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Feed consumption rate and feeding frequencies of Eri and Mulberry silkworm at Melkassa Agricultural Research Center, Ethiopia

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Based on daily feed consumption rate determined prior to experimentation , five different feeding frequencies(one, two, three, four and five times feeding per day)were evaluated to determined number of possible time of feeding according to laboratory environmental conditions. Ply-wood made feeding trays, which are having the sizes of 90 cm x 60 cm were used to conduct the experiment. On each feeding tray, 400 hundred larvae were put to evaluate the number of feeding times. The treatments were laid out in randomized block design with four replications each. Significantly higher silkworm mortalities were observed in one times feeding per day for 2nd , 3rd and 4th instars larvae followed by two times feeding per day. Maximum larval growth period, lower weight of matured larvae, lower length of thread and silk ratios were recorded in one and two times feeding per day than the other treatments. Therefore, two times feeding per day for 1stand 2ndinstar, and 3-4 times feeding per day for 3^{rd,} 4th and 5thinstars larvae of castor feeding silkworms were recommended for all cropping seasons. Similarly, two times feeding per day for 1stand 2ndinstar larvae and 3-4 times feeding per day for 3nd, 4rd and 5th instars larvae of mulberry feeding silkworms were recommended from December to May cropping seasons. However, two times feeding per day for 1stand 2ndinstar and three times feeding per day for 3nd, 4rd and 5thinstars were recommended for mulberry feeding silkworms from June to November.

Keywords:-Feeding frequencies, Temperature, Relative humidity, silkworm larvae, Mulberry and castor leafs

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INTRODUCTION

The quality and quantity of feed plants can play an important role in growth and development of silkworm, particularly during adult and larval stage, which in turn influence the expression of cocoon productivity traits. This also leads to the increase in body size and dry weight of cellular mass which are dependent on the rate of metabolism, absorption of nutrients, and stage of development. In recent times, there has been a remarkable improvement in the production of silk by domestic silkworms (kedir *et.al.*, 2015).

Success of silkworm crops depends upon spacing given, feed quality, frequency of feeding and

environmental conditions in each instars in the rearing bed (Ahmed et.al., 2015a). Feeding frequency and overcrowding in rearing bed affects the economics of cocoon crop significantly as over feeding leads to leaf wastage and higher leaf cocoon ratios (Ahmed et.al, 2015b). While overcrowding of silkworm in rearing bed leads to insufficient consumption of feeds, poor growth and higher incidence of disease, resulting in low cocoon yield of inferior cocoon quality (Krishnaswam*et.al.*, 1977).Superior quality of silkworm feeds should be feeds to late age and young larvae and quantitative differences in feed influence both the larval growth and cocoon character of mulberry and Er-silkworms. According to Krishnaswam*et.al.*, (1978a), it is known that silkworm consumes 14% and 80% of the total quantity of leaf in IV and V instars, respectively. As per the environmental conditions of different seasons, feed is given two times per day in rainy season, while three times per day in rainy season, while three times during winter season and summer seasons (Krishnaswam*et.al.*, 1978a)

Different feeding schedules are followed in different agro climatic zones of the world in which silkworm rearing would be practiced. If the temperature and humidity can be maintained at the desired level such as 25-27 ^{o}C and 70-80%RH, respectively, four feeding per day in case of leaf feeding method for late age and three feedings per day in case of young age larvae system are advocated in summer season, while two feeding per day in rainy and winter seasons. However, depending on the weather condition, it is desirable to increase or decrease the feeding frequency without affecting the quantum of feed required at a particular instars, which considerably affects the cocoon quality (Krishnaswam*et.al*, 1978b).

The production of silk from lepidoptera insects in Africa, particularly in Ethiopia is still infancy in comparison to other developing countries like China and India and other European Countries. The major cause for the underdevelopment of silk production in Ethiopia is lack of extension and management practices to produce quality silk. In Ethiopia, production of silk was started during the Italian invasion in 1936 and discontinued when the Ethiopian heroes drove out the Italian invaders during 1941. The silk production experiment was re-started in 1990 by Melkassa Agricultural Research Center although there are some major constraints to boost the production. Among these problems lack of management practices including determination of quantity of feed per day and feeding frequencies are factors that hinder silk production (Kedir et.al., 2015). Therefore, it is crucial to determine quantity of feed required perday for each instars of silkworms and feeding frequencies according to environmental conditions of the study area. Thus, this experiment was proposed to determine quantity of feed required and feeding frequencies for castor and mulberry silkworms according to the environmental conditions of the study area.

MATERIAL AND METHODS

The experiments were conducted at Melkassa Agricultural Research Center, in sericulture and apiculture research laboratory during 2011-2013. Prior to experimentation, daily feed consumption rate were determined for both Eri and Mulberry silkworms. To determine the quantity of feed for each instar, five feeding trays which are having equal amount of larvae were used and equal amount of feeds were given. The feed/leaf was added for each treatment immediately after they finished during the larval growing period for both day and night until all the larvae moved to spinning. Rearing bed space and silk ratios were taken to evaluate the daily quantity of feed determination. Based on daily feed consumption determined, five different feeding frequencies(one, two, three, four and five times feeding per day)were evaluated to determine number of possible time of feeding under normal laboratory environmental conditions. Ply wood made feeding tray with the sizes of 90 cm x 60 cm were used to conduct the experiment. On each feeding tray, four hundred larvae were put to evaluate the number of feeding times. The treatments were laid out in completely randomized design with four replications. Daily temperature and relative humidity were recorded using thermo hygrometer during the experiment. Silkworm mortality percentage in each instars (1st, 2nd, 3rd, 4th and 5th), larval period, weight of matured larvae, average filament length and silk ratios were used to evaluate the feeding frequencies. Any dead larvae observed during data collection were replaced from the larvae's of the same age and species types from other feeding trays with the collected data for the feeding frequencies were subjected to SAS 6.12 software.

RESULTS AND DISCUSSIONS

Daily feeding quantum required and bed space for both mulberry (bivoltine, multivoltine) and Eri-silkworm (Eri India and Eri 3.4) instars are indicated in Table 1 and 2. Both rearing bed space and amount of feeds required for all the three species were recorded differently, for the reason that of different in their species and sizes. Depending on the larval age, the requirements in surface and space for silkworm rearing are presented in table 2. It appears that for young larvae, the needs in surface and space are small and the 5thinstar requires more surface and space, but this is for only few days (6-7 days) (Table 1).Eri and Mulberry silkworm larval mortality were higher in one and two times feeding/day for all instars, except in the 1st instars of the two times feeding/day (Figure 1 and 2).However, larval mortality was lower in three, four and five times feeding per day in all instars (Figure 1 and Figure 2). According to Kirishnaswami et al.1971 and Abiy et. al., 2015, the healthy growth of the silkworms

Table 1. Recommended quantity of mulberry and castor leaf required per day foreach instar of 100 eggs/larvae of Mulberry bivoltine, mulberymultivoltine and Erisilkworms (Average of five treatments**)**.

Instars	Days	Quantity of mulberry (kg/gm) (Mulberry bivoltine)	Quantity of mulberry (kg/gm) (Mulberry muoltivoltine)	Quantity of mulberry (kg/gm) (Eri India and 3.4)
I	1	0.0040kg=4.0 gm	0.002kg=2.0gm	0.0038kg=3.8gm
	2	0.0056=5.6	0.0036=3.6	0.0053=5.3
	3	0.0069=6.9	0.0049-4.9	0.0066=6.6
	4	0.0019=1.9	0.002=1.0	0.0034=3.4
	5	0.0015=1.5	0.0015=1.5	0.0025=2.5
	Total	**19.6**	**13.0**	**21.6**
II	1	0.0125=12.5	0.011=11	0..321=32.1
	2	0.0175=17.5	0.0145=14.5	0.0345=34.5
	3	0.005= 5	0.002=2.0	0.0061=6.1
	Total	**62.07**	**27.5**	**72.7**
III	1	0.035=35	0.015=15	0.06874=68.74
	2	0.055=55	0.035=35	0.075=75
	3	0.054=54	0.024=24	0.078=78
	4	0.0175=17.5	0.0135=13.5	0.0569=56.9
	Total	**161.5**	**161.5**	**278.64**
IV	1	0.07=70	0.04=40	0.097=97
	2	0.13=130	0.21=210	0.242=242
	3	0.155=155	0.15=150	0.285=285
	Total	**355**	**400**	**624**
V	1	0.21=210	0.21=210	0.450=450
	2	0.3=300	0.22=220	0.640=640
	3	0.45=450	0.35=350	0.75=750
	4	0.55=550	0.45=450	0.59=590
	5	0.69=690	0.59=590	0.94=940
	6	0.4=400	0.50=500	0.680=68
	7	0.2=200	**2320**	**4050**
	Total	**2800**		
Grand Total		**3.39 kg**	**2.92kg**	**5.045kg**

Table 2. Recommended rearing bed space required for 100 eggs/larvae's of Mulberry mulivoltine, mulberry bi-voltine and Erisilkworms (Average of five treatments).

Instars	days	Rearing bed space (sq.cm) (Mulberry multivoltine)		Rearing bed space (sq.cm) (Mulberry bi-voltine)		Rearing bed space (sq.cm) (Eri India and 3.4)	
		At the beginning	At the beginning	At the beginning	At the end	At the beginning	At the end
I	1 2 3 4 5	0.0024	0.0049	0.0027	0.0058	0.0037	0.0069
II	1 2 3	0.0049	0.0143	0.0058	0.0150	0.0069	0.0254

Table 2. Continuation

III	1 2 3 4	0.0143	0.0339	0.0150	0.0350	0.0254	0.0458
IV	1 2 3	0.0339	0.0649	0.0350	0.0689	0.0458	0.0856
V	1 2 3 4 5 6	0.0649	0.1289	0.0689	0.1392	0.0856	0.2457

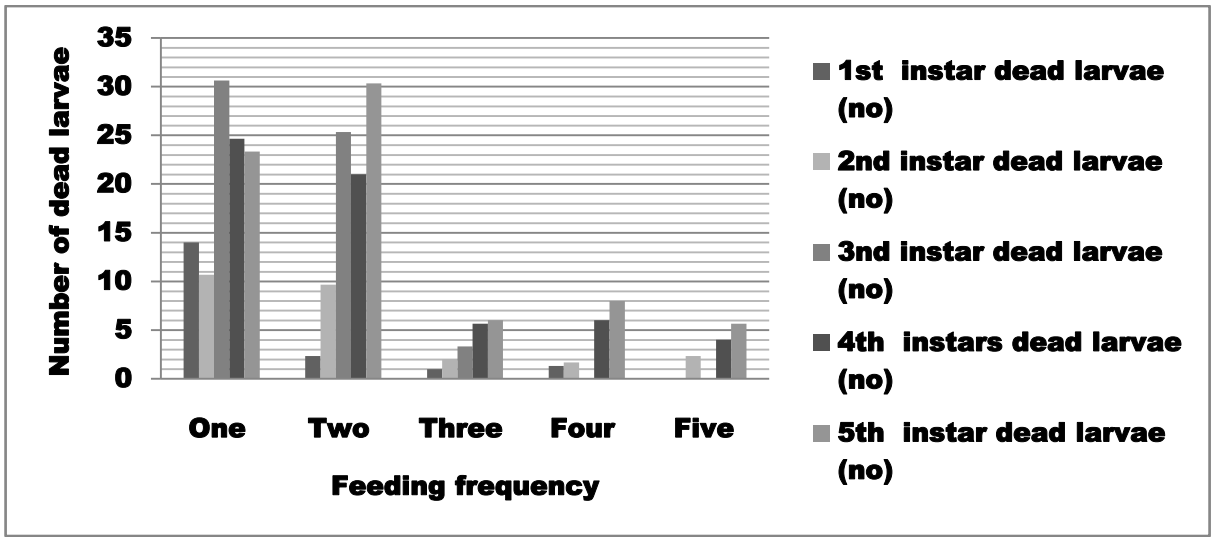

Figure 1. Effects of different feeding frequencies on different instars of Eri-silkworm larval mortality during summer and winter cropping seasons (combinedAnova for both seasons).

Table 3. Effects of different feeding frequencies on larval period, weight of matured larvae, length of spinning thread and silk ratios of Eri **-** silkworm both during summer and winter cropping seasons(combined Anova for both seasons).

Treatments Feedingtime/day	larval period (Days)	Wight of 10 matured larvae 6 days after 4th molt (gm)	Length of the cocoon thread (m)	Silk ratio %
One times	29.00 ±0.00a	48.67 ±5.48c	4.45 ±0.05e	9.91 ±0.24b
Two times	30.33 ±0.88a	52.64 ±2.96c	5.49 ±0.12d	9.33 ±0.13c
Three times	24.66 ±0.33b	66.66 ±3.71b	6.70 ±0.12c	11.03 ±0.17a
Four times	25.00 ±0.57b	83.68 ±2.40a	8.53 ±0.08b	11.50 ±0.14a
Five times	23.66 ±0.33b	85.36 ±3.30a	8.99 ±0.24a	11.41 ±0.16a
CV%	**3.74**	**9.91**	**2.79**	**2.83**

The same letter within a column means there was no significant difference from each other at 1% level of probability (Student-Newman-Keul`s Range Test).

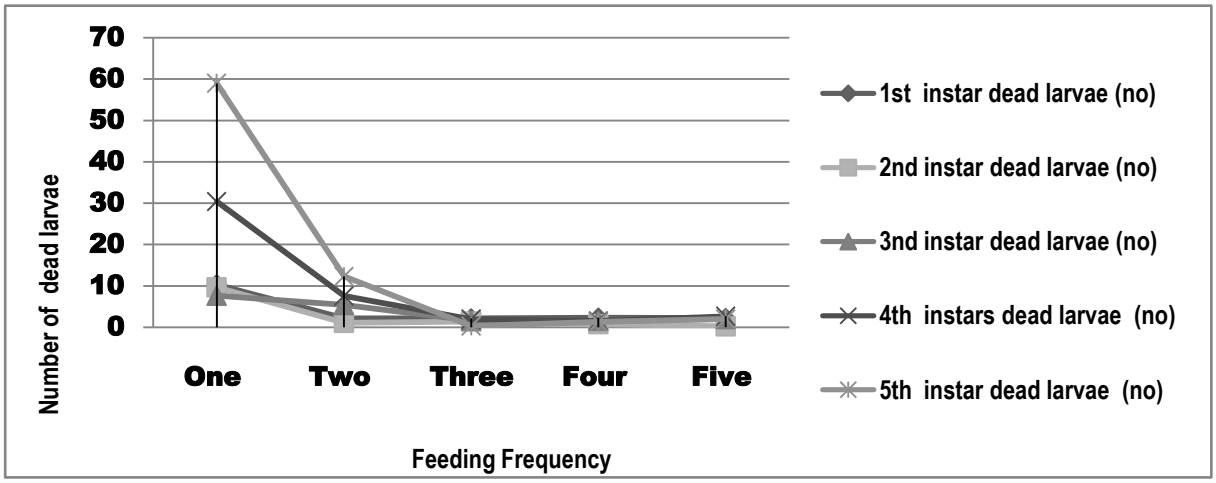

Figure 2. The rate of mortality on mulberry silkworm affected by different feeding frequencies (December – May)

and ultimately the economic traits such as cocoon yield, shell weight, larval weight and silk percentage are negatively influenced by less feeding frequency per day. Significantly ($P<0.01$) higher larval period, lower weight of matured larvae, lower length of single cocoon thread and silk ratios are observed in one and two times feeding per day. However, significantly lower larval period, higher weight of matured larvae, higher length of single cocoon thread and higher silk ratios were recorded in four and five times feeding per day followed by three times feeding/day compared to one and two feeding per day(Table 3 ad 4). Krishnawami*et. al*, 1977and Ahmed et.al., 2015b, reported that, three to four times feeding/day for Eri silkworms resulted in higher larval weight, lower larval mortality and shorter larval durations than two times feeding /day. Similarly, Das *et.*al 1994 and Kedir et.al., reported both Eri and mulberry feeding silkworm larval duration considerably extended in one and two times feeding/ day than 3, 4 and 5 times feeding/day. On the other hands, Krishnawami *et. al*, 1977 and Ahmed et. al., reported that, silkworms larval mortality was significantly very high in one and two times feeding/ day compared to 3 ,4 and 5 times feeding/day.

Significantly higher silkworm larval mortality was observed in four and five time feeding per day than the other treatments for 1stinstars larvae (Table 5). Similarly, higher larval mortalities were obtained in two, three, four and five times feeding/day for 2nd instar. However, significantly higher mulberry feeding silkworm larval mortalities were recorded in one and two times feeding per day for 3rd, 4th and 5th instars than the other treatments (Table 5). Das *et al, (*1994) also reported that, higher mortalities and lower silk ratios were recorded in one and two times feeding/day than three and above feeding time/day. This study is also in agreement with Krishnaswami *et al*., 1977 and Ahmed et.al., 2015a, who observed more matured larval weight in 2 times feeding /day with plucked leaves in the young age and 3, 4 and 5 times feeding/day with matured leaf from third and above instar larval period. Likewise, feeding frequencies of 3 and 4 times/day was found superior and resulted higher larval weight as shown in Das *et al*., (1994) and Chandrashekar, (1996). Rearing of silkworms with different feeding regimes caused marked influence on late age larval duration and overall larvae unlike its lower effect on young-age worms. The larval duration in the present study followed the trend observed in previous studies (e.g. Das *et al*., 1994; Chandrashekar, 1996). Haniffa*et al.,* 1988 and Ahmed et.al., (2015) showed when the numbers of feeds were reduced from 4 to 1 times feeding/day, the larval period was extended. Krishnaswami*et al*. (1978a; 1978b; 1980) also observed that, prolongation of larval period as a result of under feeding. According to Anonymous 1987 and Ahmed et.al., 2015a, a shorter silkworm larval duration, higher larval weight and good quality were recorded in 3 and above feeding/day than one time feeding/day of mulberry silkworms. This study also showed that the number of feeding times per day increased from 3 to 4 times per day and from 2 to 3 times per day during winter cropping season for late and young age larvae's, respectively. Whereas 3 and 2 times feeding per day during summer cropping season for late and young age larvaes, respectively. This is for the reason that of higher leaf moisture losses during winter cropping season and lower moisture losses from the leaf during summer cropping season.

Table 4. Effects of different feeding frequencies of mulberry silkworms on different parameters (December – May)

Treatments Feeding/day	larval period (days)	Wight of 10 matured larvae 6 days after 4th molt (gm)	Length of the cocoon thread (m)	Silk ratio %
One time	29.65 ± 0.31 a	28.69 ± 1.56 b	659.50 ± 63.00 b	19.73 ± 0.44 b
Two times	29.31 ± 0.30 a	33.35 ± 2.33 b	561.50 ± 61.00 b	19.38 ± 0.46 b
Three times	26.33 ± 0.86 b	43.03 ± 1.94 a	680.20 ± 11.35 b	21.74 ± 0.65 a
Four times	23.25 ± 0.34 c	45.76 ± 0.79 a	970.20 ± 36.02 a	22.75 ± 0.39 a
Five times	23.54 ± 0.30 c	44.51 ± 0.74 a	967.51 ± 36.02 a	22.48 ± 0.51 a
CV%	**3.48**	**7.19**	**18.03**	**4.58**

Same letter within a column show no significant difference from each other at 1% level of probability (Student-Newman-Keul`s Range Test).

Table 5. Effects of different feeding frequencies on mulberry silkworm larval mortality (June- November)

No.	Treatments Feeding /day	1st instar dead larvae (no)	2nd instar dead larvae (no)	3nd instar dead larvae (no)	4th instars dead larvae (no)	5th instar dead larvae (no)
	One times	11.33 ± 0.30b	1.78 ± 0.00b	2.14 ± 0.16a	11.00 ± 0.58a	22.00 ± 0.16a
	Two times	3.12 ± 0.31c	1.10 ± 0.15c	2.13 ± 0.13a	10.00 ± 0.56a	11.66 ± 1.20b
	Three times	15.45 ± 0.52a	1.11 ± 0.16c	0.00 ± 0.00b	0.00 ± 0.00b	1.65 ± 0.30c
	Four times	16.00 ± 0.51a	2.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	2.00 ± 0.00c
	Five times	18.00 ± 0.52a	2.20 ± 0.10a	0.00 ± 0.00b	0.00 ± 0.00b	1.32 ± 0.32c
CV%		8.15	11.49	16.71	14.08	19.10

Same letter within a column show no significant difference from each other at 1% level of probability (Student-Newman-Keul`s Range Test).

CONCLUSION

From this study, it can be concluded that two times feeding per day for 1st instar and 3-4 times feeding per day for 2nd, 3rd, 4th and 5th instars larvae of castor feeding silkworms were good both for summer and winter crops or throughout the year. Similarly, two times feeding per day for 1st instar larvae and 3-4 times feeding per day for 2nd, 3rd, 4th and 5th instars larvae of mulberry feeding silkworms were recommended from December to May cropping season. Likewise, two times feeding per day for 1st instar and three times feeding per day for 2nd, 3rd, 4th and 5th instar was recommended for mulberry feeding silkworms from June to November cropping season.

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