ABSTRACT

Tea is grown as an intensively maintained perennial monoculture crop. More than 1031 species of arthropods and nematods attack tea worldwide, of which 300 insect pests occur in India and 167 species are found in North-East India. Synthetic pesticides are the primary weapon to tackle these pests but indiscriminate use of these pesticides has caused problems like tolerance development in pests or pest resurgence. Termite is one of the major pests of tea but due to their surreptitious subterranean nature remain inconspicuous. They cause considerable damage to wooden furniture, buildings, fences, trees, crops and anything that consists of cellulose. Workers have reported termite to be one of the serious pest of tea, particularly in upper Assam where a plantation can have 50-100% of termite infestation. Very limited information is available about the termite pests of tea from this part of the country. Therefore, this work was contemplated with objectives to check first and foremost the types of termite pests that exist in Darjeeling Terai and the Dooars tea plantations. Second was to check the phylogenetic relationship among them. Third was to check if two of the most abundant termite pest species show any tolerance towards the commonly used pesticides and fourth was to check the role played by detoxifying enzymes in developing tolerance against synthetic pesticide.

The occurrence study revealed ten species of termite from tea plantations of Darjeeling Terai and the Dooars region which account for more than 20% of total reported termite diversity of West Bengal. Among these 10 species, *Odontotermes obesus* and *Microtermes obesi* were the most abundant species. Besides, other termite species

like *Coptotermes heimi*, *Heterotermes indicola*, *Pericapritermes assamensis* and *Odontotermes parvidens* were also found infesting tea bushes but with less severity. Their distribution in Terai and the Dooars plantations were very sparse and could be recorded from only few of the plantations. *Heterotermes indicola*, *Synhamitermes quadriceps* and *Pericapritermes assamensis* were previously been reported from this part of West Bengal but from forest area. Present study recorded them for the first time from tea ecosystem. *Procapritermes holmgreni* and *Euhamitermes lighti* are being reported for the first time from tea plantations of northern part of West Bengal. A new species *Nasutitermes longviewnsis* sp. nov. was recorded for the first time from Longview tea estate of Darjeeling Terai.

A phylogenetic relationship was drawn among the 10 termite species based on morphometric characters and RAPD based polymorphism. Dendrograms were constructed on the basis of shared fragments and the Similarity coefficients. Due to the lack of an out group the dendograms were an unrooted tree. The presented morphometric data based dendrogram shows broadly three major clusters (I, II and III), whereas RAPD based dendogram represented two broad clusters with coefficient value ranging from 0.38 to 0.86. The topology of the tentative phylogenetic relationship revealed by the RAPD analysis is partially concurrent with the dendogram based on morphometrics, and both showed an overall similarity among the cluster I and II. Phylogenetic results of present study based on morphometric and RAPD analysis are in agreement with the results of Singla et al. (2015) and Murthy et al. (2015). Present study is a preliminary inventory to shed light on the phylogenetic status of the termites from this part of India. A further more elaborate work may give clearer picture of phylogeny of termites from this part of world.

Four commonly used pesticides (chlorpyrifos 20% EC, cypermethrin 35% EC, endosulfan 10% EC and imidacloprid 17.8% SL) were screened for tolerance status of *O. obesus* and *M. obesi* collected from different organically and conventionally managed tea plantations. The LC_{50} values obtained for these termite species indicated that a population from organically managed plantation has less tolerance level against these pesticides (3.92-15.04 ppm), whereas populations from conventionally managed plantations had higher LC_{50} values indicating higher level of tolerance (16.96-139.05 ppm). Similarly, the detoxifying enzymes namely general esterases, glutathione *S*-transferases and cytochrome P450 also exhibited differential activity based on management type of a plantation. Populations from conventionally managed Western and Eastern Terai, and Western, Central and Eastern Dooars plantations exhibited increased level of enzyme expression with very high activity ratios (2.70-20.66 folds) compared to the populations from organically managed Dooars and Terai plantations where detoxifying enzymes showed very low AR values (1.00-1.56 folds). The densitometric analysis of electrophoregram of GE revealed intense and darkly stained bands in population from conventionally managed plantations indicating higher expression level compared to faintly stained bands in the population from organic plantations showing low expression.

The results of bioassay of pesticides and differential detoxifying enzymes expression in two termite pest species suggested that there is a directional selection of these pests due to the exposure to pesticides which in turn help in proliferation of a termite pest population with increased physiological capabilities of tolerating pesticide load. The simple regression relationship of resistance factor (RF) of chlorpyrifos and activity ratio (AR) of each detoxifying enzymes for both pest species distinctly showed a dependence of RF on AR. These findings suggested that with the increase of detoxifying enzyme

expression, the tolerance level of a pest increases. Therefore, hyperactivation of detoxifying enzymes can be used as an indicator of high tolerance level in termite pests.

A termite colony has as many as four castes at different stages of development. To check if there is any difference in the tolerance status at caste level, worker and soldier castes of *O. obesus* and *M. obesi* collected from a conventional plantation were subjected to bioassay of pesticides and detoxifying enzyme analysis. Worker caste showed higher expression of GE (9.44), GST (299.75) and CYP450 (1.01) activities in comparison to soldiers. In addition densitometric analysis of non-denaturing gel of GE showed intensely stained bands in worker caste, whereas soldier exhibited faintly stained bands. This may be due to the fact that while foraging worker castes get more exposure to pesticides which in turn might have given rise to more tolerant worker caste.

Even though present work has added to the knowledge of termite pest species from tea ecosystem of Darjeeling Terai and the Dooars region of West Bengal yet more extensive work can give much better information. A strategic approach with better knowledge of termite biology will give planters an edge over these pests which can help them in reducing pesticide load in the environment apart from economically much viable pest control alternatives.