and C 305 when raised under similar conditions had a mean grain protein content of 12·5 and 10·8% respectively. Seventeen wheat varieties had a grain protein content higher than WG 357. Six wheat varieties (WG 2194, WG 2180, WG 2080, WG 2100, WG 2036 and WG 2032) exhibited a protein content higher than 13·0%. These six varieties might be used as donors for high grain protein content.

Variation for Pelshenke value ranged from 61 to 250 minutes. Twenty wheat varieties had a Pelshenke value higher than 200 minutes. Nine varieties exhibited a Pelshenke value higher than 150 minutes and four had a range of 100 to 150 minutes.

Wheat variety WG 2080 had a Pelshenke value of 222 minutes and protein content 13·1%. It has the same height as WG 357 but nine days earlier in anthesis than the latter. Three other wheat varieties, namely, WG 2122, WG 2085 and WG 2142 which had a protein content higher than WG 357 belonged to a very strong dough category. These four wheat varieties would be useful parents in the hybridization programme for ameliorating Pelshenke value and grain protein content.

Punjab Agricultural University,
Regional Research Station,
Gurdaspur 143 521,
November 19, 1979.

A. S. RANDHAWA*
KARAM CHAND.

1. Austin, A., Hanslas, V. K., Bhagia, N. K. and Daya Ram, *All India Coord. Wheat Improv. Project—Report on the Coordinated Experiments Wheat Quality*, 1978–79, p. 1.

STUDIES ON SILKWORM DISEASES

Phage and Serotyping of *Bacillus thuringiensis* Strains Occurring in the Sericultural Tracts of Karnataka

Bacillus thuringiensis is a well-known pathogen on lepidopterous and to a lesser extent on other insects. The mulberry silkworm *Bombyx mori* is among the more susceptible insects to the bacterium. At the same time *B. thuringiensis* preparations have enormous potential as a microbial insecticide for pest control. Thus there may exist conflicting interests in the use of *B. thuringiensis* preparations in intensive sericultural tracts and several studies must be carried out before these preparations can be considered safe for use in sericultural areas.

As a part of our investigations on the diseases of silkworms, several *Bacillus* strains were isolated from dead silkworms, excreta, rearing room dust, mulberry garden soil, etc., and purified by the usual methods. The H-antigens of, and antisera against authentic serotypes as well as the local isolates were prepared as per the procedures suggested by Norris[1]. Agglutination was checked in tubes.

Bacteriophages capable of lysing *B. thuringiensis* were also isolated from mulberry garden soil. A number of strains were used as hosts and phages from lytic regions were picked and purified by routine phage techniques. Three strains (labelled as VTP1, VTP2, and VTP3) were selected for the detailed studies on host-parasite interactions and these were used for testing the sensitivity of different *Bacillus thuringiensis* strains. Phage sensitivity was checked by preparing a lawn of the host strain and spotting a small droplet of phage preparation.

Bacillus thuringiensis strains were first isolated from a serious epizootic in Devanhalli area. Tables I and II give the details regarding the incidence of *Bacillus thuringiensis* from different materials and the frequency of incidence of different serotypes. These

TABLE I

Bacillus *species from sericultural areas*

Source	Number of isolates		Total
	Crystal forming	Non-crystal forming	
Soil	4	4	8
Leaf	3	6	9
Rearing room dust	2	2	4
Silkworm larvae	17	9	26
Egg sheet	1	1	2
Tray litter	1	2	3
Total	28	24	52

TABLE II

Frequency of incidence of different serotypes of Bacillus thuringiensis

Serotype	Number of strains out of 20 strains*
H_1 Berliner	2
H_3 Alesti/Kurstaki	2
H_4 Sotto/Dendrolimus/Kenyae	7
H_5 Galleriae/Canadensis	2
H_6 Entomocidus	1
H_7 Aizawae	1
H_8 Morrisoni	3
Unknown	2**

* Some more strains are to be typed. These may be mostly H_4.

** These two though crystal forming did not cross react with any of the antisera we have prepared.

TABLE III

Phage sensitivity of Bacillus *strains*

Phage strains	*B. thuringiensis* serotypes		*Bacillus strains isolated in MCBL — Number of strains	
	Sensitive	Resistant	Sensitive	Resistant
VTP 1	H_1, $H_{5a, 5c}$, H_6, H_{11}	H_{3a}, H_{3ab}, H_{4a4b}, H_{4ab}, H_{4a4c}, H_{5a5b}, H_7, H_8, H_9, H_{10}, H_{12}	2	61
VTP 2	H_1, H_{4a4c}, H_{5a5c}, H_6	H_{3a}, H_{3ab}, H_{4a4b}, H_{4ab}, H_{5a5b}, H_7, H_8, H_9, H_{10}, H_{11}, H_{12}	6	57
VTP 3	H_{3a}, H_{3ab}, H_{4a4b}, H_{5a5b}, H_{5a5c}, H_6, H_7, H_8, H_9, H_{10}, H_{11}	H_1, H_{4ab}, H_{4a4c}, H_{12}	34	29

* Includes both crystalliferous and non-crystalliferous strains. A number of recently isolated *Bacillus* strains are included here, but not in the results presented in Tables I and II.

isolates which were obtained from Kolar, Bangalore and Mandya Districts show that a number of serotypes occur in the region. Serotype H4 (Sotto/Dendrolimus/Kenyae) is the most prevalent. Pathogenicity studies showed that strains belonging to serotype H3 (Alesti/Kurstaki) and H4 were the most virulent (unpublished data). Sensitivity to the phages of different strains is given in Table III. VTP3 attacks the maximum number of isolates. It has also been reported that phages capable of lysing *B. thuringiensis* were able to grow on non-crystalliferous species like *B. cereus*[2]. Phage sensitivity and the geographical distribution of *B. thuringiensis* serotypes have formed the subject-matter of other studies also[3,4] Majumder *et al*[5] reported the isolation of a pathogen from *Heliothis obsoleta* in Mysore which was later identified as *B. thuringiensis* var *thuringiensis*. This is the first report on the typing of *B. thuringiensis* strains occurring in this region and the data are presented here with the hope that it will be useful to the microbial ecologist as well as to the epizootiologist of insect diseases.

The authors are thankful to Dr. E. Afrikian, Director, Institute of Microbiology, Abovian City, Armenian SSR, USSR, for providing us with the lyophised cultures of *B. thuringiensis* serotypes; to the Central Silk Board, Government of India, Bombay, for financial assistance; to the officers of the Department of Sericulture, Government of Karnataka, for their kind cooperation and Sri. R. Ramanath for his help. Our thanks are also due to Sri. S. Kalidas, Foreign Languages Section, Indian Institute of Science, for the English translation of the review by Dr. Afrikian (Ref. 4).

Microbiology and Cell Biology Laboratory,
Indian Institute of Science,
Bangalore 560 012,
November 26, 1979.

V. N. VASANTHARAJAN.
N. MUNIRATHNAMMA.

1. Norris, J. R., *J. Appl. Bact.*, 1964, **27**, 439.
2. Chapman, A. M. and Norris, J. R., *J. Appl. Bact.*, 1966, **29**, 529.
3. Azizbekyan, A. A. and Netyska, E. M., *Microbiologiya*, 1978, **47**, 521.
4. Afrikian, E. G., *Entamopathogenic Bacteria, Progress in Microbiology Issue No*. 10, Academy of Sciences, U.S.S.R., 1975.
5. Majumder, S. K., Muthu, M. and Pingale, S. V., *Curr. Sci.*, 1955, **24**, 122.