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Research Article

CORRELATION STUDIES BETWEEN BIOCHEMICAL AND PHYSIOLOGICAL PARAMETERS OF SILKWORM HAEMOLYMPH WITH ECONOMIC CHARACTERISTICS OF SILKWORM, *BOMBYX MORI* L.

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Abstract

A detailed study was carried out on biomolecules and economic attributes using multiple regression analysis to investigate their relationship in the silkworm, *Bombyx mori*. The activity of protein, carbohydrate, amylase, acetylcholinesterase and peroxidase in the haemolymph was estimated. The commercial characters viz., larval-duration, mortality, weight, cocoon weight, shell weight, shell ratio, pupal weight, fecundity, deformed moths, survival at spinning were selected. The results of quantitative analysis were subjected for statistical analysis against selected commercial characters to know the level of correlation between them. The results of statistical analysis clearly showed that protein, carbohydrate and amylase has highly positive correlation with selected commercial characters except larval mortality and deformed moths. In contrast, the peroxidase indicated highly positive correlation with larval mortality and deformed moths only. The acetylcholinesterase has exhibited a different trend on different days.

Keywords Correlation, Haemolymph, Pesticides, Silkworm.

INTRODUCTION

Mulberry is infested by several pests and these pests affect the growth of mulberry and cause considerable damage to the plant and loss in leaf yield.The studies have focused on the effect of insecticides on *B. mori* dealing with toxicity, retardation of growth and development, fecundity, mortality, food utilization and economic parameters (Dutta *et al*., 2003). To overcome this problem, safe waiting period should be followed for leaf harvest (Narasimhanna, 1988).Silkworms exposed to residue of insecticides in the mulberry leaves could affect the growth and reproduction, economic characteristics of cocoons, eclosion and fecundity (Bhosale *et al*., 1988). The silkworm, *B. mori* has least resistance to insecticides and country's silk production was reduced by more than 30 per cent annually because of insecticide poisoning in China (Bing *et al*., 2010). The correlation between yield and biochemical parameters and genetic variability for egg characters (Chatterjee *et al*., 1993) were reported. However, correlation studies combining biomolecules with commercial characters of silkworm *Bombyx mori* L. are rather scarce. Hence, the present investigation was undertaken.

MATERIALS AND METHODS

Collection and storage of haemolymph

The haemolymph was collected from the first day to sixth day of fifth instar in each treatment. From each replication ten larvae were randomly selected. For extracting the haemolymph in fifth instar, third abdominal legs were amputated with sterilized blade and the haemolymph thus bled was immediately drawn into pre-cooled eppendorf tubes containing phenyl thiourea at 1mg/tube (Plate 1). Phenyl thiourea was used to avoid the activity of prophenol oxidase that causes melanization of the haemolymph samples (Etebari *et al*., 2006). To ensure complete extraction of haemolymph, the larvae were gently pressed from anterior and posterior ends simultaneously until no more haemolymph oozed out of the wound. The samples were centrifuged at 3000 rpm for 15 minutes to separate out the phenylthiourea crystals and haemocytes. The supernatant was used for the estimation after proper dilution (Mahesha *et al*., 2000). The samples were labelled and then preserved in deep freezer at - 20°C till further use.

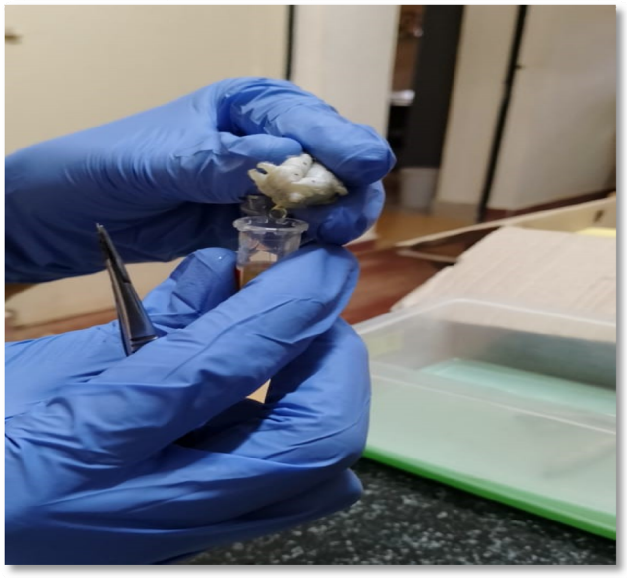

Plate 1. Collection of haemolymph from silkworm

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Quantitation of Biomolecules

The total proteins in the haemolymph was estimated by using Lowry's method (Lowry *et al*., 1951) using crystalline Bovine Serum Albumin (BSA) as standard (Plate 2).The quantitative estimation of total carbohydrate in the haemolymph of silkworm was done by Anthrone method (Dubois *et al*., 1956) using glucose as standard.The quantitative estimation of amylase activityin the haemolymph of silkworm was done as per the procedure given by Tanaka and Kusano (1980). The Acetylcholinesterase activity assay kit provides a simple and direct procedure for measurement of AChE levels in a haemolymph sample as estimated byEllman *et al*. (1961). The method proposed by Castillo *et al*. (1984) was adopted with slight modifications for assaying the activity of peroxidase in the protein extract using Guaiacol as substrate.

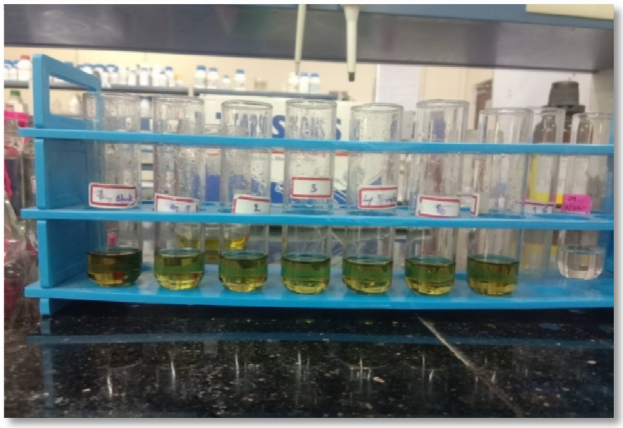

Plate 2. Biochemical analysis ofsilkworm haemolymph

Correlation

The data was analysed statistically for the nature and magnitude of correlationbetween economic parameters and total protein, carbohydrate, amylase, acetylcholinesterase and peroxidase were figured out using multiple regression analysisfor better interpretation of the data.

RESULTS AND DISCUSSION

The results and discussion on the research topic entitled"Analysis of correlation between biochemical and physiological parameters of silkworm haemolymph with economic characteristics of silkworm *Bombyx mori* L." conducted during 2021-2022 at University of Agricultural Sciences, GKVK, Bangalore, presented below and discussed in the light of earlier reports published.

Correlation of haemolymph biomolecules and enzyme activities with economic parameters

The inter-relationship between characters is expressed in statistical term as correlation, which shows how change in one character results in the change of the other character. The knowledge of correlation among various commercial characters is one of the important requirements in breeding programmes for evolving new breeds of silkworm *B. mori* L. with better economic characters (Mahesha *et al*., 2013). The correlation may be positive, negative or neutral. During the course of present study, the following correlations discussed under sub headings (below tables)

Correlation of haemolymph total protein with economic parameters of silkworm (*Bombyx mori* L.)

During the course of present study, it was found that highly significant ($p \leq 0.01$) positive correlations were obtained between haemolymph total protein and fifth instar larval duration on first day (r=+0.902) and second day (r=+0.836), it was found that moderately significant ($p \leq 0.05$) positive correlations were obtained on third day (r=+0.794), fourth day (r=+0.748) and fifth day (r=+0.716), it was non-significant and positive correlations were obtained on sixth day (r=+0.661). The highly significant ($p \leq 0.01$) negative correlations were obtained between haemolymph total protein and larval mortality in percentage on first day (r=-0.893), second day (r=-0.911), third day (r=-0.865), fourth day (r=-0.850) and fifth day (r=-0.825). It was found that moderately significant ($p \leq 0.05$) negative correlation was obtained on sixth day (r=-0.785) (Table 2).

The haemolymph protein was positively and significantly correlated with fifth instar larval weight (r=0.796, 0.855, 0.842, 0.820, 0.780 and 0.751 on day 1,2,3,4,5 and 6 respectively), cocoon weight (r=0.844, 0.888, 0.869, 0.848, 0.804 and 0.777 on day 1,2,3,4,5 and 6 respectively), shell weight (r=0.955, 0.965, 0.937, 0.935, 0.900 and 0.875 on day 1,2,3,4,5 and 6 respectively), cocoon shell ratio (r=0.775 and 0.707 on day 1 and 2 respectively), pupal weight (r=0.788, 0.845, 0.829, 0.809, 0.768 and 0.739 on day 1,2,3,4,5 and 6 respectively), fecundity (r=0.949, 0.870, 0.822, 0.775, 0.721 and 0.673 on day 1,2,3,4,5 and 6 respectively), survival at spinning (r=0.893, 0.911, 0.865, 0.850, 0.825 and 0.786 on day 1,2,3,4,5 and 6 respectively). The haemolymph protein was negatively and significantly correlated with larval mortality (r= -0.893, -0.911, -0.865, -0.850, -0.825 and -0.785 on day 1,2,3,4,5 and 6 respectively), deformed moths (r= -0.952, -0.923, -0.880, -0.846, -0.799 and -0.757 on day 1,2,3,4,5 and 6 respectively).

Table 1. Larval parameters of fifth instar silkworm (*B. mori* L.) as influenced by feeding pesticide treated mulberry leaves

Treatments	5th instar larval duration (h)	5thinstar larval weight (g)	Larval Mortality (%)	Survival at spinning (%)	Cocoon weight (g)	Shell weight (g)	Cocoon shell ratio (%)	Pupal weight (g)	Fecundity (No.)	Deformed moths (No.)
T_1 – Carbofuron 3G	200.01	2.93	5.42	94.58	1.78	0.30	17.32	1.61	482.55	2.00
T_2 – Dimethoate 30EC	199.64	3.07	9.09	90.91	1.81	0.31	17.60	1.64	497.85	2.67
T_3 – Novluron 10EC	154.86	2.54	12.35	87.66	1.56	0.23	14.92	1.44	326.65	11.00
T_4 – Azadirechtin 0.03EC	198.08	2.33	8.46	91.54	1.51	0.30	19.54	1.35	467.80	4.34
T_5 – Fenazaquin 10EC	159.78	2.22	11.17	88.84	1.50	0.26	17.53	1.32	415.65	6.34
T_6 – Dinotefuron 20SG	184.30	2.82	9.39	90.61	1.72	0.29	16.88	1.57	457.00	4.34
T_7 – Chlorfenapyr 10EC	173.22	2.13	13.93	86.08	1.46	0.25	16.89	1.30	382.70	10.34
T_8 – Water spray	202.03	3.25	5.24	94.76	1.94	0.38	19.94	1.73	510.35	0.33
T_9 – Absolute control	204.28	3.17	5.10	94.90	1.85	0.34	18.28	1.68	503.15	0.34
F - test	*	*	*	*	*	*	NS	*	*	*
SEm ±	6.50	0.12	0.42	0.42	0.06	0.01	0.59	0.06	20.01	0.15
CD @ 5%	19.48	0.36	1.24	1.24	0.19	0.04	1.77	0.18	59.98	0.44

Table 2. Correlation coefficients among the total protein and economic parameters of silkworm *B. mori* L. as influenced by feeding pesticide treated mulberry leaves

Economic parameters	Protein content						R^2
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	
Fifth instar larval duration	0.902**	0.836**	0.794*	0.748*	0.716*	0.661	0.9920
Larval mortality	-0.893**	-0.911**	-0.865**	-0.850**	-0.825**	-0.785*	-0.9785
Fifth instar Larval weight	0.796*	0.855**	0.842**	0.820**	0.780*	0.751*	0.9487
Cocoon weight	0.844**	0.888**	0.869**	0.848**	0.804**	0.777*	0.9397
Shell weight	0.955**	0.965**	0.937**	0.935**	0.900**	0.875**	0.9991
Cocoon shell ratio	0.775*	0.707*	0.665	0.669	0.644	0.623	0.9221
Pupal weight	0.788*	0.845**	0.829**	0.809**	0.768*	0.739*	0.9310
Fecundity	0.949**	0.870**	0.822**	0.775*	0.721*	0.673*	0.9447
Deformed moths	-0.952**	-0.923**	-0.880**	-0.846**	-0.799**	-0.757*	-0.9461
Survival at spinning	0.893**	0.911**	0.865**	0.850**	0.825**	0.786*	0.9785

* : Significant @5%; ** : Significant @1%

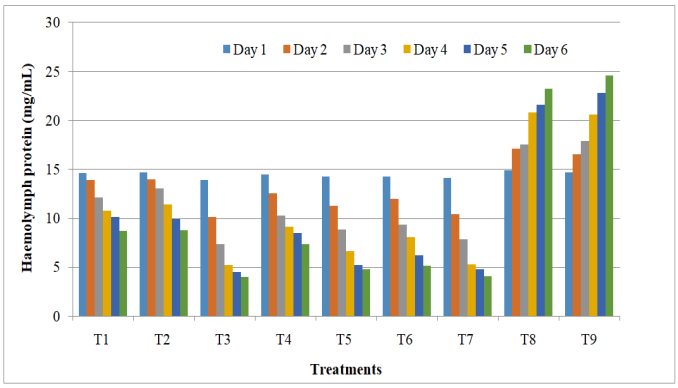

Fig. 1. Total protein content (mg/mL) in the haemolymph of fifth instar silkworm as influenced by feeding pesticide treated mulberry leaves

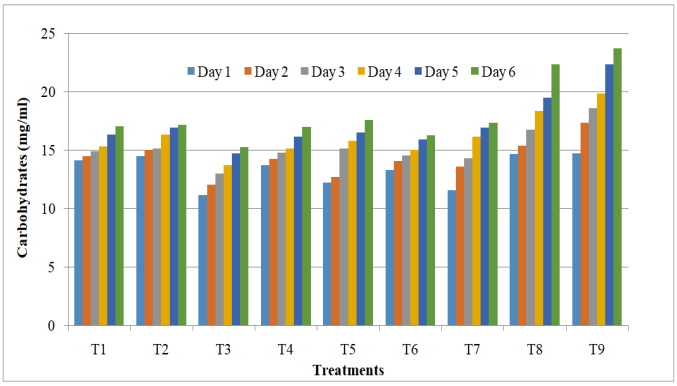

Fig. 2. Total carbohydrate content (mg/mL) in the haemolymph of fifth instar silkworm as influenced by feeding pesticide treated mulberry leaves

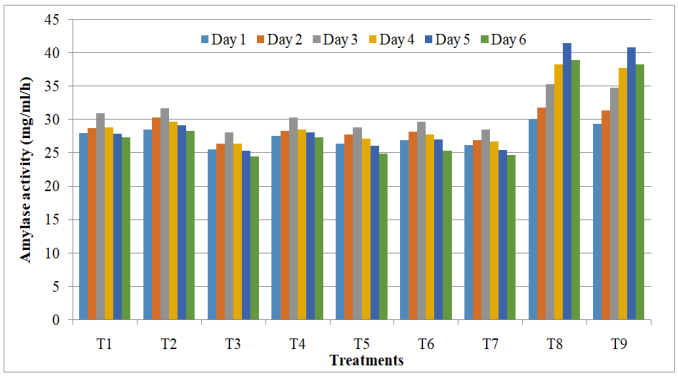

Fig. 3. Amylase activity (mg/mL/h) in the haemolymph of fifth instar silkworm as influenced by feeding pesticide treated mulberry leaves

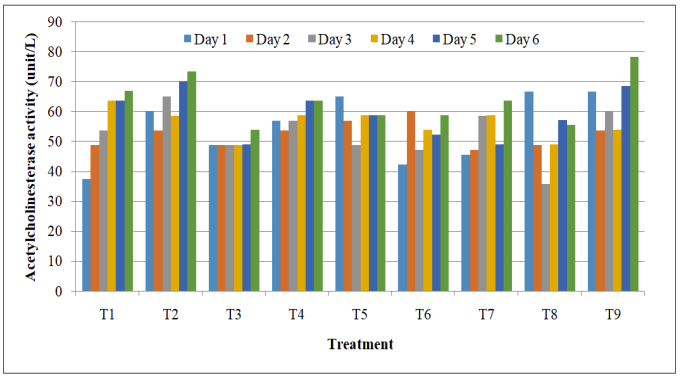

Fig. 4. Acetylcholinesterase activity (units/L) in the haemolymph of fifth instar silkworm as influenced by feeding pesticide treated mulberry leaves

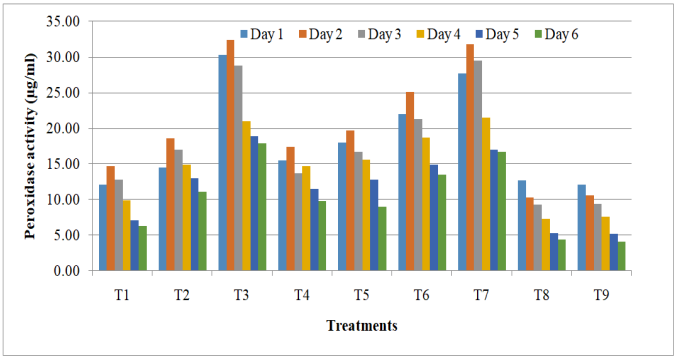

Fig. 5. Peroxidase activity (µg/mL)) in the haemolymph of fifth instar silkworm as influenced by feeding pesticide treated mulberry leaves

Table 3. Correlation coefficients among the total carbohydrate and economic parameters of silkworm as influenced by feeding pesticide treated mulberry leaves

Economic parameters	Carbohydrate content						R^2
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	
Fifth instar larval duration	0.942**	0.868**	0.656	0.589	0.578	0.562	0.9762
Larval mortality	-0.909**	-0.783**	-0.732*	-0.597	-0.620	-0.664	0.9588
Fifth instar Larval weight	0.806**	0.736*	0.610	0.574	0.578	0.590	0.8499
Cocoon weight	0.828**	0.745*	0.646	0.620	0.606	0.635	0.8455
Shell weight	0.912**	0.831**	0.797*	0.761*	0.728*	0.796*	0.9939
Cocoon shell ratio	0.720*	0.602	0.642	0.592	0.538	0.628	0.8615
Pupal weight	0.793*	0.722*	0.595	0.565	0.565	0.581	0.8166
Fecundity	0.980**	0.836**	0.737*	0.645	0.604	0.610	0.9990
Deformed moths	-0.979**	-0.836**	-0.784*	-0.668*	-0.650	-0.673*	0.9873
Survival at spinning	0.908**	0.783**	0.732*	0.598	0.620	0.664	0.9590

* : Significant @5%; ** : Significant @1%

Table 4. Correlation coefficients among the amylase activity and economic parameters of silkworm, as influenced by feeding pesticide treated mulberry leaves

Economic parameters	Amylase activity						R^2
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	
Fifth instar larval duration	0.884**	0.806**	0.793*	0.662	0.646	0.671*	0.9390
Larval mortality	0.878**	0.825**	0.858**	0.773*	0.760*	0.776*	0.9295
Fifth instar Larval weight	0.826**	0.847**	0.836**	0.761*	0.747*	0.749*	0.9557
Cocoon weight	0.866**	0.878**	0.866**	0.792*	0.776*	0.778*	0.9580
Shell weight	0.979**	0.956**	0.958**	0.899**	0.891**	0.897**	0.9924
Cocoon shell ratio	0.766*	0.705*	0.699*	0.648*	0.647	0.660	0.9494
Pupal weight	0.815**	0.832**	0.824**	0.751*	0.736*	0.737*	0.9482
Fecundity	0.913**	0.875**	0.817**	0.687*	0.670*	0.682*	0.9646
Deformed moths	0.928**	0.903**	0.871**	0.762*	0.747*	0.757*	0.9420
Survival at spinning	0.878**	0.825**	0.858**	0.773*	0.760*	0.776*	0.9289

* : Significant @5%; ** : Significant @1%

But, the correlation coefficient was positively non-significantly correlated in respect of fifth instar larval duration (r = 0.661 on day 6) and cocoon shell ratio (r = 0.665, 0.669, 0.644 and 0.623 on day 3, 4, 5 and 6 respectively) (Table 2). The results are supported by Kasmaei and Mahesha (2012a), who reported that haemolymph protein had positive correlation with larval weight, shell ratio, single shell weight, single cocoon weight, yield and fecundity and had significant negative correlation to fifth instar larval duration and total larval duration in mulberry silkworm. The haemolymph carbohydrate was positively and significantly correlated with fifth instar larval duration (r= 0.942 and 0.868 on first and second day respectively), fifth instar larval weight (r=0.806 and 0.736 on day 1 and 2 respectively), cocoon weight (r=0.828 and 0.745 on day 1 and 2 respectively), shell weight (r=0.912, 0.831, 0.797, 0.761, 0.728 and 0.796 on day 1,2,3,4,5 and 6 respectively), cocoon shell ratio (r=0.720 on first day), pupal weight (r=0.793 and 0.722 on day 1 and 2 respectively), fecundity (r=0.980, 0.836 and 0.737 on day 1,2 and 3 respectively), survival at spinning (r=0.908, 0.783 and 0.732 on day 1,2 and 3 respectively). The haemolymph carbohydrate was negatively and significantly correlated with larval mortality (r= -0.909, -0.783 and -0.732 on day 1, 2 and 3 respectively), deformed moths (r= -0.979, -0.836, -0.784, -0.668 and -0.673 on day 1, 2, 3,4 and 6 respectively). But, the correlation coefficient was positively non-significantly correlated in respect of fifth instar larval duration (r = 0.656, 0.589, 0.578 and 0.562 on day 3,4,5 and 6), fifth instar larval weight (r= 0.610, 0.574, 0.578 and 0.590 on day 3,4,5 and 6 respectively), cocoon weight (r= 0.646, 0.620, 0.606 and 0.635 on day 3,4,5 and 6 respectively), cocoon shell ratio (r = 0.602, 0.642, 0.592, 0.538 and 0.628 on day 2, 3, 4, 5 and 6 respectively), pupal weight (r= 0.595, 0.565, 0.565 and 0.581 on day 3,4,5 and 6 respectively), fecundity (r= 0.645,0.604 and 0.610 on day 4,5 and 6 respectively), survival at spinning (r= 0.598, 0.620 and 0.664 on day 4,5 and 6 respectively).

The correlation coefficient was negatively non-significantly correlated in respect of larval mortality (r= -0.597, -0.620 and -0.664 on day 4, 5 and 6 respectively) and deformed moths (r=-0.650 on fifth day) (Table 3). The activity of haemolymph amylase was positively and significantly correlated with fifth instar larval duration (r=0.884, 0.806, 0.793 and 0.671 on day 1,2,3 and 6 respectively), larval mortality (r= 0.878, 0.825, 0.858, 0.773, 0.760 and 0.776 on day 1,2,3,4,5 and 6 respectively), fifth instar larval weight (r=0.826, 0.847, 0.836, 0.761, 0.747 and 0.749 on day 1,2,3,4,5 and 6 respectively), cocoon weight (r=0.866, 0.878, 0.866, 0.792, 0.776 and 0.778 on day 1,2,3,4,5 and 6 respectively), shell weight (r=0.979, 0.956, 0.958, 0.899, 0.891 and 0.897 on day 1,2,3,4,5 and 6 respectively), cocoon shell ratio (r=0.766, 0.705, 0.699 and 0.648 on day 1,2,3 and 6 respectively), pupal weight (r=0.815, 0.832, 0.824, 0.751, 0.736 and 0.737 on day 1,2,3,4,5 and 6 respectively), fecundity (r=0.913, 0.875, 0.817, 0.687, 0.670 and 0.682 on day 1,2,3,4,5 and 6 respectively), deformed moths (r=0.928, 0.903, 0.871, 0.762, 0.747 and 0.757 on day 1,2,3,4,5 and 6 respectively), survival at spinning (r=0.878, 0.825, 0.858, 0.773, 0.760 and 0.776 on day 1,2,3,4,5 and 6 respectively). But, the correlation coefficient was positively non-significantly correlated in respect of fifth instar larval duration (r = 0.662 and 0.646 on day 4 and 5 respectively) and cocoon shell ratio (r = 0.647 and 0.660 on day 4 and 5 respectively) (Table 4). The activity of haemolymph acetylcholinesterase was positively and moderately significant correlation with fifth instar larval duration (r=0.716 on fifth day). But, the correlation coefficient was positively non-significantly correlated in respect of fifth instar larval duration (r = 0.187, 0.192, 0.185 and 0.606 on day 1, 3, 4 and 6 respectively), larval mortality (r= 0.011 on fourth day), fifth instar larval weight (r= 0.242, 0.007 and 0.365 on day 1,2 and 6 respectively), cocoon weight (r=0.261, 0.483 and 0.333 on day 1, 5 and 6 respectively), shell weight (r= 0.500, 0.019, 0.553 and 0.320 on day 1, 2, 5 and 6 respectively),

Table 5. Correlation coefficients among the acetylcholinesterase activity and economic parameters of silkworm as influenced by feeding pesticide treated mulberry leaves

Economic parameters	Acetylcholinesterase activity						R^2
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	
Fifth instar larval duration	0.187	-0.008	0.192	0.185	0.716*	0.606	0.7469
Larval mortality	-0.272	-0.036	-0.156	0.011	-0.655	-0.394	0.9670
Fifth instar Larval weight	0.242	0.007	-0.137	-0.306	-0.500	0.365	0.9089
Cocoon weight	0.261	-0.009	-0.201	-0.269	0.483	0.333	0.8850
Shell weight	0.500	0.019	-0.228	-0.193	0.553	0.320	0.8346
Cocoon shell ratio	0.567	0.064	-0.153	0.060	0.509	0.206	0.6129
Pupal weight	0.199	-0.003	-0.171	-0.301	0.458	0.336	0.8966
Fecundity	0.358	0.235	0.059	0.188	0.763	0.542	0.8924
Deformed moths	-0.390	-0.224	0.059	-0.068	-0.748	-0.487	0.9564
Survival at spinning	0.272	0.036	-0.156	-0.011	0.655	0.394	0.9671

* : Significant @5%; ** : Significant @1%

Table 6. Correlation coefficients among the peroxidase activity and economic parameters of silkworm as influenced by feeding pesticide treated mulberry leaves

Economic parameters	Peroxidase activity						R^2
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	
Fifth instar larval duration	-0.823**	-0.787*	-0.768*	-0.759*	-0.784*	-0.715*	0.9947
Larval mortality	0.883*	0.922**	0.917**	0.945**	0.940**	0.903**	0.9777
Fifth instar Larval weight	-0.619	-0.664	-0.625	-0.726*	-0.678*	-0.613	0.7469
Cocoon weight	-0.664	-0.709*	-0.667*	-0.769*	-0.733*	-0.671*	0.7469
Shell weight	-0.815**	-0.879**	-0.853**	-0.876**	-0.874**	-0.834**	0.9370
Cocoon shell ratio	-0.761*	-0.793*	-0.800**	-0.705*	-0.736*	-0.750*	0.8881
Pupal weight	-0.603	-0.647	-0.607	-0.716*	-0.674*	-0.603	0.7178
Fecundity	-0.928**	-0.891**	-0.882**	-0.823**	-0.841**	-0.836**	0.9497
Deformed moths	0.942**	0.944**	0.936**	0.908**	0.909**	0.906**	0.9310
Survival at spinning	-0.883**	-0.922**	-0.917**	-0.945**	-0.940**	-0.904**	0.9779

* : Significant @5%; ** : Significant @1%

cocoon shell ratio (r = 0.567, 0.064, 0.060,0.509 and 0.206 on day 1,2,4,5 and 6 respectively), pupal weight (r=0.199, 0.458 and 0.336 on day 1, 5 and 6 respectively), fecundity (r= 0.358, 0.235, 0.059, 0.188, 0.763 and 0.542 on day 1,2,3,4,5 and 6 respectively), deformed moths (r=0.059 on third day), survival at spinning (r= 0.272, 0.036, 0.655 and 0.394 on day 1,2,5 and 6 respectively). The correlation coefficient was negatively non-significantly correlated in respect of larval mortality (r= -0.272, -0.036, -0.156, -0.655 and -0.394 on day 1,2,3,5 and 6 respectively), fifth instar larval weight (r= -0.137, -0.306 and -0.500 on day 3,4 and 5 respectively), cocoon weight (r= -0.009, -0.201 and -0.269 on day 2,3 and 4 respectively), shell weight (r= -0.228 and -0.193 on day 3 and 4 respectively), cocoon shell ratio (r= -0.153 on third day), pupal weight (r= -0.003, -0.171 and -0.301 on day 2,3 and 4 respectively), deformed moths (r= -0.390, -0.224, -0.068, -0.748 and -0.487 on day 1,2,4,5 and 6 respectively) and survival at spinning (r= -0.156 and -0.011 on day 3 and 4 respectively) (Table 5).

The activity of haemolymph peroxidase was positively and highly ($p \leq 0.01$) significant correlation with larval mortality (r=0.883, 0.922, 0.917, 0.945, 0.940 and 0.903 on day 1,2,3,4,5 and 6 respectively) and deformed moths(r=0.942, 0.944, 0.936, 0.908, 0.909 and 0.906 on day 1,2,3,4,5 and 6 respectively). The haemolymph peroxidase was negatively and significantly correlated with fifth instar larval duration (r= -0.823, -0.787, -0.768, -0.759, -0.784 and -0.715 on day 1, 2,3,4,5 and 6 respectively), fifth instar larval weight (r= -0.726 and -0.678 on day 4 and 5 respectively), cocoon weight (r= -0.709, -0.667, -0.769, -0.733 and -0.671 on day 2,3,4,5 and 6 respectively), shell weight (r= -0.815, -0.879, -0.853, -0.876, -0.874 and -0.834 on day 1,2,3,4,5 and 6 respectively), cocoon shell ratio (r= -0.761, -0.793, -0.800, -0.705, -0.736 and -0.750 on day 1,2,3,4,5 and 6 respectively), pupal weight (r= -0.716 and -0.674 on day 4 and 5 respectively), fecundity (r= -0.928, -0.891, -0.882, -0.823, -0.841 and -0.836 on day 1,2,3,4,5 and 6 respectively), survival at spinning (r= -0.883, -0.922, -0.917, -0.945, -0.940 and -0.904 on day 1,2,3,4,5 and 6 respectively). But, the correlation coefficient was negatively non-significantly correlated in respect of fifth instar larval weight (r = -0.619, -0.664, -0.625 and -0.613 on day 1,2,3 and 6 respectively), cocoon weight (r= -0.664 on first day), pupal weight (r = -0.603, -0.647, -0.607 and -0.603 on day 1,2,3 and 6 respectively) (Table 6). The results are in conformity with Maqbool (2010), who reported that positive correlation of succinate dehydrogenase activity with cocoon yield per 10000 larvae by weight (r=+0.701), single cocoon weight (r=+0.660), single shell weight (r=+0.548).The results are also supported by Kasmaei and Mahesha (2012b), who reported that the activity of succinate dehydrogenase in haemolymph had positive correlation to cocoon weight (r=+0.319), shell weight (r=+0.246), shell ratio (r=+0.214), larval weight (r=+0.591), fecundity (r=+0.003), pupation rate.The results are supported by Bannikov *et al.* (1982), who reported that glutamate dehydrogenase activity had positive correlation with weight of silkworm larva. The results are supported by Pant and Jaiswal (1981), who reported that glutamate dehydrogenase, had positive correlation with growth and survival.

Future line of work

- Though the new insecticide molecules are popular among the farmers, there is a need to ascertain the residual toxicity in mulberry leaves for getting successful cocoon crop production.
- There is scope to analyse acetylcholinesterase activity in brain, fat body and silk gland in silkworms feed with insecticides applied mulberry leaves.

Conclusion

The study highlights significant correlations between haemolymph biomolecules, enzyme activities, and economic

parameters in the silkworm *Bombyx mori L.* Total protein levels were positively correlated with larval duration, weight, and fecundity, while exhibiting negative correlations with larval mortality and the incidence of deformed moths. Similarly, carbohydrate content demonstrated positive associations with larval duration and weight, contributing to higher cocoon quality and fecundity. Enzyme activities, particularly amylase and peroxidase, also showed significant relationships with these economic parameters, with peroxidase activity being negatively correlated with growth parameters but positively linked to larval mortality. Further research is warranted to explore these correlations in different environmental conditions and with various feeding regimes to establish comprehensive breeding guidelines.

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