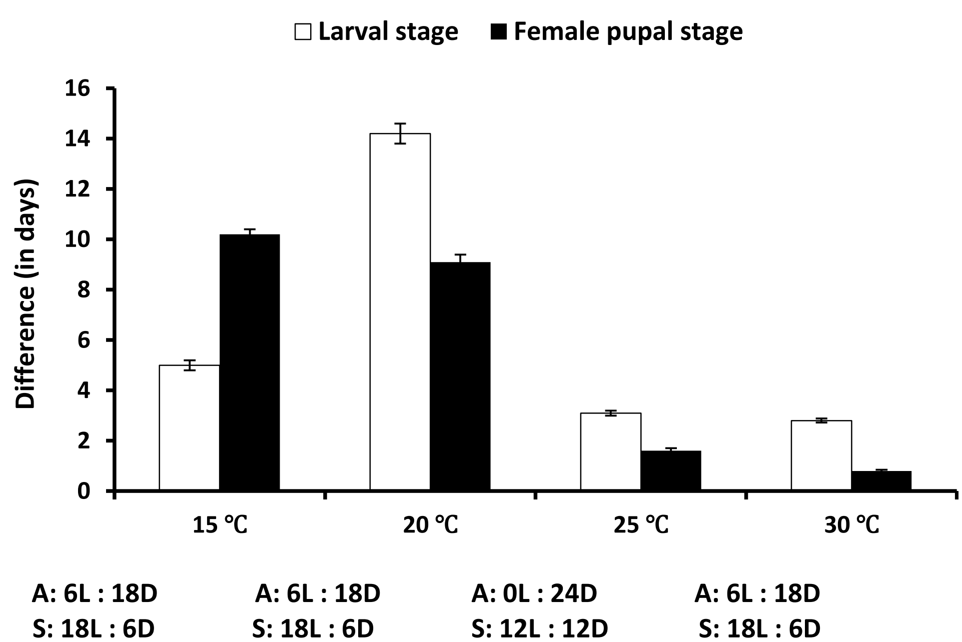

Figure 2. Photoschedules (L: D, h) and constant temperature (℃) that accelerated (A, shortest duration) and slowed down (S, longest duration) the development of *S. littoralis*.

et al., 2019; Du Plessis et al., 2020, Papp et al., 2018). Many studies on the effects of photoperiod have been primarily concerned with diapause induction in insects (Mukai and Goto, 2016; He et al., 2017; Yamaguchi and

Goto, 2019; Saunders, 2020). Photoperiod is a main factor in determining the developmental line of many insect pests (Zohdy and Abou-Elela, 1975; Eizaguirre et al., 1994; Fantinou et al., 1995; Saunders, 2020; Poitou et al., 2020). However, data in the literature on the effect of photoperiod on life history parameters of non-diapaused insects are hard to find. Very little is known about photoperiodism in S. littoralis or about other adaptations by which they synchronize their development with seasonal changes. In a preceding investigation on the effect of different photoperiods on the relative speeds of the endo-developmental stages of *Microplitis rufiventris* wasp attacking *S. littoralis* larvae, Hegazi and Fuhrer (1985) found that the short day length (6L:18D) accelerated the development of *M. rufiventris* wasp larvae, while both of 18L:6D or 0L:24D slowed down the development. The results of the present study showed that photoperiod had significant effects on the developmental durations of *S. littoralis* larvae, fresh pupal weight and the number of larval instars. The effect was temperature dependent. At 15°C, the development was faster by 5 days for the larvae and 10 days for female pupae under long day length than under short one. At 20°C, different photoperiods significantly affected the larval duration, pupal weight and percentage of larvae that passed extra instar. For instance, the larval and pupal durations were shorter by 14 and 9 days at short photoperiod than those larvae reared under long photoperiod. It is not clear which factors can cause to come out such variability among the larval durations, and the involved physiological mechanisms.

It was reported that *S. littoralis* larvae had 6 larval instars (Salama and Shoukry, 1972). The present work showed that, photoperiod can influence the number of instars of this pest. The number of instars of *S. littoralis* was variable and 7 instars could be observed at rearing constant temperature under different ranges of photoperiods, where significant percentages of *S. littoralis* larvae developed through an extra instar before pupation. Baker and Miller (1974) reported similar observation on the effect of low temperatures in addition to the larval food “chrysanthemum” of *S. littoralis* larvae on producing extra instars. Duodu and Biney (1981) mentioned that *S. littoralis* larvae had an extra molt on some plants (cotton and *Urena*) of four tested food crops. Esperk et al. (2007), reported that the most common factors influencing insect instar number are photoperiod, temperature, humidity, food quantity and quality, injuries, inheritance and sex. Low temperature combined with short photoperiod induces slow development together with additional instars in several species (Ballmer and Pratt, 1989; Shintani and Ishikawa, 1997). Grossniklaus-Burgin et al., (1994), reported that nonparasitized *S. littoralis* pass through typical six larval instars. When parasitized by the egg–larval parasitoid *Chelonus inanitus*, they passed through five larval instars and entered metamorphosis precociously, and dig into the soil for pupation.

Juvenile hormone (JH) is vitally important in the control of insect development and reproduction (Pener and Shalom, 1987; Raabe, 1989; Nijhout, 1994).These JHs are secreted by a pair of glands in the head known as the corpora allata (Wigglesworth, 1940). JH has the power to maintain insects with larval characteristics that makes it possible for the continued growth of the larval form (Wigglesworth, 1964). Ecdysone is a steroid hormone secreted by prothoracic gland that, in its active form, stimulates metamorphosis and controls molting in insects. Nijhout and Williams (1974a, b) found that JH prevents secretion of the prothoracicotropic hormone (PTTH) by the brain of the late instar larvae of *Munduca sexta*. At the beginning of the periods of PTTH release is regulated by the photoperiod and it seems that the brain is needed as an initiator (Ciemiokr and Sehnalf, 1977; Matsuda, et al., 2017) for keeping in existence of the developmental rhythms. As shown from the above results, day length has significant effect on development, number of larval instars and live pupal weight. So, day length may influence insects’ basic physiological processes, such as metabolic rates, as well as functions of the nervous and endocrine systems. The corpora allata and the prothoracic gland may be sensitive to day length changes at low temperature or the day length may affect JH biosynthesis at low temperature. The implication of the key present findings possibly could contribute to more appropriate phenological models for evaluation of pest management methods and for population dynamics analysis. It can also contribute to an understanding of the effects of weather conditions on *S. littoralis* phenology and better management strategy of the cotton leaf worm.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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