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In Vivo Effects of Antibiotics on Silkworm *Bombyx Mori* L Infected with *Bacillus Coagulans*

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The present study was aimed to screen different antibiotics *in vivo* for their effects against the bacterium *Bacillus coagulans* in silkworm *Bombyx mori* in three experimental conditions viz., a) healthy larvae treated with the antibiotics b) larvae which were first inoculated with *Bacillus coagulans* immediately after the 2nd moult and treated with the antibiotics from 24 hour after inoculation up to the end of the 5th instar (pre-inoculated larvae) and c) larvae which were treated with the antibiotics right from hatching up to the end of the 5th instar and inoculated with *Bacillus coagulans* immediately after the 2nd moult (post-inoculated larvae).
All the antibiotics used in this study stimulated better performance in improving the rearing performance and economic characters of the cocoons in healthy, pre-inoculated and post-inoculated larvae, besides reducing the mortality of infected larvae. Cephelexin and Tetracycline were more effective than the others in their overall performance under all the three experimental conditions. Chloramphenical caused greater increase in the length of the reelable silk filament, but was not as good in elevating the other parameters compared to the remaining antibiotics. Of the four concentrations of antibiotics tested, 2.0% performed better under all the three experimental conditions.

Key words: Antibiotics, *in vivo* studies, *Bombyx mori, Bacillus coagulans.*

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Introduction

The silkworm *Bombyx mori* is susceptible to diseases owing to complete domestication and consequent loss of resistance. Stability of the cocoon crop is most vital for vertical improvement of sericulture which is primarily dependent upon disease management. It is therefore essential to take preventive measures to check disease outbreak on the one hand and also finds out effective remedial measures on the other.

Antibiotics are now widely used not only in medicine but also in agriculture. They are used to treat many diseases of plants and animals. The use of antibiotics could be extended to sericulture also. Very little information is available on the comparative efficacy of different antibiotics against the bacterial diseases of silkworm *Bombyx mori.* Hence, the present investigation was aimed to screen different antibiotics against bacterial diseases of the silkworm *Bombyx mori* L.

Materials and Methods

The silkworm hybrid of Pure Mysore × NB_4D_2 was selected for the study. The silkworm larvae were brushed and reared according to Krishnaswami (1986). Six antibiotics viz., Amoxycillin, Ampicillin, Cephelexin, Chloramphenicol, Cloxacillin and Tetracycline were used in four concentrations each i.e. 1.0%, 1.5%, 2.0% and 2.5%. Required aqueous solutions were prepared in sterile distilled water, sprayed on the mulberry leaves and fed to the silkworms once in each instar up to the fourth instar and twice in fifth instar i.e. on the second and fifth days of the instar. The treated leaves were shade dried and then fed to the silkworms. Treatment with the six antibiotics was replicated four times. Each replication consisted of 100 larvae. The influence of antibiotics on growth, economic param-

eters, disease incidence and restriction of symptoms of disease, mortality etc., was examined, under the three experimental conditions. 1. In one set of experiments, healthy larvae treated with the antibiotics to test their efficacy in improving economic parameters.

2. In the second set of experiments the larvae inoculated with the pathogen at a dose of 3.8×10^5 (sub-lethal concentration) were treated with the above antibiotics from 24 hours after inoculation of the pathogen to the end of the 5th instar to find out the potential of each antibiotic in elevating the economic characters of cocoon and preventing/ controlling the disease. For this each batch of the healthy larvae were first inoculated with the pathogen immediately after the 2nd moult as the larvae enters the 3rd instar and then treated from 24 hours after inoculation up to the end of the 5th instar with the antiobitics through the feed, These larvae were called pre-inoculated larvae.

3. Another batch of healthy larvae was first treated with antibiotics from 1st instar and the treatment was continued up to the end of the 5th instar. These larvae were inoculated with the pathogen (sub-lethal concentration) immediately after the 2nd moult. These larvae were called post-inoculated larvae. The effects of antibiotics in all these experimental conditions were examined. In order to ob-

Table 1. Performance of healthy larvae treated with antibiotics with reference to different economic parameters. The values are means of 4 replicates (rearings). In each replicate of 100 larvae, values from 25 larvae/cocoons at random were average for each parameter

S.No	Treatments	Matured Larval Weight (g)	Cocoon Weight (g)	Effective rate of rearing (%)	Shell Weight (g)	Shell Ratio (%)	Filament Length (m)	Denier	Floss (%)
1	Control	3.30	1.80	77.50	0.32	17.06	621.25	2.45	5.15
	Ampicillin								
2	1.0	3.65	1.85	85.75	0.34	17.93	834.75	2.36	3.95
3	1.5	3.69	1.93	87.00	0.35	18.46	819.50	2.40	4.07
4	2.0	3.56	2.03	88.75	0.39	19.68	793.75	2.42	4.15
5	2.5	3.28	2.02	93.25	0.38	18.45	785.75	2.43	4.21
	Amoxycillin								
6	1.0	3.56	1.79	81.00	0.34	18.66	793.50	2.38	4.52
7	1.5	3.71	1.91	86.25	0.35	18.36	969.25	2.41	3.96
8	2.0	3.55	2.12	89.25	0.38	18.60	813.00	2.40	4.26
9	2.5	3.35	1.95	88.25	0.37	18.66	800.50	2.44	4.43
	Cephelexin								
10	1.0	3.54	2.01	82.00	0.39	18.78	792.75	2.38	3.50
11	1.5	3.69	2.12	81.75	0.39	18.33	756.50	2.43	3.66
12	2.0	3.69	2.15	90.75	0.39	18.05	716.50	2.51	3.72
13	2.5	3.75	2.17	86.50	0.39	17.53	719..75	2.51	3.31
	Chloramphenicol								
14	1.0	3.56	2.00	82.25	0.38	18.39	713.50	2.51	4.08
15	1.5	4.01	2.04	89.75	0.36	17.76	980.75	2.45	3.84
16	2.0	3.61	2.09	92.75	0.37	17.89	980.75	2.42	4.24
17	2.5	3.53	2.13	93.50	0.36	17.75	782.25	2.45	4.08
	Cloxacillin								
18	1.0	3.60	2.17	82.75	0.39	17.59	762.25	2.41	3.72
19	1.5	3.87	2.18	85.00	0.39	17.91	735.75	2.52	4.08
20	2.0	4.01	2.09	94.25	0.35	17.61	788.25	2.47	3.77
21	2.5	3.72	2.04	89.75	0.37	18.24	764.00	2.49	3.93
	Tetracycline								
22	1.0	3.70	2.00	85.50	0.37	17.80	715.75	2.48	3.87
23	1.5	3.83	2.05	88.75	0.37	18.41	744.25	2.48	4.14
24	2.0	3.90	2.09	89.00	0.36	17.49	775.50	2.46	4.13
25	2.5	3.74	2.18	93.00	0.37	17.20	791.75	2.45	3.91
	F-Ratio	5.95	8.85	3.67	2.23	3.44	34.33	11.31	7.95
	P Value	(0.00013)	(0.0000)	(0.00528)	(0.061390	(0.00780)	(0.0000)	(0.0000)	(0.000010

Table 2. Performance of Pre-inoculated larvae treated with antibiotics with reference to different economic parameters. The values are means of 4 replicates (rearings). In each replicate of 100 larvae, values from 25 larvae/cocoons at random were average for each parameter

S.No	Treatments	Matured Larval Weight (g)	Cocoon Weight (g)	Effective rate of rearing (%)	Shell Weight (g)	Shell Ratio (%)	Filament Length (m)	Denier	Floss (%)
1	Control	3.11	1.75	82.00	0.30	17.06	571.25	2.42	5.32
2	Infected	1.68	0.99	36.75	0.11	10.63	201.50	3.35	8.72
	Ampicillin								
3	1.0	2.52	1.35	63.75	0.20	14.87	509.25	2.55	5.71
4	1.5	2.52	1.35	65.50	0.20	15.11	461.00	2.53	5.69
5	2.0	2.67	1.36	68.25	0.21	15.27	474.25	2.51	5.75
6	2.5	2.78	1.43	69.75	0.22	15.24	433.50	2.48	5.68
	Amoxycillin								
7	1.0	2.45	1.30	62.00	0.19	14.69	465.75	2.56	6.00
8	1.5	2.82	1.38	62.25	0.21	15.43	421.75	2.55	5.81
9	2.0	2.65	1.43	65.00	0.22	15.36	395.75	2.55	5.81
10	2.5	2.47	1.42	66.00	0.22	15.39	367.25	2.56	5.83
	Cephelexin								
11	1.0	2.62	1.30	67.25	0.19	14.44	383.00	2.49	5.76
12	1.5	2.77	1.37	70.25	0.21	15.00	413.75	2.53	5.62
13	2.0	2.81	1.39	71.25	0.21	15.31	405.25	2.53	5.64
14	2.5	2.79	1.43	71.25	0.21	14.67	357.00	2.51	5.56
	Chloramphenicol								
15	1.0	2.50	1.30	55.25	0.19	15.05	502.25	2.50	5.94
16	1.5	2.72	1.36	60.00	0.21	15.15	518.00	2.52	5.89
17	2.0	2.69	1.36	63.25	0.21	15.26	536.25	2.54	5.81
18	2.5	2.69	1.36	62.00	0.20	14.77	548.75	2.52	5.85
	Cloxacillin								
19	1.0	2.48	1.26	61.75	0.19	14.75	414.00	2.53	5.80
20	1.5	2.57	1.33	66.50	0.20	15.23	422.75	2.54	5.89
21	2.0	2.85	1.37	67.50	0.21	15.57	427.75	2.56	5.92
22	2.5	2.85	1.45	65.00	0.21	15.38	429.25	2.53	5.89
	Tetracycline								
23	1.0	2.43	1.27	69.25	0.19	15.01	493.50	2.50	5.48
24	1.5	2.53	1.32	72.00	0.21	16.01	463.00	2.52	5.68
25	2.0	2.58	1.33	70.00	0.20	15.45	421.00	2.52	5.64
26	2.5	2.51	1.35	69.50	0.20	14.99	421.75	2.53	5.43
	F-Ratio	7.84	2.57	29.34	2.56	2.07	19.98	7.23	9.15
	P-Value	(0.00001)	(0.03431)	(0.0000)	(0.03505)	(0.7932)	(0.0000)	(0.00002)	(0.0000)

tain the pathogen, bacterial culture was maintained and the inoculum of *Bacillus coagulans* was prepared. Pathogenicity of *Bacillus coagulans* was reported by Savithri (1999).

Observations were recorded on surveillance and growth of silkworms and economic characters of cocoons, i.e. matured larval weight, cocoon weight, shell weight, shell percentage, effective rate of rearing, length of the silk filament etc., in the three experimental conditions. Comparisons of various effects were carried out using one way and two way analysis of variance (ANOVA).

Results and Discussion

Data on the influence of supplementation of antibiotics in four concentrations along with the feed to healthy silkworm larvae, pre- and post-inoculated larvae on various economic parameters are presented in tables 1 to 3. Antibiotic supplementation through mulberry leaves showed a positive effect in all the three experimental conditions. Antibiotics as growth stimulating factors are extensively used to enrich the nutrition of farm and other animals for increasing the productivity. In the silkworm *Bombyx mori*

Table 3. Performance of Post-inoculated larvae treated with antibiotics with reference to different economic parameters. The values are means of 4 replicates (rearings).In each replicate of 100 larvae, values from 25 larvae/cocoons at random were average for each parameter

S.No	Treatments	Matured Larval Weight (g)	Cocoon Weight (g)	Effective rate of rearing (%)	Shell Weight (g)	Shell Ratio (%)	Filament Length (m)	Denier	Floss (%)
1	Control	2..82	1.78	85.00	0.32	17.70	618.00	2.42	5.28
2	Infected	1.61	0.99	34.00	0.12	11.50	221.00	3.07	7.00
	Ampicillin								
3	1.0	2.78	1.57	69.75	0.25	16.06	599.25	2.50	5.41
4	1.5	2.78	1.63	71.50	0.27	16.23	597.25	2.45	5.37
5	2.0	2.88	1.65	73.00	0.27	16.36	602.25	2.45	5.16
6	2.5	2.95	1.70	75.00	0.28	16.47	600.25	2.42	5.14
	Amoxycillin								
7	1.0	2.71	1.54	66.25	0.26	17.05	532.75	2.49	5.83
8	1.5	3.09	1.59	69.75	0.28	17.30	609.00	2.50	5.36
9	2.0	2.84	1.66	75.50	0.29	17.46	596.00	2.51	5.53
10	2.5	2.69	1.70	73.25	0.29	17.25	564.00	2.51	5.68
	Cephelexin								
11	1.0	2.93	1.56	73.75	0.28	17.68	587.50	2.47	5.20
12	1.5	3.06	1.60	77.25	0.28	17.31	577.00	2.48	5.05
13	2.0	3.09	1.64	79.75	0.28	17.25	592.25	2.49	4.98
14	2.5	3.14	1.70	82.25	0.29	17.13	581.50	2.47	4.93
	Chloramphenicol								
15	1.0	2.77	1.55	64.50	0.27	17.54	630.00	2.48	5.50
16	1.5	2.87	1.60	68.25	0.27	17.05	646.00	2.46	5.30
17	2.0	2.93	1.63	71.00	0.28	16.91	649.75	2.48	5.33
18	2.5	2.79	1.68	69.00	0.28	16.47	647.50	2.45	5.55
	Cloxacillin								
19	1.0	2.75	1.52	68.75	0.26	17.30	608.50	2.44	5.30
20	1.5	2.87	1.60	79.25	0.28	17.32	626.00	2.50	5.30
21	2.0	3.12	1.67	75.75	0.29	17.04	603.50	2.49	5.80
22	2.5	2.99	1.71	74.25	0.28	16.42	580.50	2.47	5.75
	Tetracycline								
23	1.0	2.37	1.48	74.25	0.26	17.22	636.50	2.43	4.90
24	1.5	2.74	1.55	77.00	0.28	18.04	596.00	2.46	5.13
25	2.0	2.83	1.58	73.50	0.28	17.55	584.00	2.48	5.28
26	2.5	2.82	1.62	73.25	0.28	17.28	590.75	2.46	5.23
	F-Value	43.29	4.30	58.86	2.36	8.39	7.84	13.55	10.43
	P-Value	(0.0000)	(0.00183)	(0.0000)	(0.04868)	(0.0000)	(0.00001)	(0.00000)	(0.0000)

also some studies were carried out by different workers after enriching the leaves with small quantities of antibiotics before feeding (Murthy *et al* 1951, 1954, Sharada and Bhat 1956, Shyamala *et al* 1962, Verma and Atwal 1963, Radha *et al* 1981). Antibiotics as feed supplements were first reported by stockstad and Jukes in 1949. The beneficial effects of antibiotics have been attributed to a). Conditioning the composition of internal flora b) Possible growth factors c) Their potential disease control activity (Goldberg 1959).

All the six antibiotics used in this study stimulated better performance in improving the rearing performance and economic characters of the cocoons in healthy, pre-inoculated and post-inoculated larvae, besides reducing the mortality of infected larvae.

Healthy larvae treated with antibiotics

Healthy larvae treated with antibiotics showed significantly higher weights at maturity compared to those of the untreated batches, maximum larval weight (4.01 g) being with 1.5 Chloramphenicol and 2.0 Cloxacillin followed by Tetracycline 2.0%. The results are in agreement with

the observations of Murthy *et al.* (1951), according to whom Pencillin and Sterptomycin significantly increased the body weight of silkworm larvae. Murthy and Sreenivasaya (1953) also reported an increase in larval weight and pupal weight of the silkworm up to 9-10 per cent due to treatment with Aureomycin and Chloromycin. Shyamala *et al.* (1959) indicated that chloromycetin could be broken down by the silkworm intestine both *in vivo* and *in vitro.* P-amino benzoic acid and P-nitro-benzaldehyde did not have any antibacterial action, it was found to stimulate growth when given small quantities. Shyamala *et al.* (1962) observed the influence of Chloromycetin on efficient utilization of nitrogen (7%) mineral constituents (28%) and crude fat (20%) and increased deposition of minerals in the larvae treated with chloromycetin. Krishnaswami *et al.* (1980) noticed significantly higher matured larval weights by Chloramphenicol treatment. Six antibiotics viz., Hostacycline, Ledermycin, Terramycin, Abrimox, Cloxacillin and Ampicillin showed significantly superior values in matured larval weights in the silkworm hybrid PM × NB_7 (Tayade *et al.,* 1988). Prakash and Puttaraju (2006) stated that silkworm larvae treated with Tetracycline enhanced 6.25% of higher larval weight compared to control.

In the present study it was clearly noticed that the matured larval weight was significantly high in most of the antibiotic treatments. As suggested by Murthy and Sreenivasaya (1953) and shyamala *et al.* (1962), this may be attributed to efficient utilization of nitrogen metabolism in favour of increase of larval body weight.

Cocoon weight

All the antibiotic treated batches gave significantly higher cocoon weight. Maximum cocoon weight was recorded with 1.5% Cloxacillin and 2.5% Tetracycline. Similar observations on cocoon weight were made by Murthy *et al.* (1954) under the influence of Chloromycetin. Radha Krishna Rai and Devaiah (1988) reported an increase in cocoon weight both NB_{18} and Pure Mysore race due to supplementation of Tetracycline and Chloramphenicol. Sasidharan *et al.* (1995) noticed the improvement of single cocoon weight in Chloramphenicol and Tetracycline treatments. Dechu *et al.* (1997) noticed increased cocoon weights on treatment with Amikasin 1000 ppm and Tetracycline 1000 ppm. Treatment with antibiotics seems to cause beneficial effects on growth and development of larvae which in turn might contribute to improvement in cocoon traits (Dechu 1995).

Effective Rate of Rearing (ERR)

The present investigation recorded a significant improvement in the Effective Rate of Rearing (94.25%) with 2.0% Cloxacillin. The survival rate increased significantly with antibiotic treatments compared with control. Similar observations were also made by Samson (1987) and Baig *et al.* (1990). Samson (1987) noticed that the antibiotic treated mulberry leaves fed larvae had lower the disease incidence and increased their ability to survive under natural conditions. Baig *et al.* (1990) stated that the ERR was highly significant in all treatments in all seasons, the ERR ranged from 86.68 to 92.26 per cent among antibiotic treated batches. Increased survival rate in the silkworm larvae treated with antibiotics may be due to growth stimulatory action of antibiotics.

Shell weight

The present investigation revealed an increase in shell weight. Maximum shell weight (0.39 g) was recorded with four concentrations of Cephelexin, 1.0%, 1.5% Cloxacillin and 2.0% Ampicillin. The present elevation in shell weight recorded was 6.25 to 21.87%. A similar elevation in shell weight was reported by Verma and Kushwaha (1971) due to supplementation of subamycin, aureomycin, Terramycin and Ledermycin. Dechu (1995) observed an elevation in shell weight by antibiotic treatment in the hybrid of PM × NB_4D_2. Higher shell weight was obtained with Cloxacillin 500 ppm (0.37 g), Chloramphenicol 500, 1000 and 1500 ppm (0.35, 0.36 and 0.35 g respectively) and Tetracycline 1000 ppm (0.34 g). These observations support the results of the present investigation.

Shell Percentage

Shell percentage was significantly elevated by antibiotic supplementation. Improvement over control ranged from 0.82 to 7.91 per cent. A similar increase in shell percentage was obtained by Verma and Atwal (1963) by supplementation of Chloramphenicol. Radha *et al.* (1981) reported that elevation in shell percentage was associated with Cloxacillin 500 ppm (20.0%), Chloramphenicol 1000 ppm (19.12%) and 500 ppm (18.79%).

In contrast to this, Murthy *et al.* (1954) observed that the presence of Chloromycetin did not influence the shell percentage. Sharadha and Bhat (1956) also reported that the production of silk was not influenced appreciably by Chloramphenical supplementation. Similar observations were made by verma and Kushwaha (1971), Krishnaswami *et al* (1980) and Radhakrishna Rai in (1987).

Variability in performance in terms of shell ratio may be attributed to the fact that high shell percentage is the resultant of high increment of shell weight and lower shell percentage would be due to increment in the cocoon weight as a whole where in pupal weight contributes highly Dechu (1995).

Filament length

Antibiotic supplementation elevated the length of the filament. Length of the filament improved by 15.21 to 57.86 % over the control. The present findings supported by Murthy *et al.* (1951), Murthy and Sreenivasaya (1953), Verma and Kushwaha (1971). Murthy *et al.* (1951) concluded that Pencillin and Streptomycin along with protein hydrolysates increase the meterage of reelable silk. Radha and Muthukrishna (1980) reported that the maximum filament length and silk weight with Paushamycin 200 ppm and 100 ppm level respectively might be due to the effective streptomycin (forming a part of the drug) on the protein synthesis in silkworm. Tayada *et al.* (1988) stated that Hostacycline, Ledermycin, Terramycin, Abrimox, Cloxacillin and Ampicillin increased the length of the filament.

Denier

Even though lower values for denier were recorded in antibiotic treatments, no significant variation was noticed in single filament denier in all the antibiotic supplemented silkworm larvae compared to the control. Lowest denier (2.36) was noticed in 1.0% Ampicilln followed by 1.0% Amoxycillin and 1.0% Cephelexin (2.38). Significantly high denier was recorded with 1.5% Cloxacillin (2.52) followed by 2.0 and 2.5% Cephelexin and 1.0% Chloramphenicol (2.51). Dechu (1995) reported that the denier of the filament was significantly less in Chloramphenicol 1500 ppm (2.81), Chloramphenicol 500 ppm (2.83), Cloxacillin 1500 ppm (2.85) and Tetracycline 1000 ppm (2.86). It was higher with Neomycin 500 ppm (3.01), Gentamycin 1500 ppm (3.01) and Bactrim 1500 ppm (3.02). On the contrary, Radhakrishna Rai and Devaiah (1988) failed to record a positive influence from Tetracycline and Chloramphenicol at 0.04, 0.08 and 0.12%.

Floss Percentage

Lower floss content was recorded in antibiotic treated healthy, pre and post-inoculated larvae. The antibiotics could help to reduce the floss content which increased under infection. The results are on the lines of an earlier report of Tayade *et al.* (1988) who stated that Abrimox and Cloxacillin treatments showed significantly lower values than all other treatments. All the antibiotics used in the present study showed more or less the same degree of effects. Cephelexin is the most effective in reducing the floss content. Verma and Kushwaha (1971) reported lower floss percentage in all the antibiotic treatments compared to the control. Results of the present study on floss content with antibiotic treatment correlated well with the increase in shell percentage under these treatments, which speaks well for the favourable effects of antibiotics in reducing disease and promoting the economic parameters.

Effects of Antibiotics under Pre- and Post-Inoculated Conditions

The results on the effects of six antibiotics under pre- and post-inoculated conditions demonstrate significant decrease in mortality and improvement in economic traits of cocoons. Results of the present study receive support from the findings of Afrikian (1960), Narayanan *et al.* (1973), Krishnaswami *et al.* (1980) and Radhakrishna Rai (1987).

Afrikian (1960) stated that proper use of certain antibiotics makes it possible to suppress the bacterial infection in silkworm and to improve the quality of silk production by these larvae. Antibiotics like erythromycin, Kanamycin, Aureomycin and Terramycin have been shown to be highly effective against bacterial disease. The application of antibiotics resulted in almost complete suppression of cultures of bacteria of the *Bacillus cereus thuringiensis* group. According to Narayanan *et al* (1973) Chloramphenicol and Tetracycline inhibited the growth of *Bacillus thuringiensis.* Krishnaswami *et al.* (1980) reported that larval survival increased and disease incidence decreased, when Chloramphenicol was fed to silkworms. Radha *et al* (1981) noticed that enterocycline was more effective against flacherie.

Both pre-inoculated and post-inoculated larvae, showed significant improvement in the larval weights, cocoon weight, filament length and survivance compared to the infected larvae which were untreated with antibiotics. Minimum mortality was found in Tetracycline and Cephelexin. This elevation of economic characters may be due to the control of fast multiplication of the entire intestinal microflora including *Bacillus coagulans.* Similar results in controlling flacherie by oral administration of antibiotics along with mulberry leaves were reported by several workers. Iizuka *et al* (1970) reported the prevention of multiplication of streptococcus sps in silkworm gut by the addition of antibiotics like Tetracycline and Spiramycin.

Matsumoto *et al* (1985) reported that the intestine of larvae infected with infectious flacherie virus contained a large number of bacteria at moulting period. When Chloramphenicol was supplemented to the infected larvae, the bacteria that remained during moulting were cleared from the intestine and the life of the infected larvae was prolonged. A report from Central Sericultural Research and Training Institute (CSR & TI), Mysore, India, stated that Cloxacillin at 0.05 and 0.01% was effective in reducing the mortality due to flacherie and also in increasing the survival rate of silkworm larvae (Anonymous 1980). Baig et al (1990) found that mulberry leaf supplemented with 0.1% of Gentamycin, Cloxacillin, Streptomycin and Kanamycin as a feed was effective in increasing the survival rate and preventing occurrence of both grasserie and flacherie. Radhakrishna Rai (1987)

stated that in NB_{18} and Pure Mysore, the antibiotic Chloramphenicol and Tetracycline significantly reduced the larval mortality due to flacherie diseases. Ignoffo *et al.* (1977) and Manchev and Vangelov (1979) noticed that administration of Tetracycline increased the resistance against *Bacillus thurigiensis* and lowered lethality in silkworms and cabbage looper. Sasidharan *et al.* (1995) reported that all the antibiotics tested significantly reduced the incidence of Streptococcus infection and improved the cocoon weight, shell weight and effective rate of rearing. Radha and Muthukrishnan (1980) stated the incidence of flacherie was totally absent in the worms that were fed with leaves treated with Tinidozole, Metronidozole, Cotrimoxazole, which is a combination of two antibacterial drugs Trimethoprim and sulpha-methoxazole and Paushamycin (an antibiotic chemically containing Oxytetracycline 15% w/w and streptomycin 1.5% w/w) The increase in cocoon production might be due to the control of flacherie. This is well supported by the findings of Plorde (1972) and Anonymous (1979) who have stated that Tinidazole produces a quality better response in controlling the intestinal infectious diseases in human beings. Siva prakasam and Rabindra (1997) found that Tetracycline supplementation reduced the grasserie mortality besides enhancing the larval and cocoon parameters.

In both disease-induced conditions (viz-pre- and post-inoculated) antibiotic supplemented larvae showed significant improvement in shell weight and filament length and this elevation was maximum with Chloramphenicol. This may be due to the positive influence of antibiotics on the effective utilization of nitrogen and in turn on the protein synthesis. This observation is well supported by Verma and Atwal (1963) who noticed that Cholomycetin supplementation yielded more silk than the control silkworms. Radha and Muthukrishna (1980) reported increased filament length and silk weight in Paushamycin-supplemented larvae. Eid *et al.* (1989 a,b) stated that infection with *Bacillus thuringiensis* decreased the quantity and physical properties of Eri silk but supplementation of Tetracycline enhanced the quantity and quality of the silk produced by the diseased larvae.

Several studies reported that economic characters of silkworms improved by feeding the worms with mulberry leaves sprayed with different antibiotics.The stimulatory effect of antibiotics on growth can probably be explained by stimulation of growth of useful microorganisms, formation of stable strains that are less harmful, reduction of occurrence of sub-clinical infections etc. All these factors may have a favourable effect on silkworm growth (Nagarajan and Radha 1990).

In pre-inoculated and post-inoculated conditions the survivance and economic parameters were elevated by antibiotic supplementation in the present study. But the effectiveness of antibiotic treatments was more significant in post-inoculated conditions than in pre-inoculated ones. This indicates that administration of antibiotics prior to induction of disease is more helpful than their administration after the induction of the disease. Supplementation of antibiotics prior to inoculation would probably build up some resistance to the pathogen on the part of the host, which may help to fight against the bacteria infiltrating later. Under pre-inoculated conditions it appears that the process of damage to the host would have already been initiated by the time the antibiotic treatment was started. This naturally results in a repair situation than a preventive one. Thus recovery towards healthy controls would be less in pre-inoculated larvae than in post-inoculated Larvae.

Based on the current findings, all the tested antibiotics were found effective in elevating the beneficial characters of the cocoons and in preventing the incidence of bacterial disease caused by *Bacillus coagulans*. All the six antibiotics used in this study stimulated better performance in improving the rearing performance and economic characters of the cocoons in healthy, pre-inoculated and post-inoculated larvae, besides reducing the mortality of infected larvae. Cephelexin and Tetracycline were more effective than the others in their overall performance under all the three experimental conditions. They improved most of the economic characters and reduced the mortality due to bacterial disease. Chloramphenicol caused greater increase in the length of the reelable silk filament, but was not as good in elevating the other parameters compared to the remaining antibiotics. Of the four concentrations of antibiotics tested 2.0% performed better under all the three experimental conditions.

The present study reveals that use of antibiotics could be an effective tool in improving the general health of the silkworms, in reducing their mortality due to bacterial infection, and in improving the economic parameters in infected worms by reverting them towards the healthy ones. Better performance under post-inoculated condition compared to the pre-inoculated condition reveals that pre-treatment with antibiotics could be an effective guard for prevention and/or control of bacterial disease. In addition to this, the antibiotics improved the performance of the healthy larvae at the same time the antibiotics had no adverse effects, antibiotics may be suggested for regular use in the rearing practices irrespective of the incidence of disease or its absence for better rearing performance and economic productivity.

References

Afrikian, E.G. (1960) Causal agents of bacterial diseases of the

silkworm and the use of antibiotics in their control. J Insect Pathology **2**, 299-304.

Anonymous (1979) Pamphlet on cystazole (documented evidence). Brown and Burk, Pharmaceutical (P) Ltd, Madras.

Anonymous (1980) Effect of antibiotics on cocoon crop and incidence of loss due to diseases. Ann Report CSR& TI, Mysore pp. 109-110.

Baig, M., B. Nataraju and M.V. Samson (1990) Studies on the effect of antibiotics on the rearing performance and loss due to diseases in silkworm, *Bombyx mori* L Ind J Seric **29**,54-58.

Dechu, P.S., R. Govindan, M.C. Devaiah and T.K. Narayanaswamy (1997) Effect of antibiotics on the growth and cocoon parameters of silkworm *Bombyx mori* L. Mysore J Agric Sci **31**, 41-46.

Dechu, P.S. (1995) Effect of antibiotics on the growth of silkworm *Bombyx mori* L. and disease management. M.Sc . Dissertation, University of Agricultural Sciences, Bangalore pp. 21-95.

Eid, MAA, El-Nakkady AN and Saleh M.A (1989 a) Elongation and amino acid Profiles of silk produced by larvae of *Philosamia recini* (Boisd) in response to different treatments Ind J Seric vol **28**, 238-247.

Eid, MAA, El-Nakkady AN and Saleh M.A (1989 b) Restoring silk gland function of diseased larvae *Philosamia recini* (Boisd) by administration of Antibiotic. Ind J Seric **28**, 238-247.

Goldberg, H.S. (1959) Antibiotics, their chemistry and non-medical uses. D Van Nostrand Co Inc, Princeton, New Jersey pp. 597.

Ignoffo, C., Y. Horie and T.Couch (1977) Effect of antibiotics on insecticidal activity of *Bacillus thuringiensis*. J Invert Pathol **30**, 277-278

Krishnaswami, S., S. Kamala Singh, R. Raghuraman, R.G. Geetha Devi and K.V. Benchamin (1980) Chloramphenicol as a growth promoter in silkworm *Bombyx mori* L Proc Seric Symp Semi Coimbatore. pp. 130-132.

Krishnaswami, S. (1986) New Technology of silkworm rearing. CSR & TI Bulletin **2**, 1-23.

Manchev, M. and S. Vangelov (1979) Attempts to use medicines in the control of diseases of the silkworm Bombyx mori L. Testing the tolerance and the Pharmacokinetics of the antibiotics Tetracycline, Doxacycline, Streptomycin and Gentamycin. Zhivotnovdni Nauki (Bulgaria) Animal Science **16**, 111-116.

Matsumoto, T., Y.F. Zhu and K. Kurisu (1985) Mixed infection with infectious flacherie virus and bacteria in *Bombyx mori* L. J Seric Sci Jpn **54**, 453-458.

Murthy, M.R.V. and M. Sreenivasaya (1953) Effect of antibiotics on the growth of Silkworm *Bombyx mori* L. Nature **172**, 684-685.

Murthy, M.R.V., D. Shankaranarayana and M. Sreenivasaya (1954) Role of chloromycetin in the nutrition of silkworm *Bombyx mori* L. J Sci. industr Res **13**, 331-335.

Murthy MRV Shankarappa BS and Sreenivasaya M (1951) Influence of antibiotics on the growth of the silkworm *Bombyx mori* L. Curr Sci **20**, 269-270.

Narayanan, K., S. Jayaraj and T.R. Subramanian (1973). Sensitivity of Bacillus thuringiensis Berliner to two antibiotics and a sulphanilamide, Hindustan Antibiotic Bull **15**, 14-15.

Plorde, J.J (1972) Diseases caused by Protozoa. In: Principles of internal medicine (ED. Wintrobe MM, Thorn, Gw, Adams RD, Braunwald E, Isselbacher KJ and Petersdorf RG), McGraw Hill-Kogokusha Ltd, Tokyo, pp. 1014-18.

Prakash and Puttaraju (2006) tetracycline: Boon for silkworm and bane for Uziflies. Indian Silk **4**, 14-16.

Radha and T.S. Muthukrishnan (1980) Effect of certain chemicals on the growth and disease control of silkworm *Bombyx mori* L . Proceedings of Sericulture Symposium and Seminar Coimbatore

Radha, N.V., T. Natarajan, T.S. Muthukrishnan and S. Oblisami (1981) Effect of antibiotics on the growth and productivity of mulberry silkworm. Proceedings of Sericulture symposium and seminar 1980, TNAU, Coimbatore pp. 173-177.

Radhakrishna Rai and Devaiah (1988) Effect of antibiotics on the incidence of diseases in silkworm *Bombyx mori* L. Proceedings of International Congress on Tropical Sericulture Practices, Bangalore. Feb 18-23, 1988.

Radhakrishna Rai (1987) Effect of antibiotics on the growth, development and incidence of disease in silkworm *Bombyx mori* L M.Sc Dissertation, University of Agricultural Sciences Bangalore pp. 20-55.

Samson, M.V. (1987) Bacterial diseases of silkworm and their control. Ph.D Thesis. University of Mysore.

Sasidharan, T.O., M.V. Samson Govindaiah and Datta RK (1995) Effect of antibiotics on *Streptococcus faecalis* infection in the silkworm *Bombyx mori* L. Bull Seric Res **6**, 53-57.

Savithri, G. (1999) Biology of the silkworm *Bombyx mori* L with special reference to disease and treatment with antibiotics. Ph.D Thesis. Sri Padmavati Mahila visvavidyalayam (Women"s University) India.

Sharada, K. and J.V. Bhat (1956) Effect of Chloromycetin and Glysine on the growth and production of silk by *Bombyx mori* L J Ind Inst Sci **38**, 136-147.

Shyamala, M.B., M.R.V Murthy and J.V. Bhat (1959) Chloromycetin in the nutrition of silkworm *Bombyx mori* L. II. Influence of digestion and utilization of protein, fat and minerals. J Insect Physiol **4**, 229-234.

Shyamala, M.B., K. Sharada, G. Maya and J.V. Bhat (1962) Chloromycetin in the nutrition of silkworm *Bombyx mori* L J. Seric **1**, 21-26.

Stockstad, E.L.R and T.H. Jukes (1949) Poultry nutrition. Conference Federation meetings, Chicago Arch Biochem **27**, 499.

Tayade, D.S., M.D. Jawale and Unchegaonkar (1988) Effect of antibiotics on the growth of silkworm *Bombyx mori* L Ind J Seric **2**, 69-72.

Verma A.N. and A.S. Atwal (1963) Effect of Chloromycetin, glycine and Molasses on the growth and production of silk by *Bombyx mori* L (Lepidoptera: Bombycidae) Ind J Seric **1**, 1-3.

Verma, S.K. and K.S. Kushwaha (1971) Effect of four Tetracycline antibiotics on the growth of silkworm, *Bombyx mori* L Ind J Agric Sci **41**, 1009-1017.