

Contents

Page No.

1. INTRODUCTION

- 1.a Tea plantation of Darjeeling Terai and the Dooars 1-2
- 1.b Pest problem in tea with emphasis on lepidopteran pests 2-5
- 1.c Prospects of research with entomopathogenic bacteria
as biopesticide 6-10

2. REVIEW OF LITERATURE

- 2.a Pesticide use pattern in tea cultivation of Darjeeling Terai
and the Dooars and its associated problems 11-12
- 2.b Microbials as natural control agents 13-17
- 2.c Importance of isolation of new strains of bacteria
for developing potential biopesticides 17-18

3. OBJECTIVES AND SCOPES OF STUDY 19

4. MATERIALS AND METHODS

- A. Survey of major lepidopteran tea pests: a study on the
occurrence of bacterial infection 20
 - A.a Tea Estates/plantations surveyed for tea pest 20-22
 - A.b Collection and processing of dead larvae 23
 - A.c Isolation of Entomopathogenic Bacteria 23
- B. Characterization of bacterial strains isolated from the lepidopteran
pest species (viz. *Buzura suppressaria*, *Hyposidra talaca*,
Eterusia magnifica and *Caloptilia theivora*) 23
 - B.a Morphological Characteristics: Determination of cell
morphology 23-24
 - B.b Biochemical Characteristics 24-26

B.c Physiological Characteristics of bacterial strains	27
B.c.i Growth characteristics: determination of generation time	27
B.c.ii SDS-PAGE profile (Qualitative) of crystal protein	27
B.c.iii Qualitative (SDS-PAGE) analysis of whole body protein of bacteria	27-28
C. Bioassay: Determination of LC ₅₀ value and LT ₅₀ values	28-29
D. Cross infectivity testing	29
D.a Other lepidopteran tea pests	29-30
D.b Mulberry silkworm (<i>Bombyx mori</i>) (Locally cultured multivoltine race)	30
E. Field trials on biocontrol efficacy	31
F. Statistical analysis	32

5. RESULTS

I. Loopers (<i>Buzura suppressaria</i> and <i>Hyposidra talaca</i>)	
A. Symptoms of bacteria infected larvae	33
B. Mortality of <i>Buzura suppressaria</i> due to bacterial infection	33-34
C. Mortality of <i>Hyposidra talaca</i> due to bacterial infection	34-35
D. A glimpse of the bacterial strains isolated from the loopers (<i>B. suppressaria</i> and <i>H. talaca</i>)	35-36
E. Preliminary characterization and selection of Bacterial strains from <i>B. suppressaria</i>	36-37
E.a Morphological Characteristics	37-39
E.b Biochemical Characteristics	39-40
E.c Growth characteristics: determination of generation time	41
E.d SDS-PAGE of crystal protein	41-42
E.e Qualitative (SDS-PAGE) analysis of whole body protein	42

profile of *Bacillus* strains

F. Preliminary characterization of Bacterial strains from <i>H. talaca</i>	
F.a Morphological Characteristics	43-44
F.b Biochemical Characteristics	44-47
F.c Growth characteristics: determination of generation time	48
F.d SDS-PAGE analysis of crystal protein	49
F.e Qualitative (SDS-PAGE) analysis of whole body protein of bacterial strains	50
G. Results of bioassay	
G.a Bioassay of <i>Bacillus</i> strains of <i>B. suppressaria</i>	50-51
G.b Bioassay of <i>Bacillus</i> strains of <i>H. talaca</i>	52-53
H. Results of cross-infectivity of bacterial strains to other lepidopteran tea pests	54
H.a Cross infectivity of <i>Bacillus</i> strain BS01 to <i>H. talaca</i> and <i>C. theivora</i>	54
H.a.i To <i>H. talaca</i> caterpillar	54-56
H.a.ii To <i>C. theivora</i> caterpillar	54-56
H.b. Cross infectivity of <i>Bacillus</i> strain HT01 to <i>B. Suppressaria</i> and <i>C. theivora</i>	57
H.b.i To <i>B. suppressaria</i> caterpillar	57-59
H.b.ii To <i>C. theivora</i> caterpillar	57-59
H.c Cross infectivity of <i>Bacillus</i> strain HT02 to <i>B. suppressaria</i> and <i>C. theivora</i>	60
H.c.i To <i>B. suppressaria</i> caterpillar	60-62
H.c.ii To <i>C. theivora</i> caterpillar	60-62
I. Cross infectivity to beneficial lepidopteran (silk worm)	63
I.a Cross infectivity of <i>Bacillus</i> strains of <i>B. suppressaria</i> and <i>H. talaca</i> to silk worm	63
J. Field trials on biocontrol efficacy	63-67

II. Leaf roller (<i>Caloptilia theivora</i>)	
A. Symptom of bacteria infected larvae	68
B. Mortality of <i>Caloptilia theivora</i> due to bacterial infection	68-69
C. A glimpse of the bacterial strains isolated from the leaf roller (<i>C. theivora</i>)	69
D. Preliminary characterization of entomopathogenic bacterial strains	70
D.a <i>Bacillus</i> strains	70
D.a.i Morphological Characteristics	70-72
D.a.ii Biochemical Characteristics	73-74
D.a.iii Growth characteristics: determination of generation time	75
D.a.iv SDS-PAGE profile of crystal protein of bacteria	75
D.a.v Qualitative (SDS-PAGE) analysis of whole body protein of bacteria	76
D.b <i>Enterobacter</i> strain	76
D.b.i Morphological characteristics	76-77
D.b.ii Biochemical characteristics	77-78
E. Results of bioassay	79
E.a Bioassay of <i>Bacillus</i> strains	79-80
E.b Bioassay of <i>Enterobacter</i> sp. DD01	81
F. Results of cross infectivity of the entomopathogens to other lepidopteran tea pests	82
G. Cross infectivity to beneficial lepidopteran (silk worm)	82
G.a Cross infectivity of <i>Bacillus</i> strains	82
G.b Cross infectivity of <i>Enterobacter</i> strain	82
H. Field trials on biocontrol efficacy	82-84
III. Red slug (<i>Eterusia magnifica</i>)	
A. Symptom of bacteria infected larvae	85
B. Mortality of <i>Eterusia magnifica</i> due to bacterial infection	85-86
C. A glimpse of the bacterial strains isolated from the red slug (<i>E. magnifica</i>)	86-87

D. Preliminary characterization of bacterial strains from <i>E. magnifica</i>	87
D.a Morphological Characteristics	88-89
D.b Biochemical Characteristics	89-91
D.c Growth characteristics: determination of generation time	91-92
D.d SDS-PAGE profile of crystal protein	92
D.e Qualitative (SDS-PAGE) analysis of whole body protein of bacterium	93
E. Results of bioassay	93-94
F. Result of cross infectivity to other lepidopteran tea pests	94
G. Result of cross infectivity to beneficial lepidopteran (silk worm)	94
H. Field trials on biocontrol efficacy	95-99
6. DISCUSSION	100-110
7. REFERENCES	111-123
8. SUMMARY	124-127
9. HIGHLIGHTS OF THE FINDINGS	128-129
ACKNOWLEDGEMENT	130
ANNEXURES	
I. List of abbreviations used	131
II. List of published/accepted papers	132-133
III. Reprints of published papers	
IV. <i>Corrigendum</i>	134-140