



Incidence of *Erythrina* gall wasp (*Quadrastichus erythrinae* Kim), an invasive insect pest on *Erythrina* spp., in major black pepper (*Piper nigrum* L.) areas of Kerala and Karnataka, India

(Manuscript Received: 14-09-09, Revised: 27-01-10, Accepted: 17-05-10)

Keywords: Black pepper, *Piper nigrum*, *Erythrina* spp., *Erythrina* gall wasp, *Quadrastichus erythrinae*

The coral tree (*Erythrina* spp.) (Fabales: Fabaceae) is widely used as a live standard (support tree) for trailing black pepper vines (*Piper nigrum* L.) in major black pepper growing countries including India. Around 20 *Erythrina* spp. occur in India, among which *E. variegata* L. and *E. subumbrans* (Hassk.) Merr. are commonly used as live standards, for trailing black pepper vines in Kerala and Karnataka. Very few foliage insect pests have been reported on *Erythrina* spp. in India. However, a new invasive insect pest, the *Erythrina* gall wasp (EGW) *Quadrastichus erythrinae* Kim (Hymenoptera: Eulophidae) has become a serious threat to the cultivation of *Erythrina* trees in the country. The larvae of EGW induce the formation of galls in tender leaves and stems and heavy infestations result in loss of growth and even death of trees.

The EGW was first reported on *Erythrina* sp. from Reunion Island, Mauritius and Singapore as a new species (Kim *et al.*, 2004). The pest, which has invaded many countries across Asia and the Pacific, is one of the most invasive and destructive insect pests in recent years. In Hawaii, the impact of the pest has been so devastating that some of the endemic species of *Erythrina* are in danger of becoming extinct (Gramling, 2005). In India, the EGW was first recorded on *Erythrina* spp. from the southern districts of Kerala including Thiruvananthapuram District (Faizal *et al.*, 2006; Isaac and Pillai, 2006) and also from Pune, Satara, Sangli and Kholapur districts in Maharashtra and Belgaum and Dharwad districts in Karnataka (Kore, 2006). Rajkumar *et al.* (2007) reported that the black-thorned *Erythrina* sp. was severely infested by the pest in Idukki District of Kerala. The pest has also

been observed in Kanyakumari and Nilgiris districts in Tamil Nadu. However, no information is available on the incidence of EGW in major black pepper growing areas of Kerala and Karnataka and hence, surveys for the incidence of EGW on *Erythrina* spp. were conducted in 13 taluks of Idukki, Kozhikode, Kannur and Wayanad districts in Kerala and three taluks in Kodagu district in Karnataka during April to July 2008. These districts account for around 70 % of the area under black pepper in the country. The total number of locations and black pepper gardens covered during the survey include 97 and 273 in Kerala and 39 and 63, in Karnataka, respectively (Table 1).

From each garden, 15 trees were selected at random and the number of trees with symptoms of damage was recorded and the total number of twigs available and number infested was also recorded to calculate the percentage of trees/twigs infested in each

Table 1. Incidence of *Quadrastichus erythrinae* on *Erythrina* spp. in major black pepper growing districts

District	No. of taluks surveyed	No. of locations surveyed	No. of gardens surveyed	Mean per cent infestation	
				Tree	Twig
Idukki	4	29	87	53.4 (47.0) ab	33.7 (35.5) ab
Kozhikode	3	19	65	32.9 (35.0) a	27.4 (31.6) ab
Kannur	3	27	61	39.1 (38.7) ab	17.2 (24.5) a
Wayanad	3	22	60	59.6 (50.5) b	40.8 (39.7) b
Kodagu	3	39	63	51.8 (46.0) ab	30.3 (33.4) ab

Figures in parentheses are arcsine transformed values

Means followed by the same letter within each column are not significantly different at P = 0.05

garden. The percentage of trees/twigs infested was also calculated for each taluk and each district. Two species of *Erythrina* viz., *E. variegata* and *E. subumbrans*, and further three distinct types of *E. variegata* viz., black-thorn type, white-thorn type and dense-thorn type were generally used as standards in various regions. The data was subjected to ANOVA using SPSS package after arcsine transformation and post hoc Duncan's multiple range test was used to distinguish significantly different means. The mean and standard deviation ($\frac{1}{2}$ SD) of per cent twigs infested in each species/type was taken for calculating pest susceptibility ratings (Bhumannavar *et al.*, 1988) of various *Erythrina* spp.

The surveys indicated that the EGW was present in all the districts and taluks surveyed in Kerala and Karnataka. The pest infestation affected the growth of *Erythrina* standards resulting in reduction in foliage and available shade for black pepper vines. In many gardens, the pest infestation led to mortality of *Erythrina* standards resulting in collapse of the entire canopy of black pepper vines (Figs. 1 and 2). However, there were significant differences in the percentages of trees/twigs infested by the pest in various districts/taluks. The percentage of trees infested by EGW was significantly higher in Wayanad district (59.6), which was on par with Idukki (53.4), Kodagu (51.8) and Kannur (39.1) districts. The percentage of twigs infested by EGW was also significantly higher in Wayanad district (40.8), which was on par with Idukki (33.7), Kodagu (30.3) and Kozhikode (27.4) districts (Table 1). Among the various taluks, the percentage of trees infested by EGW was significantly higher in Virajpet (73.8) which was on par in all other taluks except Vadakara (8.6) and Madikeri (9.2). The percentage of twigs infested by EGW was significantly higher in Mananthavady (48.7)



Fig. 1. Tender leaves and stems of *Erythrina* sp. infested with *Quadrastichus erythrinae*



Fig. 2. Mortality of *Erythrina* sp. due to severe infestation of *Quadrastichus erythrinae*

which was on par in all other taluks except Madikeri (5.4) (Table 2).

The EGW has spread to all black pepper areas from the plains and midlands (Kozhikode and Kannur districts) to high altitudes (>1000 m) in Idukki, Wayanad and Kodagu districts within a few years since its first establishment in India. Typically an introduced species might become invasive if it can out-compete native species for resources such as food and space. However, invasive species often coexist with native species for an extended time and gradually their superior competitive ability become apparent when its population grows larger

Table 2. Incidence of *Quadrastichus erythrinae* on *Erythrina* spp. in major black pepper growing taluks

State	District	Taluk	Mean per cent infestation	
			Tree	Twig
Kerala	Idukki	Thodupuzha	52.5 (46.4) ab	32.9 (35.0) ab
		Peerumedu	48.2 (44.0) ab	30.6 (33.6) ab
		Udumbanchola	57.4 (49.2) ab	37.6 (37.8) ab
	Kozhikode	Devikulam	40.1 (39.3) ab	17.7 (24.9) ab
		Kozhikode	65.5 (54.0) ab	46.8 (43.5) b
		Koyilandy	39.6 (39.0) ab	28.1 (32.0) ab
		Vadakara	8.6 (17.0) a	15.6 (23.3) ab
	Kannur	Thalassery	33.3 (35.2) ab	13.4 (21.5) ab
		Taliparamba	33.9 (35.6) ab	12.9 (21.1) ab
		Kannur	50.3 (45.2) ab	25.8 (30.5) ab
Wayanad	Mananthavady	72.4 (58.3) b	48.7 (44.3) b	
	Sultan's Battery	42.3 (40.5) ab	34.1 (35.7) ab	
	Vythiri	63.9 (53.1) ab	41.4 (40.0) b	
Karnataka	Kodagu	Madikeri	9.2 (17.7) a	5.4 (13.5) a
		Somwarpet	65.4 (54.0) ab	39.2 (38.8) b
		Virajpet	73.8 (59.2) b	46.4 (42.9) b

Figures in parentheses are arcsine transformed values
Means followed by the same letter within each column are not significantly different at P = 0.01 for trees and P = 0.05 for twigs

ter it adapts itself to its new environment (Sax *et al.*, 2002; Tilman, 2004). Very few foliage insect pests have been recorded on *Erythrina* spp. in India, and hence the EGW probably did not have a competitor for its establishment on *Erythrina* spp. and was able to spread vast areas within a short period. The extremely small size of adults aided its dispersal to newer areas and its adaptability to a wide range of environmental conditions also enabled it to attain an invasive status within a short period.

The incidence and severity of damage caused by EGW significantly varied on various *Erythrina* spp. and also on various types of *E. variegata*. The pest infestation was significantly higher in white-thorn type of *E. variegata* wherein a mean of 91.8% trees and 66.8% twigs were infested by the pest. The pest infestation was significantly lower in dense-thorn type of *E. variegata* wherein a mean of 15.0% of trees and 10.2% of twigs were infested by the pest. The pest infestation on the trees (48.9%) and twigs (25.9%) in *E. subumbrans* was on par with that of black-thorn type of *E. variegata* (47.2% and 28.3%, respectively) (Table 3).

Table 3. Incidence of *Quadrastichus erythrinae* on various species/types of *Erythrina* in Kerala and Karnataka

Species / Type	Mean per cent infestation	
	Tree	Twig
<i>Erythrina variegata</i> (black-thorn type)	47.2 (43.4) b	28.3 (32.1) b
<i>E. variegata</i> (white-thorn type)	91.8 (73.4) c	66.8 (54.8) c
<i>E. variegata</i> (dense-thorn type)	15.0 (22.8) a	10.2 (18.6) a
<i>E. subumbrans</i>	48.9 (44.4) b	25.9 (30.6) b

Figures in parentheses are arcsine transformed values
Means followed by the same letter within each column are not significantly different at P = 0.01

The rating of resistance/susceptibility of various species/types of *Erythrina* to EGW based on percentage of damaged twigs indicated that *E. variegata* (dense-thorn type) could be classified as moderately resistant (<17.1% mean twig damage) and *E. variegata* (white-thorn type) highly susceptible (>43.2% twig damage) in the field. *E. variegata* (black-thorn type) and *E. subumbrans* were moderately susceptible (17.8 to 30.4 % twig damage) to the pest in the field (Table 4).

Messing *et al.* (2008) screened 71 species of *Erythrina* in Hawaii to EGW infestation based on field observations and sleeve-cage experiments, and found that 2 species were free from attack. Species endemic to Africa were more resistant to EGW than those from other

Table 4. Resistance of *Erythrina* spp. to *Quadrastichus erythrinae* based on twig damage

Category	Criteria for classification (per cent twig damage)	Species/Type
Highly resistant	No twig damage (0)	Nil
Moderately resistant	(Less than mean - $\frac{1}{2}$ SD) twig damage (<17.1)	<i>E. variegata</i> (dense-thorn type)
Moderately susceptible	(Mean - $\frac{1}{2}$ SD to mean) twig damage (17.1-30.4)	<i>E. variegata</i> (black-thorn type), <i>E. subumbrans</i>
Susceptible	(Mean to mean + $\frac{1}{2}$ SD) twig damage (30.5-43.2)	Nil
Highly susceptible	(More than mean + $\frac{1}{2}$ SD) twig damage (>43.2)	<i>E. variegata</i> (white-thorn type)

continents. The probable reason for the lower incidence of EGW in Kozhikode and Kannur districts observed in the study may be due to the widespread cultivation of dense-thorn type of *E. variegata* in these districts. The variation in susceptibility of various species/types of *Erythrina* to EGW offers great potential as a management strategy against the pest.

Acknowledgements

We thank Dr. V.A. Parthasarathy, Director, IISR, Calicut, for providing the necessary facilities for the study. We also thank Mr. K.K. Sasidharan, Technical Assistant, IISR, Calicut, for technical assistance during the surveys, Mr. K. Jayarajan, Technical Officer, IISR, Calicut, for analysis of data and Dr. A.K. Pradeep, Curator (Herbarium), Department of Botany, University of Calicut, Kerala, for identification of *Erythrina* spp./types.

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Indian Institute of Spices Research
Marikunnu P. O., Calicut - 673 012, Kerala, India

T.K. Jacob,
S. Devasahayam