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ACKNOWLEDGEMENTS. We thank Mr David F. Chapman (Department of Publication Support, Istanbul Medicine Faculty) for assistance in preparing this article.

Received 23 July 2015; revised accepted 25 August 2016

doi: 10.18520/cs/v112/i03/619-624

Comparative analysis of digestive amylase activity in some tropical and temperate breeds of mulberry silkworm, *Bombyx mori* L.

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In the current study amylase activity was carried out by analysis of digestive fluid in diapausing and non-diapausing strains of mulberry silkworm, *Bombyx mori* L. Six different breeds, viz. Pure Mysore, Nistari, NB_4D_2, SH_6, $SKAUR_6$ and $SKUAST_{28}$ were selected for the study. The average digestive amylase activity was found highest in Nistari during spring (664.82 µg) and summer (993.97 µg) seasons. However, among the bivoltine breeds SKUAST-28 with the average amylase activity during spring (148.47 µg) and summer (144.04 µg) seasons was found to be a superior breed with respect to this parameter. The amylase activity in tropical non-diapausing breeds is higher than that in the bivoltine breeds of silkworm which is responsible for their higher survival rate under unfavourable conditions.

Keywords: Amylase activity, *Bombyx mori* L., diapuasing and non-diapausing strains, maltose, survival.

THE silkworm, *Bombyx mori* L. is an important sericigenous insect which feeds on mulberry leaves and the digestibility of the silkworm larva largely depends on the activity of an enzyme called 'amylase'. Amylase is a hydrolytic enzyme found in micro-organisms, plants and animals which is involved in the digestion and carbohydrate metabolism in insects[1] including carbohydrates available in the form of starch in mulberry leaves[2]. The ability to digest more food influences the growth, development and resistance to diseases, stresses and better survival under different environmental conditions[3]. Amylases from different origins have been characterized[4,5]. The effect of BmNPV infection on the digestive enzyme activity in the silkworm, *Bombyx mori* was studied earlier by others and the activities of amylase, invertase, trehalase and protease were analysed in the infected silkworms[6]. Amylase activity was determined in two Eri silkworm, *Samia cynthia* ricini Boisduval breeds, viz. brick red cocoon and plain white cocoon breeds fed on three different host plants (Castor, *Ricinus communis* L; Tapioca, *Manihot utilessima* Phol. and Barkessuru, *Ailanthus excelsa* Roxb.)[7]. Amylase activity was studied in the digestive juice and haemolymph during the 5th instar larval stage. Comparative studies were carried out on the digestive amylase activity of 4th and 5th instar larvae of *Antheraea mylitta* Drury during outdoor and indoor rearing programmes[8].

Keeping in view the role of amylases in better digestibility and consequently the survival of silkworms, the present study was carried out to evaluate the difference in the amylase activities of diapausing and non-diapausing strains of silkworm, *Bombyx mori* L.

Six breeds of the mulberry silkworm comprising two multivoltines (Pure Mysore and Nistari), two temperate bivoltine breeds (SKAU-R-6 and SKUAST-28) and two tropical bivoltine breeds (NB_4D_2 and SH_6) were used in the present study. Disease-free layings of these races were obtained from the germplasm bank maintained at the Central Sericultural Germplasm Resource Centre (CSGRC), Hosur (Tamil Nadu) and the Silkworm Breeding and Genetics section TSRI (SKUAST-K), Mirgund.

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The material was incubated under laboratory conditions at 25°C and relative humidity of 75% and allowed to hatch. The silkworm breeds were reared as per standard package of practices[9].

The experiment was laid out in a completely randomized block design with four replications for each treatment. Each replication comprised 200 silkworms of uniform age and size retained after third moult. From each replication and treatment, ten larvae were randomly selected and starved for 4 h. The worms were then subjected to brief exposure to chloroform vapours resulting in the vomiting of gut juice. The required amount of vomited gut juice was collected in pre-cooled eppendorf tubes. Digestive juice samples were centrifuged @ 10,000 r/10 min (ref. 4). The supernatant was transferred to new tubes and kept at –20°C for analysis.

The amylase activity in the digestive fluid of six different, *Bombyx mori* breeds was determined following the standard procedure[10,11]. Two grams of soluble starch was dissolved in 1 litre of phosphate buffer (0.01 M NaH_2O_4 + 0.01 M Na_2HPO_4); 0.05 M NaCl was added and the pH adjusted to 6.8. The solution was shaken well in hot water bath to dissolve the starch completely and filtered. Ten test tubes were taken for each race and 10 µl of digestive juice sample were added with 2 ml of starch solution to each test tube. The samples were incubated at 37°C for 30 min. The reaction was then terminated by adding 2 ml of DNS solution to each test tube followed by heating in boiling water for 5 min. Finally, optical density values of the reaction mixture were recorded at 525 nm using spectrophotometer. OD values were converted into concentration of maltose released by preparing the standard curve of maltose. Maltose (25 mg) was dissolved in 25 ml of phosphate buffer of 6.8 pH. From this stock solution, serial dilutions of maltose solutions were prepared by adding 100 µl of stock solution (which will have 100 µg of maltose) and 1900 µl of phosphate buffer, 200 µl of stock (200 µg of maltose) and 1800 µl of buffer etc. up to 1000 µl of stock and 1000 µl of buffer. Thus, the total volume of all the serial dilutions was exactly 2000 µl or 2 ml. For each sample of 2 ml, 2 ml of DNS was added and boiled for 5 min in water bath. After cooling, the OD values of the serially diluted maltose solutions were recorded at 525 nm. A standard graph was prepared by plotting the OD values against the serially diluted maltose. The regression equation was obtained using the EXCEL software. The equation is

$$\text{Concentration of maltose} = \text{OD} \times 521.34 + 89.87.$$

The amylase activity was expressed as µg of maltose released per 10 µl of digestive juice for 30 min.

During spring, the amylase activity levels in midgut digestive juice showed its peak on the fifth day of fifth instar larvae of silkworms. From the 1st to 2nd day gradual increase and on 3rd to 4th day gradual decrease in enzyme activity in multivoltine breeds were observed; however in case of bivoltine breeds, generally an increasing trend with respect to digestive amylase activity was observed upto the fifth day (Figure 1). The enzyme activity showed significant reduction from sixth day onwards till the end of the fifth instar (Table 1).

The average enzyme activity was highest in Nistari (664.82 µg/10 µl) followed by Pure Mysore (619.72 µg/10 µl), SKUAST-28 (148.47 µg/10 µl), NB_4D_2 (124.41 µg/10 µl), SKAU-R-6 (122.12 µg/10 µl) and SH_6 (118.98 µg/10 µl).

1st day: On the first day of fifth instar, the activity of digestive amylase was significantly maximum in Pure Mysore (445.42 ± 17.76 µg/10 µl), while the enzyme activity was minimum in NB_4D_2 (107.59 ± 1.02 µg/10 µl). The enzymatic activities recorded in other breeds during the same day include: Nistari (372.95 ± 8.28 µg/10 µl), SH_6 (108.89 ± 1.09 µg/10 µl), SKAU-R-6 (111.37 ± 1.05 µg/10 µl) and SKUAST-28 (130.78 ± 3.54 µg/10 µl).

2nd day: A significant difference was found among the breeds with respect to digestive amylase activity on the second day of fifth age silkworm larvae. The activity was recorded significantly high in Pure Mysore (595.56 ± 26.36 µg/10 µl), followed by Nistari (502.89 ± 2.72 µg/10 µl). Among the bivoltine breeds, SKUAST-28 showed the highest activity of 132.61 ± 1.46 µg/10 µl, followed by SKAU-R-6 (114.88 ± 2.49 µg/10 µl), NB_4D_2 (112.54 ± 0.86 µg/10 µl) and SH_6 (109.80 ± 1.17 µg/10 µl), however they do not differ significantly from one another.

3rd day: There was significant difference among multivoltine breeds in the activity of digestive amylase during the third day of fifth age silkworm larvae. Maximum activity was found in Nistari (597.91 ± 14.71 µg/10 µl), whereas Pure Mysore showed 549.03 ± 10.89 µg/10 µl. Among bivoltine breeds, SKUAST-28 showed the maximum digestive amylase activity of 141.47 ± 2.04 µg/10 µl, followed by SH_6 (120.23 ± 2.11 µg/10 µl), SKAU-R-6 (118.27 ± 1.25 µg/10 µl) and NB_4D_2 (115.41 ± 1.84 µg/10 µl), however they were found at par with each other.

4th day: The activity of digestive amylase differed significantly among breeds on the fourth day of fifth age silkworm larvae. Significantly higher digestive amylase activity was observed in Nistari (569.21 ± 27.11 µg/10 µl) and Pure Mysore (515.93 ± 21.07 µg/10 µl). Among bivoltine breeds, SKUAST-28 was found superior in terms of amylase activity and it showed an activity of 163.50 ± 3.90 µg/10 µl, which was significantly different from that of SKAU-R-6 (116.45 ± 0.76 µg/10 µl). NB_4D_2 with digestive amylase activity of 129.48±1.56 µg/10 µl was found at par with SH_6 (125.96 ± 1.96 µg/10 µl of digestive juice/30 min).

5th day: The digestive amylase activity was significantly maximum in Nistari (1103.35 ± 17.03 µg/10 µl), followed by Pure Mysore (912.27 ± 10.68 µg/10 µl), SKUAST-28 (173.93 ± 1.95 µg/10 µl), NB_4D_2 (140.69 ±

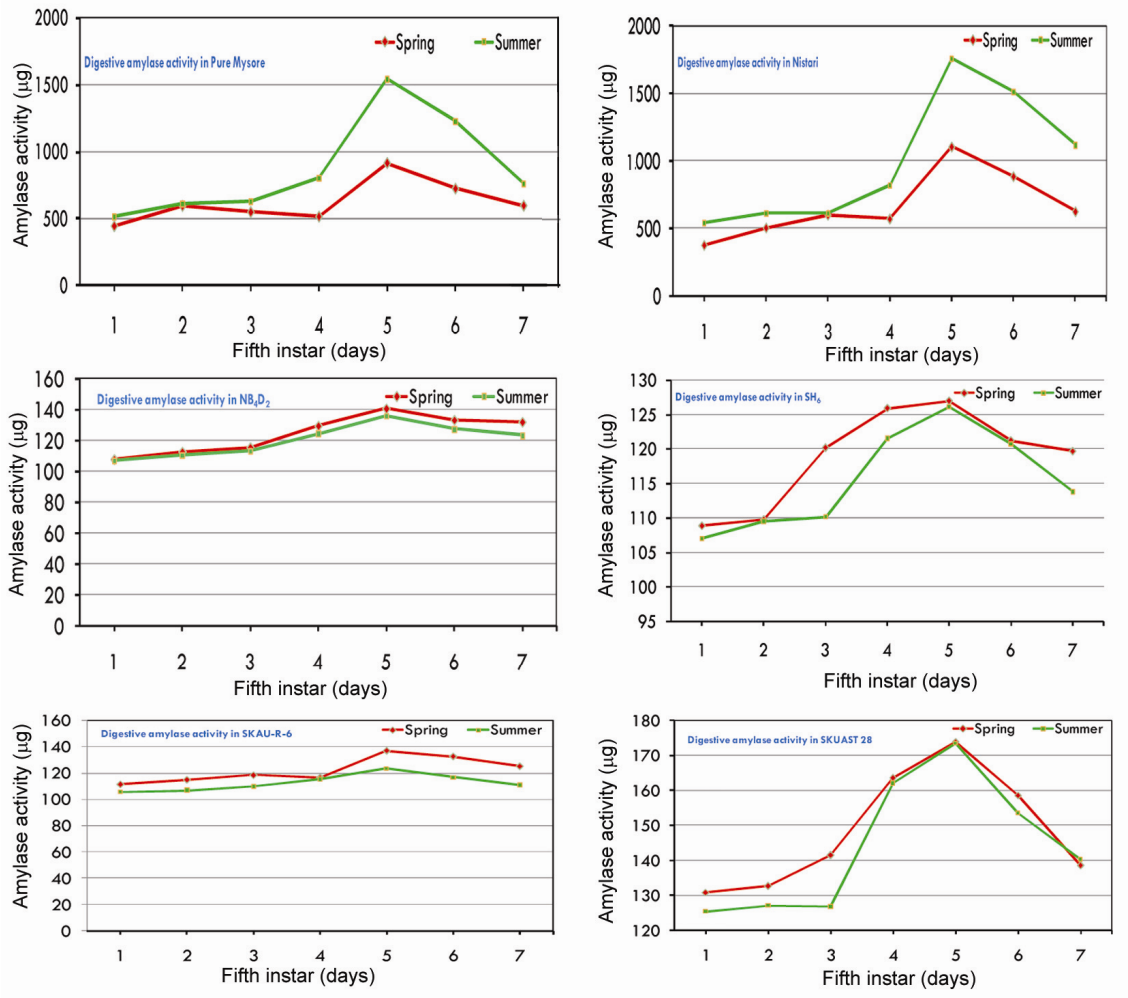

Figure 1. Digestive amylase activity in the 5th instar larvae of different breeds of silkworm, *Bombyx mori* L.

2.31 µg/10 µl), SKAU-R-6 (136.65 ± 0.91 µg/10 µl) and SH_6 (127.01 ± 0.57 µg/10 µl). Significant differences were recorded between NB_4D_2 and Pure Mysore, Pure Mysore and SH_6, SKAU-R-6 and Pure Mysore, SKUAST-28 and Pure Mysore, NB_4D_2 and SKUAST-28, SH_6 and SKUAST-28, SKAU-R-6 and SKUAST-28 but the differences were found to be insignificant between NB_4D_2 and SH_6, SKAU-R-6 and NB_4D_2, SH_6 and SKAU-R-6 with respect to digestive enzyme activity.

6th day: The digestive amylase activity was found to differ significantly among the different breeds under study. It was significantly maximum in Nistari (884.25 ± 14.53 µg/10 µl). Pure Mysore showed the digestive amylase activity of 723.03 ± 21.65 µg/10 µl, which was the second best and it also differed significantly from all other races. Among the bivoltine breeds, SKUAST-28 exhibited its superiority by recording an enzyme activity of 158.55 ± 2.22 µg/10 µl, which was significantly different from SH_6 (121.27 ± 1.95 µg/10 µl) but at par with SKAU-R-6 (132.35 ± 1.00 µg/10 µl) and NB_4D_2 (133.26 ± 1.13 µg/10 µl of digestive juice/30 min).

7th day: The digestive amylase activity was significantly maximum in Nistari (623.32 ± 13.57 µg/10 µl), whereas lowest activity was recorded by SH_6 (119.71 ± 1.33 µg/10 µl). The digestive amylase activity recorded in other breeds include: Pure Mysore (596.86 ± 16.41 µg/10 µl), NB_4D_2 (131.96 ± 0.71 µg/10 µl), SKAU-R-6 (124.92 ± 1.45 µg/10 µl) and SKUAST-28 (138.48 ± 2.28 µg/10 µl).

During summer, the amylase activity levels in the midgut digestive juice of multivoltine breeds showed a general increasing trend, whereas the reverse was observed with respect to bivoltine breeds. The average enzyme activity was higher in Nistari (993.97 µg/10 µl), followed by Pure Mysore (873.08 µg/10 µl) during the same season. Among bivoltine breeds, SKUAST-28 displayed the highest enzyme activity of 144.04 µg/10 µl, followed by NB_4D_2 (120.17 µg/10 µl), SH_6 (115.57 µg/10 µl) and SKAU-R-6 (112.52 µg/10 µl of digestive juice/30 min). The enzyme activity of all the breeds showed its peak on the fifth day of the fifth instar, thereafter, it started declining gradually (Figure 1). The daywise changes in

Table 1. Amylase activity in the digestive juice of different breeds of silkworm, *Bombyx mori* L. during spring seasons (data pooled over same seasons of 2011 and 2012)

Race	OD/Conc.	5th instar development days							Average activity
		1st day	2nd day	3rd day	4th day	5th day	6th day	7th day	
Pure Mysore	OD	0.682	0.970	0.880	0.817	1.577	1.214	0.972	619.72
	Conc.	445.42 ± 17.76	595.56 ± 26.36	549.03 ± 10.89	515.93 ± 21.07	912.27 ± 10.68	723.03 ± 21.65	596.86 ± 16.41	
Nistari	OD	0.543	0.792	0.974	0.991	1.944	1.523	1.023	664.82
	Conc.	372.95 ± 8.28	502.89 ± 2.72	597.91 ± 14.71	569.21 ± 27.11	1103.35 ± 17.03	884.25 ± 14.53	623.32 ± 13.57	
NB_4D_2	OD	0.034	0.043	0.049	0.076	0.097	0.083	0.080	124.41
	Conc.	107.59 ± 1.02	112.54 ± 0.86	115.41 ± 1.84	129.48 ± 1.56	140.69 ± 2.31	133.26 ± 1.13	131.96 ± 0.71	
SH_6	OD	0.036	0.038	0.058	0.069	0.071	0.060	0.057	118.98
	Conc.	108.89 ± 1.09	109.80 ± 1.17	120.23 ± 2.11	125.96 ± 1.96	127.01 ± 0.57	121.27 ± 1.95	119.71 ± 1.33	
SKAU-R-6	OD	0.041	0.048	0.054	0.051	0.089	0.081	0.067	122.12
	Conc.	111.37 ± 1.05	114.88 ± 2.49	118.27 ± 1.25	116.45 ± 0.76	136.65 ± 0.91	132.35 ± 1.00	124.92 ± 1.45	
SKUAST-28	OD	0.078	0.082	0.099	0.141	0.161	0.131	0.093	148.47
	Conc.	130.78 ± 3.54	132.61 ± 1.46	141.47 ± 2.04	163.50 ± 3.90	173.93 ± 1.95	158.55 ± 2.22	138.48 ±	
$CD_{(P \leq 0.05)}$		24.446	32.638	22.83	42.370	24.886	32.140	26.311	

OD = Optical density value at 525 nm, Conc. = μg of maltose/10 μl of digestive juice. Each value represents the mean ± SE of four replications.

the activity of the digestive amylase during fifth instar among different breeds (Table 2) during summer are reflected as follows.

1st day: On the first day the amylase activity was found significantly maximum in Nistari (539.78 ± 11.62 μg/10 μl) among all the breeds under study; however among bivoltine breeds, it was significantly higher in SKUAST-28 (125.31 ± 1.42 μg/10 μl), followed by NB_4D_2 (107.06 ± 0.76 μg/10 μl), SH_6 (107.04 ± 0.76 μg/10 μl) and SKAU-R-6 (105.50 ± 0.56 μg/10 μl), which were found at par with each other.

2nd day: Significantly high amylase activity was recorded in Nistari (610.94 ± 20.16 μg/10 μl), followed by Pure Mysore (605.99 ± 19.62 μg/10 μl), however the two were found to be at par with each other. Among bivoltine breeds, SKUAST-28 registered the highest amylase activity of 127.010 ± 1.19 μg/10 μl, followed by NB_4D_2 (110.19 ± 1.18 μg/10 μl), SH_6 (109.54 ± 1.59 μg/10 μl) and SKAU-R-6 (106.80 ± 1.95 μg/10 μl of digestive juice/30 min).

3rd day: Significant differences were recorded among the different silkworm breeds with respect to digestive amylase activity during fifth age. The maximum activity was shown by Pure Mysore (664.12 ± 23.75 μg/10 μl), which was significantly different from the amylase activity of Nistari (608.46 ± 23.70 μg/10 μl). Among bivoltine breeds, SKUAST-28 showed the maximum digestive amylase activity of 126.75 ± 1.07 μg/10 μl followed by NB_4D_2 (113.32 ± 0.56 μg/10 μl), SH_6 (110.19 ± 0.67 μg/10 μl) and SKAU-R-6 (109.67 ± 1.10 μg/10 μl of digestive juice/30 min).

4th day: There was significant difference among the breeds with respect digestive amylase activity during the fourth day of the fifth age larvae of silkworm. The highest activity was observed in Nistari (817.78 ± 20.69 μg/10 μl), while the lowest activity was observed in SKAU-R-6 (115.15 ± 1.81 μg/10 μl). The amylase activity recorded in other breeds include: Pure Mysore (800.32 ± 30.71 μg/10 μl), NB_4D_2 (124.40 ± 1.94 μg/10 μl), SH_6 (121.53 ± 2.89 μg/10 μl) and SKUAST-28 (162.07 ± 2.22 μg/10 μl of digestive juice/30 min).

5th day: The digestive amylase activity was significantly maximum in Nistari (1755.54 ± 116.19 μg/10 μl) during summer, followed by Pure Mysore (1543.23 ± 56.41 μg/10 μl) and SKUAST-28 (173.54 ± 3.13 μg/10 μl). Lowest amylase activity was registered in SKAU-R-6 (123.23 ± 3.20 μg/10 μl), which was found at par with NB_4D_2 (135.74 ± 2.03 μg/10 μl) and SH_6 (126.10 ± 1.51 μg/10 μl of digestive juice/30 min).

6th day: The digestive amylase activity was found to decline from sixth day onwards and it differed significantly among the breeds. It was significantly maximum in Nistari (1508.30 ± 47.73 μg/10 μl), followed by Pure Mysore (1228.34 ± 59.78 μg/10 μl). Among bivoltine breeds, maximum activity was shown by SKUAST-28 (153.46 ± 2.84 μg/10 μl), followed by NB_4D_2 (127.27 ± 1.54 μg/10 μl), SH_6 (120.75 ± 1.54 μg/10 μl) and SKAU-R-6 (116.58 ± 1.74 μg/10 μl of digestive juice/30 min).

Table 2. Amylase activity in the digestive juice of different breeds of silkworm, *Bombyx mori* L. during summer seasons (data pooled over same seasons of 2011 and 2012)

Race	OD/Conc.	5th instar development days							Average activity
		1st day	2nd day	3rd day	4th day	5th day	6th day	7th day	
Pure Mysore	OD	0.812	0.990	1.101	1.362	2.787	2.183	1.278	873.08
	Conc.	513.19 ± 9.07	605.99 ± 19.62	664.12 ± 23.75	800.32 ± 30.71	1543.23 ± 56.41	1228.34 ± 59.78	756.40 ± 8.93	
Nistari	OD	0.863	0.999	0.994	1.396	3.195	2.720	1.970	993.97
	Conc.	539.78 ± 11.62	610.94 ± 20.16	608.46 ± 23.70	817.78 ± 20.69	1755.54 ± 116.19	1508.30 ± 47.73	1117.03 ± 54.01	
NB_4D_2	OD	0.034	0.039	0.045	0.066	0.088	0.071	0.064	120.17
	Conc.	107.06 ± 0.76	110.19 ± 1.18	113.32 ± 0.56	124.40 ± 1.94	135.74 ± 2.03	127.27 ± 1.54	123.23 ± 3.19	
SH_6	OD	0.033	0.037	0.039	0.060	0.069	0.059	0.046	115.57
	Conc.	107.04 ± 0.76	109.54 ± 1.59	110.19 ± 0.67	121.53 ± 2.89	126.10 ± 1.51	120.75 ± 1.54	113.84 ± 1.46	
SKAU-R-6	OD	0.030	0.032	0.037	0.048	0.064	0.051	0.040	112.52
	Conc.	105.50 ± 0.56	106.80 ± 1.95	109.67 ± 1.10	115.15 ± 1.81	123.23 ± 3.20	116.58 ± 1.74	110.72 ± 1.06	
SKUAST-28	OD	0.068	0.071	0.070	0.138	0.160	0.122	0.096	144.04
	Conc.	125.31 ± 1.42	127.01 ± 1.19	126.75 ± 1.07	162.07 ± 2.22	173.54 ± 3.13	153.46 ± 2.84	140.17 ± 4.86	
CD ($P \leq 0.05$)		18.170	34.883	41.07	45.60	158.009	93.64	67.33	

OD = Optical density value at 525 nm. Conc. = μg of maltose/10 μl of digestive juice. Each value represents the mean ± SE of four replications.

7th day: The digestive amylase activity was significantly maximum in Nistari (1117.03 ± 54.01 μg/10 μl), while it was recorded minimum in SKAU-R-6 (110.72 ± 1.06 μg/10 μl). The enzyme activity recorded in other breeds include: Pure Mysore (756.40 ± 8.93 μg/10 μl), NB_4D_2 (123.23 ± 3.19 μg/10 μl), SH_6 (113.84 ± 1.46 μg/10 μl) and SKUAST-28 (140.17 ± 4.86 μg/10 μl of digestive juice/30 min).

The present study revealed that digestive amylase activity varied significantly among the breeds during the different days of the fifth instar. There was an increase in digestive amylase activity from the first day to fifth day of the fifth instar and, thereafter, its activity decreased. Several studies on the activity of digestive amylases in silkworm have revealed that activity is strong during the feeding period of the fourth and fifth instar larvae and weak at third ecdysis[4,12].

It was also observed during the present study that the activity of digestive amylase was at its peak level on the fifth day of the fifth instar. In Nistari breed the amylase activity was recorded maximum (1103.35 μg), followed by Pure Mysore (912.27 μg) and SKUAST-28 (173.93 μg of maltose/10 μl of digestive juice/30 min) during spring (Table 1). The same trend was repeated during summer with Nistari registering significantly maximum digestive amylase activity of 1755.54 μg, followed by Pure Mysore (1543.23 μg) and SKUAST-28 (173.54 μg of maltose/10 μl of digestive juice/30 min) (Table 2). These findings are similar to the reports of other researchers who observed significantly minimum digestive amylase activity of 0.05 μg of maltose/0.05 ml/30 min in NB_7, while significantly maximum activity of 0.2 mg of maltose/0.05 ml/30 min was observed in KA breed[13–15].

In the present study, it was also revealed that digestive amylase activity attained its peak on the fifth day of the fifth instar during both seasons, which could be correlated with the quantum of food ingested during this period. In a similar kind of study, maximum amylase activity was found in late middle part of the fifth instar of silkworm[16]. Higher digestive amylase activity in low yielding breeds (multivoltines) and low digestive amylase activity in high yielding breeds (bivoltines) exhibited in the present study also receive support from the findings of many other authors who revealed that diapausing strains showed negligible digestive amylase activity, while the non-diapausing strains registered strikingly higher amylase activity[4,14,17]. However variations in the levels of digestive amylase activity could be attributed to the physiological status of the insect that increases its feed consumption and utilization efficiencies. Also, it could be due to the reason that digestibility of starch in multivoltine and bivoltine breeds is quite different[4].

In the present study bivoltine breeds performed comparatively better in spring and among them the activity of digestive amylase was much higher in SKUAST-28 than other breeds during both seasons; however in multivoltines, the activity in summer was relatively higher than in spring season. Seasonal fluctuations in the activity of digestive amylase in different silkworm breeds could be attributed to leaf quality and environmental effects which

have a profound effect on the activity of amylase among different breeds of silkworm, *Bombyx mori* L.[18].

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Received 5 March 2016; revised accepted 3 June 2016

doi: 10.18520/cs/v112/i03/624-629

Silent foray of three soft scale insects in India

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This study documents three scale insects, viz. *Kilifia acuminata* (Signoret) (Hemiptera: Coccidae), *Trijuba oculata* (Bain) (Hemiptera: Coccidae) and *Protopulvinaria longivalvata* Green (Hemiptera: Coccidae) from India as new entrants. All these insects are polyphagous and attack several economically important plant species. *K. acuminata* has been reported from important plant genera like *Artocarpus*, *Eugenia*, *Psidium*, *Syzigium*, *Passiflora*, *Coffea*, *Citrus*, *Litchi* and *Manilkara*, while *T. oculata* has been reported to infest *Annona*, *Ficus* and *Vitis*. *P. longivalvata* has been recorded on important crops, viz. *Mangifera*, *Psidium*, *Syzigium*, *Piper*, *Coffea*, *Citrus* and *Camelia*. Brief diagnostic characters in live and mounted condition are provided. Information about host range, distribution and natural enemies of these scale insects is also furnished. New plant host records for scales and new host–parasitoid association have been documented. Possibilities of these scale insects becoming serious pests and a threat to economically important plants are also discussed.

Keywords: Distribution, natural enemies, plant host, scale insects.

WORLDWIDE, exotic invasive species are responsible for environmental and economic problems. Although some exotic species are efficiently kept at bay through both biotic and abiotic processes, several lack effective natural enemies and undergo explosive population increases and geographic spread. Such species commonly transform and negatively affect the native ecosystems, threaten biotic integrity and contribute to the disappearance of endangered species[1–6].

While compiling records on invasive species, Pimentel *et al.*[7] documented more than 120,000 non-native species of plants, animals and microbes in USA, UK, Australia, South Africa, India and Brazil. In these countries, non-native species are estimated to cause damage at more than US$ 314 billion per annum. In Europe, Australia and North America, arthropod invasions are relatively well documented, whereas in other parts of the world, information regarding arthropod invasions is scarce and dispersed[8].

Scale insects are one of the most commonly transported groups of insects in plant trade. At the same time they are one of the most successful invasive groups of

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