



## Diversity of tea pests in north-east India and their biological control methods

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### Abstract

India is the second largest producer of *Camellia sinensis* (L.) O. Kuntze (tea) in the world after China. Over 1.2 billion kg of tea were produced in India in the fiscal year 2022. Among the major tea producing states in India, Assam and West Bengal occupies the top-most positions. Due to country's extensive tea cultivation resources, it is well understood that a significant percentage of India's economy is generated from tea exportation. However, the most challenging problem currently being faced by Indian tea growers is dealing with its pests and diseases. At least 720 different bug and mite species infest India's tea crops which is a major issue and needs to be combated. Although there are a variety of synthetic insecticides being used to control pests, it results in various harmful affects. Also, the Indian government is placing more attention on implementing new rules for goods that are traded abroad as well as the Plant Protection Code (PPC) for tea. Therefore, emphasis should be put more on biological control methods as well as use or organic techniques to bring the pest population below threshold level. North-east, being the major tea producing states of the nation has focused on these techniques which has increased its yield as well as resulted in no loss of crops due to pest infestation.

**Keywords:** tea, pest, pest management, biological control methods, north-east India

### Introduction

Tea, *Camellia sinensis* (L.) O. Kuntze is one of most economically important crop of India covering a plantation area of 639 thousand hectares in India as of 2020 and around 117 thousand hectares under small tea growers of Assam. India's tea production can be dated back to 1823 when Robert Bruce first discovered tea plants growing wild in upper Brahmaputra valley and adjoining areas (Sivanesan 2013). It was Maniram Dewan who first commercialized tea production. Thereafter, in 1833, Britishers started tea gardening in Lakhimpur district of India. 'Assam Company' which was a British government's company took control over the tea gardens from the East India Company in the year 1839. Its headquarter was established at Nazira. India ranks 4<sup>th</sup> in terms of tea exports accounting for 10% of total exports. India exported tea for a total of approximately US\$ 687.9 million in 2021. Tea from Assam, Darjeeling, and Nilgiri in India are among the best in the world. Black tea accounts for around 96% of all tea exports from India and is the most common type. World's first institute dedicated to tea research has been established at Jorhat in the year 1911 named Tocklai Tea Reseach Institute. Also, on 25<sup>th</sup> September 1970, Tea Auction Centre was established at Guwahati, Assam which is one of the largest tea auction centres in the world.

India exported 201 million kg of tea in total between 2021 and 2022. It sends tea abroad to more than 25 different nations. Some of the top countries importing tea from India are China, Russia, Iran, the United Arab Emirates, the United States, and the United Kingdom. The major tea producing states of India are Assam, West Bengal, Tamil Nadu, Kerala, Karnataka and in a limited area of Tripura, Uttarakhand, Uttar Pradesh, Himachal Pradesh (Fig. 1)

However, every year, pest infestation of tea plants causes a major damage to the crops leading to heavy losses for the economy. According to reports from various regions of the world, tea plantation may be infested by 82 species of nematodes and 1031 species of arthropods (Chen and Chen, 1989) [10]. 230 different types of insect and mite pests attack tea throughout Asia (Muraleedharan, 1992) [25]. Assam, which is a significant producer of Indian tea have been reported to be infested by 16 nematodes and 173 arthropods as major and minor pests in North East India (Hazarika *et al.*, 1994) [15] along with other regions. According to Muraedharan and Chen (1997), [26] order Lepidoptera has the highest percentage of pest species among insect pests (32%), followed by order Hemiptera (27%).

To control these pests, a range of synthetic insecticides are often used. However, numerous problems could arise from the simultaneous use of so many pesticides, such as the development of resistance, adverse effects on non-target species including parasitoids and insect predators, disruption of the ecological balance, and the accumulation of pesticide residues on tea leaves (Hazarika *et al.*, 1994) [15]. This has led to the shift of focus to biological control methods. This shift in importance from chemical-based plant protection to the adoption of an integrated approach based primarily on use of biocontrol measures and need-based application of botanicals and safer pesticides has reduced a heavy burden on this field. Such a strategy might result in a decrease in pesticide application-related residues and ancillary issues (Hazarika *et al.*, 2001) [14, 16]. To understand the way of how these control methods needs to be applied, it is of utmost importance to first know about the major pests infesting the desired plants and its behavior or season of activity.

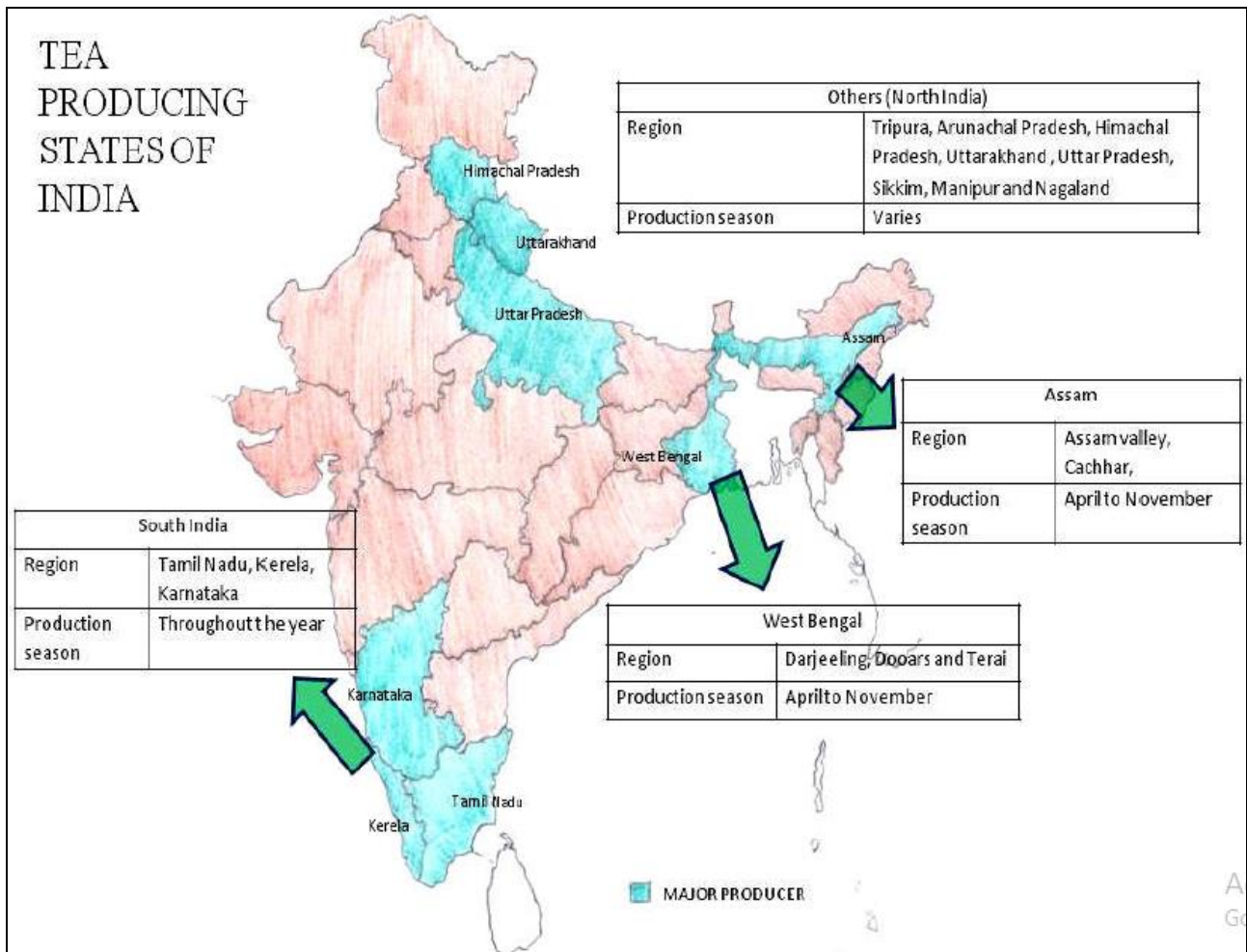


Fig 1: Major Tea producing states of India (Subba, 2017) [35]

**General Geographic Features of North-East India and Assam**

North-east India comprises of eight states which are Assam, Arunachal Pradesh, Manipur, Mizoram, Meghalaya, Nagaland, Sikkim, and Tripura. The region's overall geographic area is 262185 km<sup>2</sup> or 7.9% of India's total land area (NEDFi Databank). Out of four, one of India's Biodiversity Hot Spots is also located in this area.

The state of Assam is located between 24° 09' N to 27° 58' N latitudes and 89° 42' to 96° 01' E longitudes. It accounts for 2.4 % of India's land area which is about 78,438 km<sup>2</sup> (Bhagawati *et al.*, 2019) [7]. The Brahmaputra and the Barak are the two important rivers which flows through this state along with their tributaries, thus making the soil of fertile enough for cultivation of crops. The average temperature of the state ranges between 35° C and 7° C in summer and winter respectively thus having a sub-tropical monsoon climate (Kar *et al.*, 2017). The annual rainfall received ranges between 200 to 300 cm and the relative humidity is 60-80% (Bhagawati *et al.*, 2019) [7].

**Tea Cultivation in North-East India**

The topographic and climatic factors make this region suitable for tea plant cultivation. The temperature and monsoon brings out the best yield. Sloping terrains are essential for tea plantations as they do not survive in stagnant water. Therefore, the tea estates of Assam are located at a height. Also, the soil is loamy, porous, acidic with less Calcium content which is an add-on advantage for

tea plantation. The tea industry employs about 17% of the people in Assam. Assam plantations mostly produce black tea, although they also make a limited amount of green and white teas. There are thousands of acres of land covered by more than 850 tea estates and more than 2500 tea gardens. More than six lakh people are engaged in the tea business on a daily basis in Assam, which accounts for around half of all the workers employed by the tea industry on a daily basis nationwide (Arya, 2013) [2]. Both Orthodox tea and CTC (Crush/Tear/Curl) tea are produced in this region. An officially recognised Geographical Indication (GI) is Assam Orthodox Tea.

**Major Tea Pests Found in North-East India with Emphasis on Assam**

Some of the pests of tea which have been reported from various states of North-east India are *Helopeltis theivora* (Hemiptera:Miridae); *Buzura suppressaria* (Lepidoptera:Geometridae); *Scirtothrips dorsalis* (Thysanoptera: Thripidae); *Hyposidra talaca* (Lepidoptera:Geometridae); *Empoasca flavescens* (Homoptera: Cicadellidae); *Eterusia aedea* (Lepidoptera: Zygaenidae); *Toxoptera aurantii* (Hemiptera:Aphididae); *Oligonychus coffeae* (Acari: Tetranychidae); *Aleuroparvus theae* (Hemiptera: Aphelinidae); *Microtermes* sp. (Isoptera: Termitidae); *Fiorinia theae* (Hemiptera:Diaspididae) and *Cydia leucostoma* (Lepidoptera: Tortricidae). These insect pests have been discussed in detail in the following table:

**Table 1:** Tea pests of North-east India

Name of Pest	Damaging stage	Site of Attack	Seasonal Incidence	Damaging symptoms
<i>Helopeltis theivora</i> (Tea Mosquito Bug)	Nymph and adult	Young and tender shoots	June-November	A ring-shaped spot initially develops at the sap-sucking point, which turns to translucent light brown after a day. Later, it changes its colour to dark brown, appears as a depressed spot, and dries up.
<i>Buzura suppressaria</i> (Common Looper)	Nymph and adult	Growing shoots and buds	February-March	Young leaves' margins are pierced. Young ones are frequently observed on developing shoots and buds scrubbing on the surface of leaves. In extreme conditions, bushes lose all of their leaves.
<i>Scirtothrips dorsalis</i> (Tea thrips)	Nymphs and adult	Young succulent leaves and partly opened or unopened buds	March-April	The surface of the leaf changes to being uneven, curly, and matty, with parallel feeding marks and 2-4 sandpaper lines on either side of the midrib.
<i>Hyposidra talaca</i> (Black Inch worm)	Larval stages	Tender and mature leaves	February-March	The instars nibble on tender leaves and make holes on them. In severe cases, bushes completely lose their foliage and shoots are also attacked.
<i>Empoasca flavescens</i> (Tea Jassid)	Nymph and adult	Young leaves and tender shoots	March-July	The negatively impacted leaves curl downward and become unequal. The edge becomes recurved, gets brown, and then dries up. The afflicted leaves may have brownish discoloration along the midrib and veins.
<i>Eterusia Aedea</i> (Red Slug Caterpillars)	All larval stages	Mature leaves	March-December	Bushes can totally lose all of their leaves during severe infestation, and the bark may also occasionally suffer harm.
<i>Toxoptera aurantii</i> (Aphids)	Nymphs and adults	January-April	Buds, young leaves and tender stems	Leaves are twisted and creased below tipping level.
<i>Oligonychus coffeae</i> (Red Spider mite)	Nymphs and adults	March-May and September-October	Mature tea leaves	The larva, nymphs, and adults lacerate plant cells, leaving tiny, recognisable reddish brown markings on the upper surface of mature leaves. In severe infestations, these marks turn red and prevent the plant from photosynthesising, resulting in defoliation and crop loss.
<i>Aleuroparvus theae</i> (Tea Whitefly)	Nymphs and adults	Almost throughout the year	Ventral surface of tea leaves	Affected leaves become uneven and curl downwards
<i>Microtermes</i> sp. (Termite)	Adult	Mainly during winter	Shoot, bark tissue	They target the young, healthy shrubs' bark tissues. Once inside, they hollow out the stem or they replace the entire woody component with earth elements.
<i>Fiorinia theae</i> (Scale insect)	Adult	Almost throughout the year	Leaves	They suck sap through piercing and sucking mouthparts. When infestations are severe, it may result in leaf yellowing or wilting, a stunted or unthrifty appearance of the plants, and eventually the death of the entire plant or a portion of it.
<i>Cydia leucostoma</i> (Tea Flushworm)	Larval stages	November to May	Buds, top leaves of young shoot	Early instars feed superficially on the epidermis while later ones damaged the inner layers. Upper surface of leaves become corrugated. The folding of leaves leads to formation of nest-like structure.

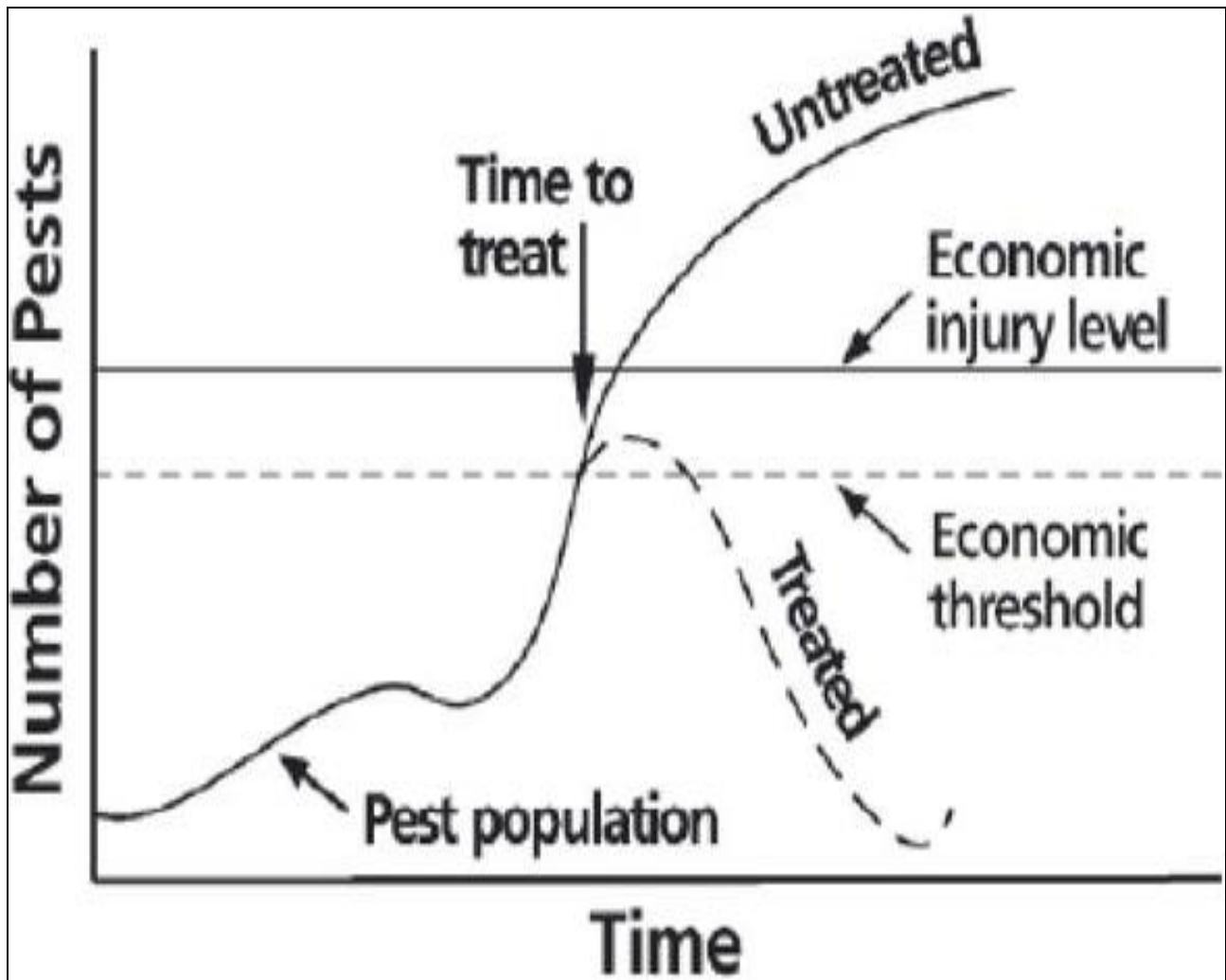
**Source:** (Kabir and Das, 2015; Bulletin on Integrated Management of Tea Pests of North-East India by Tocklai Research Association; Roy et al., 2017; Dubey, 2018; Kumaravadivelu, 1994) [18, 28, 11, 21]

### Biological Control Methods: An Eco-Friendly Approach

Plants are guarded against these pest species by natural means. One of the earliest, most environment friendly, and efficient methods of pest management is biological control. Pest organisms are maintained by the use of natural enemies rather than externally applied chemicals in biological management. Smith (1919) [33] coined the term "biological control" to describe the use of natural enemies to manage insect pests. It is the only approach to pest management that is both environment friendly and improves species diversity and biodiversity inside an agro-ecosystem. They are generally non-toxic and non-pathogenic to humans, animals, and other beneficial or industrial species. Due to its great target specificity and lack of negative side effects, its use has been steadily growing (Fadel and Sabour 2002). By

keeping the pest population below the economic threshold level, natural enemies combat insects, bacteria, fungi, and viruses that could harm crop plants and maintain ecosystem equilibrium.

A small number of pests can be tolerated, but when the number of pests reaches a threshold, it becomes necessary to take action. The term "damage border" refers to the lowest degree of damage to crop plants at which the damage can be quantified, and the phrase "economic injury level" refers to the lowest number of insects that will result in economic loss (EIL). The pest density at which control measures should be implemented to stop an expanding pest population from reaching the point of economic injury is known as the economic threshold level (ETL). [Figure 2]



(Source: Kaur and Kaur, 2020) [20]

**Fig 2:** Graphical representation of EIL and ETL

The diversity of natural enemies in the tea ecosystem is important for biological control in tea. Numerous natural enemies have been identified as parasitoids (various braconids, bethylids, eulophids, ichneumonids, tachinids, and muscids), mostly against lepidopterans (Stiling and Corelissen, 2005), predators (coccinellids, syrphids, mirids, phytoseiids, and spiders), and pathogens (entomopathogenic

fungi (EPF), entomopathogenic nematodes (EPN), viruses, and bacteria) that are naturally occurring either from a single species or group of insect pests in tea ecosystem. The number of braconids, coccinellids or phytoseiids, and EPF exceeds that of other agents in each group (Takagi, 1978; Muraleedharan *et al.*, 1988; Agnihothrudu, 1999; Hazarika *et al.*, 2001) [37, 24, 1, 14, 16].

**Table 2:** Biological Control Agents of different tea pests

Name of Pest	Biological control Agents		
	Predators	Parasitoids	Pathogens
Red Spider Mite	<i>Oligota flaviceps</i> , <i>Verania vincta</i> , <i>Verania discolor</i> , species of the families Phytoseiidae and Stigmaeidae.	<i>Bracon</i> sp., <i>Microbracon</i> sp., <i>Atherigona orientalis</i>	<i>Verticillium lecani</i> , <i>Metarhizium anisopliae</i> <i>Paecilomyces fumosoroseus</i> , <i>Hirsutella thompsonii</i>
Thrips	<i>Aelothrip sintermedius</i> , <i>Mymarothrips garuda</i> , <i>Chrysoperla carnea</i>	Trichogrammatid, <i>Megaphragma</i> sp.	<i>Metarhizium anisopliae</i>
Tea Mosquito Bug	<i>Chrysoperla carnea</i> , Preying mantids,	<i>Erythmelus helopeltidis</i> .	<i>Cladosporium</i> sp., <i>Aspergillus niger</i> , <i>A. flavus</i>
Aphids	Species of coccinellids and syrphids, <i>Hippodamia divergens</i> , <i>Forficula Auricularia</i> , <i>Cryptogonus Bimaculata</i> , <i>Asarcina aegrota</i>	<i>Trioxys</i> sp. and <i>Aphelinus</i> sp.	<i>Aspergillus</i> sp. and <i>Verticillium lecanii</i>
Common Looper	<i>Reduviid</i> bugs	<i>Apanteles fabiae</i> ,	<i>Bacillus thuringiensis</i>

		<i>Apanteles ta, probanae</i>	
Tea Flushworm	Carabidae, <i>Micromus timidus</i>	Nine species of braconids, two ichneumonids, one encyrtid, <i>Ascogaster, Apanteles aristaeus</i>	<i>Bacillus thuringiensis, Nucleopolyhedrosis virus.</i>
Termite	<i>Calotes namoricola, Coranus soosai, Sennopithecus entellus</i>	<i>Multisentis myrmecobius</i>	<i>Metarhizium anisopliae</i>
Tea Jassid	<i>Marpissa</i> sp., <i>Phidippus pateli, Phidippus</i> sp. and <i>Salticus</i> sp.	Dyrnid wasp	<i>Cephalosporium</i> sp.
Scale Insect	<i>Jauravia quadrinotata, Trionata</i> sp. and <i>Scymnus</i> sp.	<i>Prospaltella</i> sp., <i>Spidiaotiphagus</i> sp., <i>Aphytis</i> sp.	<i>Aschersonia</i> sp., <i>Duarius</i> sp. and <i>Fusarium</i> sp.
Black Inch Worm	<i>Tetraponera rufonigra, Oxyopes</i> sp., Shield bug, Mermithid nematode worm	<i>Cotesia</i> sp., <i>Argyrophyllax</i> sp.	<i>Bacillus thuringiensis</i>

**Source:** Muraleedharan *et al.*, 1988; Muraleedharan and Radhakrishnan, 1989; Sana, 1989; Hazarika and Chakraborti, 1998; Sudhakaran and Muraleedharan, 1998; Hazarika *et al.*, 2001; Babu *et al.*, 2008a; Babu *et al.*, 2008b; Ahmed *et al.*, 2009; Basu Majumder, 2010; Bordoloi *et al.*, 2011; Mamun and Ahmed, 2011; Basu Majumder *et al.*, 2012) [24, 23, 31, 36, 14, 16, 3, 4, 6, 8, 22, 5].

## Conclusion

Tea plantation, being a monoculture, is infested by around 1031 species of arthropods and 82 species of nematods. To control them, it is of utmost importance for the cultivators to know about the pests, its life cycle, behaviour, damaging techniques, etc. Only then it will be possible to decide the appropriate control strategy. Under natural circumstances, these pests are suppressed by a number of parasitoid species, predators, and a few pathogens. Different facets of biocontrol, such as the impact of agro management methods, the role of native and exotic natural enemies, and their release on pest populations, should be highlighted. Pathogens caused by bacteria and viruses need to be used more in the future. In this ecology where pesticides are widely used, pesticide-resistant breeds of predators and parasitoids have also considerable promise. Utilizing genetic engineering, pest-resistant tea clones can be created.

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