Erythrina gall wasp *Quadrastichus erythrinae*, yet another invasive pest new to India

Invasions by alien species upset the balance of native ecosystems and many of them cause considerable economic loss. Free trade propelled by economic liberalization has intensified the movement of goods across frontiers and geographic barriers without much quarantine, enhancing chances of introduction of exotic pests into agroecosystems. The invaders proliferate in the absence of natural enemies in the new-found home. Recently introduced exotic pests, namely the coffee berry borer *Hypothenemus hampei* Ferrari[1], serpentine leaf miner *Liriomyza trifolii* (Burgess)[2], spiralling whitefly *Aleurodicus dispersus* Russell[3] and the coconut eriophyid mite *Aceria guerreronis* Keifer[4] have spread rapidly and established well in India and continue to inflict considerable economic loss despite concerted efforts to contain them[5].

The *Erythrina* gall wasp *Quadrastichus erythrinae* Kim (Hymenoptera: Eulophidae) was named and described only a year ago after being noticed as a serious pest of *Erythrina* in Singapore, Mauritius and Réunion[6]. The pest is reported to damage five species of *Erythrina* in Taiwan by formation of gall-enlargement and malformation, leading to severe defoliation and even death of trees[7]. *Erythrina* spp. (Fabaceae), popularly known as coral tree, are grown throughout the tropics as windbreak for soil and water conservation and for planting around homesteads[8]. *Erythrina stricta* Roxb., a quick-growing species with showy red flowers, is grown as a standard for trailing black pepper (*Piper nigrum* L.) and vanilla (*Vanilla planifolia* Andr.) throughout south India. Its leaves are used as a favourite fodder in sheep and rabbit rearing. Severe incidence of *Q. erythrinae* has been noticed on *E. stricta* in the plains of Thiruvananthapuram District, Kerala since April, 2005 on a serious proportion. Interestingly, during the same period the pest was also reported from Hawaii infesting three different species of *Erythrina*[9].

Symptoms and nature of damage observed on *E. stricta* were similar to those described by Yang *et al.*[7]. Female wasp (Figure 1) thrusts eggs into tender tissues of shoots using the exerted ovipositor. Apodous, creamy white larvae (Figure 2) develop individually in chambers formed inside the meristematic tissue. Proliferation of tissues in the attacked portion results in gall formation. Galls are formed on the entire developing stem, petiole and leaf lamina with characteristic enlargement and malformation (Figure 3). The mean thickness of galled petioles was 3.1 times more than that of normal. In the case of tender stem, infestation resulted in enhancement of mean thickness twice. Multiple galls with layers of larval chambers are formed in the affected portion. Infected leaves fail to attain the normal size and shrivel with thick galls on them. Petioles and tender stem enlarge in thickness and present a curly appearance with knot-like galls on them. From a single abscised infested leaf, up to 271 wasps emerged. Similarly a five centimetre long piece of galled petiole and tender stem produced up to 51 and 64 wasps respectively. Sex ratio of wasps emerging from galls was highly skewed towards males, with 2.7 males emerging for each female. Severely infected branches appear stunted and bushy. Galled leaves and tender branches finally dry up. As the newly emerging leaves are converted into galls, there is severe reduction in the number and size of leaves besides complete cessation of growth. Such trees present a scrawny appearance with malformed and crinkled shoot.

Sustainable control of the pest can probably be achieved by classical biological control using natural enemies from the homeland of the gall wasp. But the origin and distribution of the wasp is yet to be determined. A few parasitic wasps belonging to Encyrtidae, Eupelmidae and Pteromalidae were reared from galled *Erythrina* twigs in Taiwan[7]. Pruning of infected branches results in trees putting forth fresh growth which again get affected by the pest, further debilitating the trees. Pruning and burning of the affected shoots in an entire locality on a community basis may yield result. Application of systemic pesticides may be tried as a short-term emergency measure. In Hawaii though pruning failed to contain the damage, bark injection of the systemic pesticide imidacloprid had some effect in protecting new growth[10]. Spread of the pest to hill tracts of south India where

Figure 1. *Quadrastichus erythrinae* – female wasp.

Figure 2. Larva of *Erythrina* gall wasp.

Figure 3. Symptoms of gall wasp infestation.

Diagnostic characters of *Quadrastichus erythrinae*

Adults sexually dimorphic. Female 1.4–1.6 mm long, dark brown with yellow markings; head yellow except gena posteriorly brown; antenna pale brown except scape pale posteriorly; pronotum dark brown; mid lobe of mesoscutum with a characteristic inverted triangular dark brown area anteriorly; legs pale except fore- and hind-coxae brown, fore- and midfemur ventrally brown, pretarsi dark brown; gaster brown to dark brown; antenna with one large anellus and three funicular segments; postmarginal vein rudimentary. Male smaller than female, 1.0–1.2 mm long, pale-white to pale yellow as opposed to yellow in female; gaster in anterior half pale, rest dark brown; legs entirely pale; antenna with four funicular segments.

Erythrina is widely used as a live standard for trailing black pepper and vanilla would necessitate management measures on a large scale.

Wasps of the family Eulophidae are parasitoids on a variety of arthropods with a few phytophagous species. *Q. erythrinae* is the only phytophagous member of the genus.

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Activities of some catabolic and anabolic enzymes of carbohydrate metabolism during developmental phases of fruit-bodies of *Dictyophora indusiata* and *Geastrum fornicatum*

Many basidiomycetous fungi and particularly the members of Gasteromycetes are very important in forest ecosystem and help in recycling of cellulosic forest wastes[1]. Although metabolism of carbon compounds both *in vivo* and *in vitro* were studied in many soil bacteria[2] and lower fungi[3,4], little information is available in higher Basidiomycetes[5,6]. Operation of glyoxylate pathway and its involvement in the basidiospores of *Lycoperdon* and in some members of Agaricales has been reported earlier[7]. In these organisms, pathways for central carbohydrate metabolism were not studied. In the present study two key enzymes of catabolic pathways, viz. phosphofructokinase (PFK) and isocitrate dehydrogenase (ICDH), and two enzymes for anabolic pathways, viz. fructose bis-phosphatase (FBPase) and iso-citrate lyase (ICL) were assayed from the cell-free extracts (CFE) of different developmental phases of fruit bodies of *Dictyophora indusiata* and *Geastrum fornicatum*. Also presence of these enzymes in different parts of the mature fruit bodies was assessed.

Fruit bodies of *D. indusiata* and *G. fornicatum*[1] were collected from forest floor of Santiniketan at their different developmental phases as mentioned in Table 1. These were washed thoroughly, cut into pieces, homogenized, sonicated by ultrasonic needle probe and centrifuged to obtain cell-free extracts (CFE) following the method of Mandal and Chakrabartty[8]. These CFEs were used as source of enzymes. PFK (EC 2.7.1.11) and ICDH (EC 1.1.1.42) were assayed following the methods of Heath and Gaudy[9] and Khouw and McCurdy[10]. On the other hand, FBPase (EC 3.1.3.11) and ICL (EC 4.1.3.1) were determined following the standard methods[11,12]. Protein was estimated following the method of Lowry *et al.*[13].

Results from Table 1 indicate a slight increase of activity of PFK and ICDH up to emergence stage of fruit bodies, which followed a declining trend with the ageing of fruit bodies in both the fungi (Table 1). On the other hand, specific activity of FBPase, an enzyme responsible for gluconeogenesis increased gradually with the maturation of fruit bodies. This type of growth-phase-dependent expression of metabolic activities was reported in other organisms also[14]. Mandal and Chakrabartty[15] observed that key enzymes of Embden Meyerhof Parnas pathway and