INTRODUCTION

1. Introduction

Tea has made a reputation as a cheap and readily available beverage and is being recognized as a health drink as well. It is accepted as a socializing factor in almost all circles as it is non-alcoholic and non-carbonated and spreads across the globe surpassing all economic barriers due to its affordability as well as embracing the class factor. This great popularity of tea, draws attention of almost all tea producing countries from the economic point of view.

Tea, *Camellia sinensis* (L.) O. Kuntze, cultivation in India has a long history and is confined to specific locations, of which the Districts of Darjeeling and Jalpaiguri of West Bengal and a large part of Assam of N.E. India has gained importance both for quality and high yield. A few words on the historic advent of tea plantation, the physiognomy of the tea-growing regions of N.E. India, and economics of tea will help in understanding the background of tea plantation - its problems and prospects from this part of India.

Information regarding the indigenous tea in the Assam areas was known since 1815. Major Bruce was possibly the first man to start a tea nursery in 1826 on the garden attached to his bungalow at Sadiya, Assam. The first samples of tea manufactured by primitive methods was sent to Calcutta in 1836, which Lord Auckland acknowledge as of Good Quality. In 1837 the Assam Tea Company was established and in 1838, 8 chests containing 350 lbs were dispatched to England for sale.

The Makaibarie and Aloobarie gardens were planted in 1857 in the Darjeeling hills. Following these, Puntunghar in 1861 and Champta in 1862 were laid in the Terai and Singel, Manja, Fallowdhi, Atulpur, Sal Kotee, etc. on the slopes. By 1914, Assam had 762 tea gardens followed by Darjeeling and Duars with 156 and 118 gardens respectively (Dozey, 1922). This was followed by rapid growth in the Nilgiris, Travancore-Wynaad and the Annamalais. From the modest beginning in 1838, tea today plays a major role in the economics of India, occupying a leading position both in production and export.

The tea growing regions of Darjeeling district of West Bengal is located between 26° 31' and 27° 13' North latitude and 87° 59' and 88° 30' east longitude covering an area of 3149 sq. km (Fig. 1). The Northern part of the district has the distribution of eastern Himalayan range while the southern part consists of a stretch of alluvial plain at the base of the hills and is known as the Terai.

The Terai is situated 91 meters above sea level with an average rainfall of 350 cm. and an average temperature of maximum 30°C and minimum 12°C. The soil is moderately acidic, rich in organic material and is suitable for tea plantation (Fig. 2). Besides heavy rainfall, Terai and its adjacent Duars regions are well watered by a number of major rivers and a host of rivulets. The major rivers from east to west of Terai and Duars are: Siltorsha, Torsha, Jaldhaka, Teesta, Mahananda, Balason and Mechi.

By 1914, the Darjeeling & Duars region had 274 tea gardens covering 1.55 lakh hectares (Dozey, 1922) which grew to 3.31 lakh hectares by 1960 and was expected to reach a mark of 4.60 lakh hectares by 2000 (as projected in the

Annual Report & Statistics, 1997). India has been exporting tea ever since the plantations went on production. West Bengal has the second largest tea growing areas, in the country, and produces about 300 million kg of tea annually (12th October 2003, The Telegraph – Daily Newspaper). For over a century, India was the largest exporter of tea in the global market but today it commands only 16%of the world market trailing behind countries like Sri Lanka with 22%, Kenya-20% and China 17%.

Tea had been accepted as a general beverage for centuries but today with intensive pharmacological studies taking place around the globe it is appreciated for its contributions in maintenance of health. First and foremost is its antioxidant properties which detoxifies and helps in the general upkeep of the body. Flavonoids in tea help in the prevention of heart diseases, cancer, dental problems and cataract as well (Chen, 1990 & 1993).

Tea as a perennial and monoculture crop growing over extensive areas provide an inexhaustible resource for colonization by several guilds of insects and mites, many of which easily attain the pest status in such a stable ecosystem. Each tea growing region has its own distinctive pest fauna though they may be found in other areas as well. More than a thousand species of arthropods are known to attack tea all over the world though only about 300 insects and mites are recorded from India (Muraleedharan et al., 2001).

Insects may consume every anatomical part of the plant but show specialization with regard to the feeding sites they occupy (Shoonhoven et al., 1998). Every part of the tea plant has a specific guild of pests. They may be

grouped as per their feeding activity on stems, roots and foliage. Some sucking insects such as thrips, jassids and aphids cause extensive damage to the plant by making the shoot unproductive. The tea mosquito bug (*Helopeltis theivora*) is a serious pest both in South and N. E. India. The major root pests of tea are grubs of cockchafer and termites. Several species of cerambycid root borers damage the roots of old plants particularly in Darjeeling (Banerjee, 1993). Among the leaf attackers, mites are most widespread. Distribution of folivores, such as flushworms, leaf rollers, bunch caterpillars are more in the lower elevations of Darjeeling. In the Terai and Duars regions of Darjeeling foothills and plains, there are often outbreaks of defoliators such as *Buzura (Biston) suppressaria* Guen. (Looper caterpillar) and *Eterusia magnifica* Butl. (Red Slug caterpillar) causing extensive damage of the foliage. *Euproctis latisfascia* Wlk. (Darjeeling Black Hairy caterpillar) though sporadic in distribution yet causes severe damage to the mother leaf of nursery plants and by consuming the mature maintenance leaves at the lower tier of tea bushes. Hence, the need for introduction of Integrated Pest Management in tea is greatly required (Barbora et al., 1994) in N. E. India.

The damage potential and recurrence of many pests are well known from tea plantations for long and many newly recruited region specific pests are now being recorded, but due to inappropriate measures taken in their control, the pest problem has further intensified. Although about Rs.15 crores is being spent in N. E. India alone for the control of pests and diseases, it has been found that about 6 to 14% of tea is lost due to insects, mites and weeds (Banerjee, 1976).

Normally 10% of the total crop is lost annually due to pests but this could rise to 40% in devastating attack by lepidopteran defoliators (Banerjee, 1993).

Routine application of chemical pesticides for the protection of tea crops has been a common and effective practice since the last 50 years but with growing usage of pesticides, the resistance of the insect pests to these chemicals has likely increased (Banerjee, 1968; Sarker and Mukhopadhyay, 2003). Therefore extreme precautionary measures must be adopted before a pesticide is introduced to tea for pest control (Das, 1962), which will also save residue build up. In 1934 there were 10 insect species known to be resistant against pesticides whereas by 1980 the figure rose to 432 and by 1990 about 500 cases were reported (Schulten, 1990). High incidence of pests in tea has led to the indiscriminate use of pesticides leading to problems such as killing of non-target organisms including natural enemies of pests (Anonymous, 2003), human health hazards, enhanced environmental hazards and above all the problems of insecticide resistances. The need for conserving natural enemies of pest (Banerjee, 1967) and an integrated approach for controlling mite pests of tea was emphasized (Banerjee, 1975a). Further, the role of Integrated Pest Management has been stressed by Muraleedharan (2000) for the ever growing pest problems in agricultural crops. It goes without saying that in the same spirit Integrated Pest Management (IPM) in tea requires planning to cover all the serious arthropod pests.

The three folivores *B. suppressaria* (Looper Caterpillar), *Et. magnifica* (Red Slug caterpillar) and *E. latisfascia* (Darjeeling Black Hairy caterpillar) that

have been considered in this study are reported as pests of tea, specially from Terai and Duars areas of Darjeeling District and the State of Assam in N.E. India. Planters of Terai and Duars are facing serious problems in combating the outbreaks of these folivores. The outbreaks have caused a considerable loss of foliage and tea production (Mukhopadhyay and Das, 2003).

In view of the growing pest problem in tea and increased resurgence of pests in spite of the use of conventional chemical pesticides, it was felt necessary to undertake the present study on "Rearing and Evaluation of Performance of some common Lepidopteran Tea Pests on Natural and Artificial Diets from the Darjeeling Region". Expectedly this investigation would reveal greater details of the nutritional ecology and aspects of life cycle of three common lepidopteran pests. This knowledge may be used in future to develop non-conventional pest management strategies.

As little is known about the detailed biology of these folivores of tea, that includes their host preference, food consumption and utilization and related performance, an attempt has been made in this study to know more about their conversion efficiencies, growth patterns and survivorship on natural and artificial diets. Research using artificial diet is of great value to nutritional ecology, especially because particular aspects of food quality, either singly or in various combinations can be precisely altered. Artificial diets can be used to determine qualitative and quantitative nutritional requirements and the impact of nutrient levels (including water), allelochemicals and nutrient-allelochemical interaction (Reinecke, 1985; Slansky and Scriber, 1985).

Tea plantation in Terai and Duars regions comprise largely of clonal varieties (Assam Type) released by Tocklai (Tea Research Association). Some of the old and relatively new released clones are: Tv_1, Tv_{18}, Tv_{25}, Tv_{26}, etc. Host preference experiment was conducted using these to find out their predilation for the clonal varieties vis-à-vis the susceptibility of these clones to the folivores in question.

Morphometric studies have been made with the developing stages (instars) of these tea pests in order to help in easy identification of different larval stages of these pests using measurement parameters. Relative growth rates of different body parts were also studied to understand the nature of growth pattern of the three species of folivores during their post - embryonic developmental stages.

To know the adaptive fitness and suitability of diet, bioassay of these three lepidopteran folivores were conducted on natural (tea leaf) and artificial diets, which included detailed study on survivorship, life cycle, food utilization efficiencies, mass budget study etc. Further the biochemical components of the two diets (natural and artificial) and components of the dry body mass of the pest reared on these two diets were analyzed in order to know the relation. Such comparative study on bio-ecology, food utilization efficiencies and performance of these folivores on two different kinds of diets (natural and artificial) appears to be essential to achieve more perfection in successful rearing and commercial application of the control technologies based on mass production. Such a facility

can be used in opening up new prospects of non - conventional pest management programmes in tea.

The success of artificial rearing of lepidopterans has contributed greatly towards pest management research and has enabled the artificial rearing of its pathogens and parasites. The efficient rearing has made it possible to conduct a sterile technique program, either using chemosterilants or irridation. Research on the development of crops resistant to lepidopterous pests increased after the advent of practical artificial diets for rearing lepidoptera (Davis and Guthrie, 1992).

Under non-conventional control methods besides nutritional ecology and dietetics, insect rearing on artificial diet appeared to be promising in providing a base for planning various control strategies. Development of insect rearing technology is very much essential in order to conduct and implement new pest control strategies such as those based on a) host plant resistance, b) production of microbial pesticides, c) biological control agents and d) sterile insect technique. Moreover rearing can provide the insect specimens (*pests*) for conducting bioassays in vivo or in vitro. The availability of a large number of laboratory reared insects are also essential for research in the field of physiology, ecology, genetic studies in addition to the development of hormonal and pheromonal manipulation and integrated control programme (Singh, 1977). Many of the advances in entomology during the past century can be attributed to the ability to rear insects successfully on artificial diets.