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EFFECT OF DIFFERENT PHOTOPERIODS AND DAILY NUMBER OF FEEDS ON SOME BIOLOGICAL AND TECHNOLOGICAL ASPECTS OF THE MULBERRY SILKWORM, *BOMBYX MORI* L.

Walaa M.M. Helaly, E.M. Metwally, S.I. Yousif- Khalil * and S.M.A. El-Shakaa
Plant Protection Dept., Fac. Agric., Zagazig Univ., Egypt

ABSTRACT

Fifth instar mulberry silkworm larvae were exposed to 2 regimes of photoperiod, i.e., 15L:9D, 17L:7D compared with 13L:11D (control). Such larvae were offered 4,5 and 6 feeds / day in each photoperiod regime at spring rearing seasons of 2005 and 2006. The effects of such treatments on some biological and technological parameters were studied. The results showed that rearing silkworm larvae during 5th instar under 15L or 17L increased significantly the weight of mature larvae, silk gland, male pupa, fresh male cocoon, cocoon shell and size of silk filament (in denier) during the two investigated seasons. Increasing the number of feeds caused significant increase in the female pupal weight, weight of fresh female cocoon and size of reelable filament. Offering 6 feeds daily to 5th instar larvae under 17L:7D photoperiod regime resulted in a significant increase in majority studied characters, viz., weight of male pupa, weight of male cocoon , weight of male and female cortex and size of reelable filament.

Keywords: ***Bombyx mori*** **L., mulberry leaves, photoperiod, reelable silk filament, mounting process, number of feeds.**

INTRODUCTION

Silkworm rearing is considered an important agricultural field for small- and large – scale projects for investment to meet with the demand of the internal needs of silkworm eggs and natural silk which is a part of the solution of nonemployee problems especially in rural societies.

* **Corresponding author :** S.I. Yousif-Khalil, **Tel. :** +20106355501
E-mail address : S.I.Yousif@gmail.com

Developing rearing technique is considered one of the main goals for increasing natural silk production, therefore, the Sericulturists directed their research vertically to enhance silk production (Huq *et al.*, 1991, Gen, 1999, Porto, 2000, Shimizu *et al.*, 2005, Mishra and Ansari 2007 and Toheed *et al.*, 2008).

The aim of the present study is oriented towards increasing silk productivity vertically via reciprocal effect of feeding photoperiodism during larval stage.

MATERIALS AND METHODS

Experiments of the present work were conducted at the Research Laboratory of Apiculture and Sericulture, Plant Protection Department, Faculty of Agriculture, Zagazig university during two spring rearing seasons of 2005 and 2006.

Rearing Technique

The Romanian mulberry silkworm, *Bombyx mori* L. (race B_{37}) was used in the present study. Silkworm eggs were incubated as usual up to hatching. Newly hatched larvae were reared until to end of the 4th larval instar on fresh mulberry leaves *Morus alba* (balady variety) under laboratory conditions of 26±2°C and 64±5 %R.H. according to the method carried out by Krish (1978).

In the first season of 2005 newly moulted 5th instar silkworm larvae (810 larvae) were divided into three main groups of 270 larvae for each photoperiod regime. These groups were divided into 3 sub groups of 90 larvae each. Three replicates of 30 larvae were considered for each sub group as follow:

Group A 13L*:11D	A1 ingested 4 feeds daily
	A2 ingested 5 feeds daily
	A3 ingested 6 feeds daily
Group B 15L: 9D	B1 ingested 4 feeds daily
	B2 ingested 5 feeds daily
	B3 ingested 6 feeds daily
Group C 17L: 7D	C1 ingested 4 feeds daily
	C2 ingested 5 feeds daily
	C3 ingested 6 feeds daily

Where* L = Light D= Darkness

During the second season of 2006, three replicates of 25 larvae were taken for each sub group.

Mounting process was taken place using carton papers that used for warpping table eggs (Shaaban, 1997). To evaluate the effect of photoperiod in association with number of feeds on the parameters of *B. mori.*, the following biological and technological parameters were measured and recorded.

Bioloical Parameters

Mean fresh weights of mature larvae, silk gland, fresh cocoon, cocoon shell and pupa as well as % mortality of 5th instar larvae, % pupation, % emergence, fecundity (number of deposited eggs/ female) and hatchability were determined.

Technological Parameters of Reeled Silk Filament

The technological studies were performed at Plant Protection Research Institute (ARC), Sharkia branch. For each treatment, 5 random cocoons were dried at 75°C for six hours for killing pupae then weighed and kept until reeling. Consequently, the length and weight of the reeled silk filament were measured. In addition, the size of reeled silk filament calculated according to Tanaka (1964) formula as follows:

$$\text{Size (dn)} = \frac{\text{weight of silk filament (g)}}{\text{length of silk filament (m)}} \times 9000$$

Data obtained were statistically analyzed according to Snedecor and Cochran (1967) methods using software Costat Computer Program (2005).

RESULTS AND DISCUSSION

The reciprocal effect of the length of photoperiod and the daily number of feeds offered to the fifth instar larvae of the mulberry silkworm *B. mori* on the biology and productivity was studied.

Biological Parameters

Weight of mature larvae

The obtained results clear that the daily number of feeds did not affect the weight of full-grown larvae under the three regimes of photoperiod during the first season (Table 1). On the other hand , the length of photoperiod induced significant effect at the two tested photoperiod regimes 15L: 9D and 17L : 7 D, resulted insignificant increase in the weight of full- grown larvae, recording 3.667 and 3.747g / larva compared to 3.378 g / control larva , regardless of the number of

Table 1. Effect of photoperiod regimes in association with daily number of feeds on some biological parameters of silkworm , *Bombyx mori* L. during spring rearing season of 2005

Photoperiod treatment	No. of feeds	Weight of full-grown larvae (g)	% mortality	% pupation	Pupal weight (g) Male	Pupal weight (g) Female	% Emergence	Fecundity	Hatchability
15 Light:	4	3.596	12.22	92.54	1.148	1.473	96.83	568.00	69.75
9 Darkness	5	3.700	18.89	100.00	1.108	1.440	93.44	643.67	83.27
	6	3.706	10.00	97.06	1.203	1.608	100.00	560.00	90.94
Mean		3.667	13.63	96.53	1.153	1.507	96.76	590.56	81.32
L.S.D.		NS	NS	NS	NS	0.128*	NS	NS	NS
17 Light:	4	3.676	10.00	97.18	1.048	1.438	97.10	670.00	74.81
7 Darkness	5	3.686	12.22	92.75	1.138	1.460	93.75	578.00	72.68
	6	3.880	11.11	95.38	1.000	1.563	90.32	659.68	80.28
Mean		3.747	11.11	95.10	1.062	1.487	93.72	635.89	75.92
L.S.D.		NS	NS	NS	0.101*	NS	NS	NS	NS
13 Light:	4	3.402	12.22	94.12	1.090	1.223	95.31	527.67	73.37
11Darkness	5	3.412	10.00	94.20	1.135	1.448	98.46	533.67	72.74
(control)	6	3.320	5.56	93.33	1.083	1.688	90.00	561.33	75.13
Mean		3.378	9.33	93.88	1.103	1.453	94.59	540.89	73.75
L.S.D.		NS	4.962*	NS	NS	0.146**	NS	NS	NS
General mean		3.598	11.358	95.17	1.106	1.482	95.02	589.11	77.00
L.S.D. photoperiod		0.127**	NS	NS	0.068*	NS	NS	60.706*	NS
L.S.D. of feeds		NS	NS	NS	NS	0.088**	NS	NS	NS
L.S.D. Interaction		NS	NS	NS	NS	0.483*	NS	NS	NS

NS = Nonsignificant

* = Significant at 5% level of probability

** = Significant at 1% level of probability

feeds. In the second season of 2006, the results showed the same trend (Table 2). The obtained results are in conformity with those reported by Janarthnan *et al.* (1994), who mentioned that there was a significant increase in weight of larvae which exposed to 24 L. period.

Larval mortality

The obtained results as shown in Table 1 indicate that the mean of mortality percentage of 5th larval instar recorded 13.63, 11.11 and 9.33% for the larvae exposed to the photoperiod regimes 15L: 9D, 17L: 7D and 13L:11D (control), respectively regardless of number of feeds during 2005 season. Analysis of data revealed insignificant differences between means in case of number of feeds, photoperiod regimes and interaction between the two factors. Similar results were obtained in the second season (Table 2). These results are in partial accordance with those reported by Toheed *et al.* (2008) who recorded that mortality percentage of larvae kept in dark was lower (13.3%) than in light (24.4%), regardless of photoperiod regimes.

Percentage of pupation

Data in Table 1 show that the mean percent pupation of the 5th instar larvae in 2005 season attained 96.53, 95.10 and 93.88% for silkworm larvae exposed to the three tested photoperiod regimes 15L:9D , 17L:7D and 13L:11D (control), successively, regardless of number of feeds. The differences among means, in this parameter, are insignificant for the number of feeds, photoperiod regimes and the interaction between the two factors. The same trend was observed in the second season (Table 2). However, Sannappa *et al.* (2003) investigated the suitable feeding frequency of *B. mori* (NB_4D_2 breed) and found that feeding 5 times/ day resulted in the highest pupation rate (93.44%).

Pupal weight

Male pupa

As shown in Table 1 the mean male pupal weight recorded 1.153, 1.062 and 1.103 g for the photoperiod regimes 15L: 9D, 17L : 7D and 13L : 11D, respectively, regardless of the number of feeds offered to the larvae during the 5th instar during the first season. Statistical analysis revealed that the differences among means of

Table 2. Effect of photoperiod regimes in association with daily number of feeds on some biological parameters of silkworm , *Bombyx mori* L. during spring rearing season of 2006

Photoperiod treatment	No. of feeds	Weight of full-grown larvae (g)	% mortality	% pupation	Pupal weight (g) Male	Pupal weight (g) Female	% Emergence	Fecundity	Hatchability
15 Light: 9 Darkness	4	3.474	36.00	90.00	1.083	1.400	81.48	628.00	93.69
	5	3.562	44.00	86.21	1.077	1.363	84.00	576.33	93.39
	6	3.518	42.67	82.14	1.130	1.503	86.96	490.67	88.11
Mean		3.518	40.89	86.12	1.097	1.422	84.15	565.00	91.73
L.S.D.		NS	NS	NS	NS	NS	NS	NS	NS
17 Light: 7 Darkness	4	3.542	48.00	84.00	0.960	1.403	85.71	469.67	93.27
	5	3.552	34.67	82.35	1.097	1.410	82.14	594.67	93.66
	6	3.736	50.67	84.62	0.963	1.593	81.82	684.67	91.74
Mean		3.580	44.47	83.66	1.007	1.469	83.22	549.67	92.89
L.S.D.		NS	NS	NS	0.990*	NS	NS	NS	NS
13 Light: 11Darkness (control)	4	3.286	37.33	83.33	1.067	1.187	92.31	490.33	88.88
	5	3.282	40.00	89.66	1.053	1.363	88.46	596.67	95.56
	6	3.188	46.67	84.00	1.027	1.680	85.71	555.67	97.64
Mean		3.252	41.33	85.66	1.049	1.410	88.83	547.56	94.02
L.S.D.		NS	NS	NS	NS	0.104**	NS	NS	NS
General mean		3.460	42.22	85.15	1.051	1.434	85.40	565.19	92.88
L.S.D. photoperiod		0.141**	NS	NS	NS	NS	NS	NS	NS
L.S.D. of feeds		NS	NS	NS	NS	0.076**	NS	NS	NS
L.S.D. Interaction		NS	NS	NS	NS	0.133**	NS	NS	NS

NS = Nonsignificant

* = Significant at 5% level of probability

** = Significant at 1% level of probability

between all means were insignificant (Table 2). The results obtained by Toheed *et al.* (2008) indicate that the mean fecundity to the adults emerged from larvae kept in dark and light were 112.6 and 46.7 eggs, respectively.

Hatchability

Data presented in Table 1 indicate that the mean percentage of hatchability is insignificantly affected by photoperiod regimes or daily number of feeds offered to 5th instar larvae during the first season of 2005. However, photoperiod regime 15L:9D gave the highest mean percentage hatchability recording 81.32%, regardless of number of feeds, meanwhile, control photoperiod regime 13L:11D gave the least mean (73.75%), regardless of number of feeds. In addition, offering 6 daily feeds resulted in the highest % hatchability for the three photoperiod regimes. Similar trend was also recorded in the second season of 2006, showing insignificant effect for photoperiod regimes number of feeds and the interaction between the two factors (Table 2).

Silk gland weight

The results in Table 3 clear that the heaviest silk gland weight was recorded when larvae exposed to 17L:7D photoperiod regime, showing 1.133g, in the first season of 2005, regardless of daily number of feeds. Meanwhile, the lightest weight(0.980g) was noticed when 5th instar larvae exposed to control photoperiod regime (13L:11D). Analysis of data revealed that the differences among the means are significant in case of photoperiod regimes, number of feeds and the interaction between the two factors. The same trend was observed in the second season (Table 4). In this respect, Janarthanan *et al.* (1994) reported significant increase in silk gland weight in the larvae exposed to 24L period.

Weight of fresh cocoon

Male cocoon

In the first season of 2005, obtained results clear that the daily number of feeds did not affect the weight of fresh male cocoon under the two photoperiod regimes 15L:9D and 13L:11D (under control conditions), Table 3. The highest mean weight of male fresh cocoon (1.500g) was resulted from offering 5 feeds daily to the 5th instar larvae under photoperiod regime 17L : 7D. Analysis of data

Table 3. Effect of photoperiod regimes in association with daily number of feeds on some biological and technological parameters of silkworm, *Bombyx mori* L. during spring rearing seasons of 2005

Photoperiod treatment	No. of feeds	Weight of silk gland (g)	Weight of fresh cocoon (g)		% cocooning	Weight of shell cocoon (g)		Shell /cocoon ratio %		Reeled silk filament		
			Male	Female		Male	Female	Male	Female	Length (m)	Weight (g)	Size (dn)
15 Light: 9 Darkness	4	1.057	1.473	1.813	97.30	0.330	0.333	22.39	18.36	754.50	0.2415	2.8804
	5	0.930	1.395	1.753	98.53	0.300	0.320	21.53	18.25	765.00	0.2343	3.0189
	6	1.230	1.613	1.998	100.00	0.363	0.355	22.41	17.74	850.50	0.2665	2.9171
Mean		1.078	1.496	1.855	98.62	0.331	0.336	22.11	18.12	790.00	0.2474	2.9388
L.S.D.		0.111**	NS	0.173*	NS	NS	NS	NS	NS	NS	0.021*	NS
17 Light: 7 Darkness	4	1.060	1.360	1.798	100.00	0.308	0.340	22.66	18.91	746.50	0.2287	2.7599
	5	1.060	1.500	1.803	100.00	0.330	0.335	22.01	18.51	688.00	0.2487	3.2981
	6	1.280	1.283	1.908	94.52	0.293	0.348	22.85	18.42	648.50	0.2320	3.4778
Mean		1.133	1.381	1.836	98.17	0.310	0.341	22.51	18.61	694.30	0.2365	3.1786
L.S.D.		0.142**	0.066**	NS	NS	0.029*	NS	NS	NS	NS	NS	NS
13 Light: 11Darkness (control)	4	0.958	1.353	1.548	96.05	0.288	0.268	21.25	17.24	704.00	0.2337	3.0236
	5	1.063	1.450	1.903	97.40	0.323	0.323	22.33	16.99	712.00	0.2411	3.0494
	6	0.918	1.398	2.040	98.75	0.290	0.328	20.72	16.14	816.00	0.2347	2.6103
Mean		0.980	1.400	1.830	97.40	0.300	0.306	21.43	16.79	744.00	0.2365	2.8944
L.S.D.		NS	NS	0.159*	NS	NS	0.039*	NS	NS	NS	NS	NS
General mean		1.064	1.426	1.840	98.06	0.314	0.328	22.02	17.84	742.78	0.2401	3.0039
L.S.D. photoperiod		0.082**	0.074**	NS	NS	0.022*	0.025*	NS	NS	69.949*	NS	NS
L.S.D. of feeds		0.082**	NS	0.107**	NS	NS	NS	NS	NS	NS	NS	NS
L.S.D. Interaction		0.128**	0.130**	0.184*	NS	3.765**	NS	NS	NS	NS	2.075*	NS

NS = Nonsignificant

* = Significant at 5% level of probability

** = Significant at 1% level of probability

revealed that the interaction between photoperiod regimes and number of feeds was significant. In the second season of 2006, the differences between means in this parameter are insignificant for number of feeds, photoperiod regimes and the interaction between the two factors (Table 4).

Female cocoon

The weight of fresh female cocoon was clearly affected by the number of feeds offered to the 5th instar larvae during 2005 season (Table 3). For instance, offering 6 daily feeds to the 5th instar larvae caused the highest mean weight of female cocoon, recording 2.040g for larvae exposed to photoperiod regime of 13L:11D (control). On the other hand, photoperiod regime seemed to be insignificantly effective, meanwhile, the interaction between the two studied factors showed significant effect. Similar results were obtained in the second season (Table 4). These results are in connection with, Toheed *et al.* (2008) who mentioned that the mean weight of cocoon was 1.06 gm in dark and 0.9 gm in light. On the other hand, Janarthanan *et al.* (1994) reported a significant increase in cocoon weight with exposing larvae to 24L period.

Cocooning percentage

Data in Table 3 show that the mean percent cocooning of the 5th instar larvae in 2005 season attained 98.62, 98.17 and 97.40% for silkworm larvae exposed to the three tested photoperiod regimes 15L:9D , 17L:7D and 13L:11D (control), successively, regardless of number of feeds. The differences among means, in this parameter, are insignificant for the number of feeds, photoperiod regimes and the interaction between the two factors. The same trend was observed in the second season (Table 4).

Weight of cocoon shell

Male cocoon shell

In the first season of 2005, data given in Table 3 indicate that the mean weight of male cocoon cortex did not differ significantly with daily number of feeds offered to the fifth instar larvae. Generally, the highest mean weight of cortices were obtained when larvae were exposed to 15L:9D photoperiod regime, recording 0.331 g. On the other hand, larvae exposed to the control photoperiod regime (13L:11D) possessed the least mean weight of male cortex weighing 0.300g. The differences between means in this

parameter, are significant in both photoperiod regimes and the interaction between the two studied factors. In 2006 season a Similar trend was also found for the effect of photoperiod regime on the mean weight of male shell (Table 4). Obtained results are in conformity with those of Janarthanan *et al.*, (1994) who mentioned that there was a significant increase in shell weight, regardless of photoperiod regimes.

Female cocoon shell

As shown in Table 3 the mean weight of female shell was not significantly affected by daily number of feeds offered to 5th instar larvae under the three regimes of photoperiod during 2005 season. On the other hand, the length of photoperiod caused significant effect at the control photoperiod regime 13L:11D, recording 0.306g . The differences between means for the daily number of feeds and the interaction between photoperiod regimes and daily number of feeds are insignificant in the two investigated seasons of 2005 and 2006. In this respect, Toheed *et al.* (2008) studied effect of light and dark exposure on the different life parameters of silkworm, and found that the mean weight of shell in dark and light was 0.20 gm and 0.16 gm, respectively.

Shell/ cocoon ratio%

Male shell/ cocoon ratio %

Data presented in Table 3 indicate that the mean percentage of shell/ cocoon ratio is insignificantly affected by photoperiod regimes or daily number of feeds offered to 5th instar larvae during 2005 season. However, photoperiod regime 17L:7D gave the highest mean percentage of shell/ cocoon ratio recording 22.51% , regardless of number of feeds, meanwhile control period regime 13L:11D gave the least mean (21.43%) regardless of number of feeds. Similar trend was also recorded in the second season of 2006 (Table 4).

Female shell / cocoon ratio%

Data in Table 3 clear that in 2005 season, the mean percentage of shell/ cocoon ratio recorded 18.12, 18.61 and 16.79% for the larvae exposed to the photoperiod regimes 15L:9D, 17L:7D and 13L:11D (control), respectively, regardless of number of feeds (Table 2). Analysis of data revealed insignificant differences between means in case of number of feeds, photoperiod regimes and

the interaction between the two factors. Meanwhile, in 2006 season the mean percentage of shell/ cocoon ratio was affected by the daily number of feeds offered to 5th instar larvae (Table 4).

Technological Traits of Reeled Silk Filament

The length (m)

In 2005 season, data presented in Table 3 reveal that the mean length of silk filament is insignificantly affected by photoperiod regimes, regardless of number of feeds. In addition, offering 6 feeds/ day to the 5th instar larvae caused the highest mean filament length recording 850.50 m at 15L:9D photoperiod regime. Statistical analysis cleared insignificant variation for the interaction between the two factors. Meanwhile, in 2006 season the effect of the three photoperiod regimes on the measured mean length of silk filament was insignificant, as well as the interaction between the two factors was also insignificant (Table 4).

The weight (g)

In the first season of 2005, data given in Table 3 indicate that the mean weight of silk filament did not differ significantly with photoperiod regimes or daily number of feeds offered to 5th instar larvae. Meanwhile, offering 6 feeds/ day to larvae resulted the highest significant mean weight of filament, recording 0.2665 g under 15L:9D photoperiod regime. In the second season, the differences between means for photoperiod regimes, number of daily feeds and the interaction between the two factors seemed to be insignificant (Table 4).

The size (in denier)

Data in Table 3 clear that the mean silk filament size recorded 2.9388, 3.1786 and 2.8944 dn for photoperiod regimes 15L:9D, 17L:7D and 13L:11D, respectively, regardless of number of feeds offered to the 5th instar larvae during 2005 season. Statistical analysis revealed that the differences between means for photoperiod regimes ,daily number of feeds and the interaction between the two factors were insignificant. In 2006 season, data presented in Table 4, clear that the mean silk filament size is insignificantly affected by photoperiod regimes, or daily number of feeds.

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تأثير الفترة الضوئية وعدد مرات التغذية على بعض الصفات البيولوجية والتكنولوجية لدودة الحرير التوتية

ولاء مجاهد محمد يوسف هلالى – السيد مجاهد متولى

سعد إبراهيم يوسف خليل – سعد محمد محمد على الشكعة

قسم وقاية النبات – كلية الزراعة – جامعة الزقازيق

تم تعريض يرقات دودة الحرير التوتية أثناء عمرها الخامس لنظامين من نظم الإضاءة والإظلام هما ١٥: ٩ ، ١٧: ٧ مقارنة بالكنترول ١٣: ١١ ساعة إضاءة : إظلام وتم تقديم ٤، ٥ و ٦ وجبات لليرقات فى كل نظام من نظم الاضاءة . وتمت دراسة تأثير تلك المعاملات على بعض الصفات البيولوجية والتكنولوجية ، وأوضحت النتائج أنه بتعريض يرقات العمر الخامس لدودة الحرير التوتية إلى ١٥ أو ١٧ ساعة إضاءة أدى ذلك إلى زيادة معنوية فى متوسط أوزان كل من اليرقة تامه النمو ،غدة الحرير، عذارى الذكور ، شرنقة الذكر الطازجة ، قشرة الشرنقة بالاضافة إلى حجم الخيط الحريرى (بالدنيير) وذلك خلال موسمى الدراسة. أدى زيادة عدد مرات التغذية إلى زيادة معنوية فى وزن العذراء الأنثى ، وزن شرنقة الأنثى الطازجة وحجم الخيط الحريرى. عند تقديم ٦ وجبات تغذية / يوم ليرقات العمر الخامس وتحت ظروف إضاءة ١٧ إضاءة : ٧ إظلام أدى ذلك إلى زيادة معنوية فى غالبية الصفات موضوع الدراسة وهى وزن العذراء الذكر ، وزن الشرنقة الذكر، وزن القشرة لكل من الذكر والأنثى ووزن الخيط الحريرى.