Proceedings of the Eighth International Workshop on Biological Control and Management of *Chromolaena odorata* and other Eupatorieae, Nairobi, Kenya, 1-2 November 2010.
Zachariades C, Strathie LW, Day MD, Muniappan R (eds) ARC-PPRI, Pretoria (2013) pp 128-133

# The impact of *Cecidochares connexa* on *Chromolaena odorata* in Guam

Gadi V.P. Reddy[1,3]*, Rosalie S. Kikuchi[1] and R. Muniappan[2]

[1]*Western Pacific Tropical Research Center, College of Natural and Applied Sciences, University of Guam, UOG Station, Mangilao, Guam 96923, USA*
[2]*IPM CRSP, Virginia Tech, 526 Prices Fork Road, Blacksburg, VA 24061, USA*
[3]*Current address: Montana State University, Western Triangle Ag Research Center, 9546 Old Shelby Rd, Conrad, MT 59425, USA*
**Corresponding author: reddy@montana.edu*

*Chromolaena odorata* (L.) King & Robinson (Asteraceae) is one of the most serious invasive weeds in Guam and on other Micronesian Islands. For biological control of this weed, a moth, *Pareuchaetes pseudoinsulata* Rego Barros (Lepidoptera: Arctiidae) from India and Trinidad and a gall fly, *Cecidochares connexa* (Macquart) (Diptera: Tephritidae) from Indonesia were introduced into Guam and other Micronesian islands in 1985 and 1998, respectively. To assess the impact of these established natural enemies, eight field sites in northern, central and southern Guam, each with well-established stands of *C. odorata*, were assessed in 2009. Measurements of various growth parameters of *C. odorata* indicated steady decline in the number of stems and leaves, and height of plants at the sites from October 2009 to September 2010. This gives a snapshot picture of the decline of *C. odorata* on Guam, likely due to the introduced natural enemies.

**KEYWORDS:** *Cecidochares connexa*; chromolaena; damage; *Pareuchaetes pseudoinsulata*

## INTRODUCTION

*Chromolaena odorata* (L.) King & Robinson (Asteraceae) is one of the most serious invasive weeds in Guam and on other Micronesian Islands (Muniappan et al. 2005). It is a problem mostly in plantations, pastures, vacant lots and disturbed forests. It grows rapidly, invading a wide range of vegetation types, forming dense monospecific stands, and smothering other vegetation (Cruz et al. 2006). Over the past 25 years considerable progress has been made in Guam and Micronesia on the biological control of *C. odorata* by implementing several projects (Zachariades et al. 2009), most of which were supported by the Tropical and Subtropical Agricultural Research program of the USDA. Implementation of these biological control projects has resulted in the marked reduction in contiguous thickets of this weed that were previously observed in the 1980s, to its current patchy distribution in Guam and on neighboring islands (Cruz et al. 2006).

The biological control program of *C. odorata* in Guam started in 1983 and has been reviewed by Muniappan et al. (2005) and Zachariades et al. (2009). A moth, *Pareuchaetes pseudoinsulata* Rego Barros (Lepidoptera: Arctiidae), was introduced to Guam from India and Trinidad in 1985, and a gall fly, *Cecidochares connexa* (Macquart) (Diptera: Tephritidae), was introduced from Indonesia in 1998 (Zachariades et al. 2009). *Pareuchaetes pseudoinsulata* and *C. connexa* were confirmed to have established in 1985 and 2002 respectively, and have since spread throughout Guam (Cruz et al. 2006). *Cecidochares connexa* established on other Micronesian islands in succeeding years (Zachariades et al. 2009). In the earlier years of the program, *P. pseudoinsulata* was responsible for complete defoliation and die-back of thickets of *C. odorata* (Muniappan and Bamba 2000). However, current patchy conditions of the weed due to an insect-induced plant defense (Raman et al. 2006), and a lack of foliage during the prolonged dry season interfere with its biology and reduce its efficacy. In contrast, *C. connexa* is highly mobile, able to colonize isolated *C. odorata* plants, forms galls which

act as nutrient sinks, is not influenced by insect-induced plant defenses, and is minimally affected by prolonged dry and wet seasons (Cruz et al. 2006).

Despite the significant suppression of *C. odorata* by *P. pseudoinsulata* and *C. connexa*, the immediate re-shooting of this weed after the onset of the rainy season and the lag period before the natural enemies increase in numbers again (R. Muniappan, pers. obs.), has resulted in a perception, especially among non-technical personnel, that additional control measures are needed. In the early 1980s, *C. odorata* was very abundant along roadsides, vacant lots and disturbed areas. Since the introduction of the agents, an area of about 50,000 acres invaded by *C. odorata* has been reduced to a current area of about 2,000 acres in Guam. This study presents a snapshot of the impact of introduced natural enemies on the population of *C. odorata* on Guam, by measuring various parameters of plant growth and abundance of *C. connexa* from October 2009 to September 2010.

## MATERIALS AND METHODS

Eight study sites, representing the entire geographic area of Guam, were selected from the north, central, and southern parts of the island. Sites with healthy stands of *C. odorata* were selected (Table 1).

A 12 channel global positioning system (GPS) (Garmin Corp., Taiwan) device was used to record longitude and latitude coordinates of the study sites. A quadrat ($1m^2$) was laid on top of *C. odorata* plants at random intervals (Brower et al. 1998), with 2-6 replicates per site, depending on the availability of *C. odorata* stands. Sites were visited once every two weeks. The number of stems, leaves, and *C. connexa* galls in each quadrat were counted, and plant height was measured. There was no incidence of *P. pseudoinsulata* within the sites during the study period. Data were averaged per site and standard errors were calculated.

## RESULTS AND DISCUSSION

The number of stems and leaves, and plant height of *C. odorata*, decreased from October 2009 to September 2010 (Fig. 1-3). The average number of stems per $m^2$ decreased from 30 ± 3.3 in October 2009 to 15.3 ± 3.0 by September 2010. The average number of leaves declined from 35.9 ± 4.8/$m^2$ to 7 ± 3.3/$m^2$ during the same period. The average plant height also declined steadily from 73.4 ± 8.0cm in September 2009 to 19.3 ± 9.4cm in October

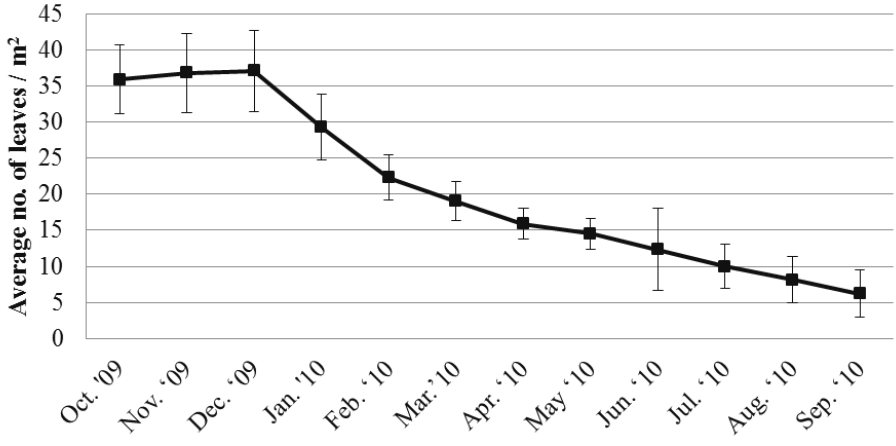


**Figure 1.** Average leaf production of *Chromolaena odorata* at selected sites on Guam.

**Table 1.** Site information (locality, site descriptions and geographic coordinates), for sites in Guam sampled for *Cecidochares connexa*.

| Locality | Coordinates | Site description | No. of samples per site (n) |
|---|---|---|---|
| Yigo | 13°31.869′N 144°52.291′E | This location in the northeastern part of the island, close to a secondary forest area, was heavily infested with *C. odorata*. It is located within the University of Guam Agricultural Research Station. | 6 |
| Agat | 13°21.789′N 144°39.001′E | It is located on the northwestern side of the island. An isolated stand of *C. odorata* that grew in a shallow area was selected for the study. This area was very close to the ocean, with associated beach strand vegetation. | 6 |
| Dededo | 13°30.700′N 144°51.173′E | It is located in northern part of the island. A long, sprawling roadside stand of *C. odorata* that grew in a relatively open location was selected. On the other side of the road was a relatively undisturbed forested area of government land. | 6 |
| Hagatña | 13°28.161′N 144°44.817′E | In an open location near a secondary forest on the central part of the island, an isolated stand of *C. odorata* that grew in a low area was selected for the study. This area had several houses and vacant lots. | 2 |
| Mangilao | 13°26.978′N 144°48.737′E | Located at the base of a limestone cliff on the eastern side of the island, the roughly circular *C. odorata* infestation established on a previously cleared area was selected. | 6 |
| Talofofo | 13°23.025′N 144°46.342′E | Located in the southern part of the island. A very long narrow stand of *C. odorata* was selected for the study. The area selected was near recently built houses. | 6 |
| Inaranjan | 13°15.259′N 144°43.300′E | *Chromolaena odorata* growing in fairly open conditions alongside a dirt track on the southeastern part of the island and somewhat sheltered from the prevailing winds by a small bluff. The stand of *C. odorata* selected was one of several occupying a previously cleared area of about 0.5 acres. | 4 |
| Merizo | 13°15.058′N 144°43.071′E | Located at the southern edge of the island. The area had previously been cleared and left fallow for a number of years, and was heavily infested by *C. odorata* plants. | 6 |

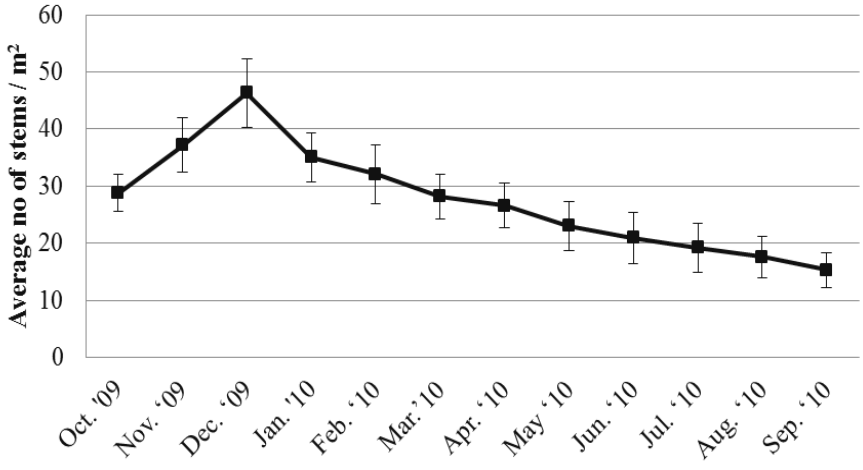


**Figure 2.** Average number of stems of *Chromolaena odorata* at selected sites on Guam.

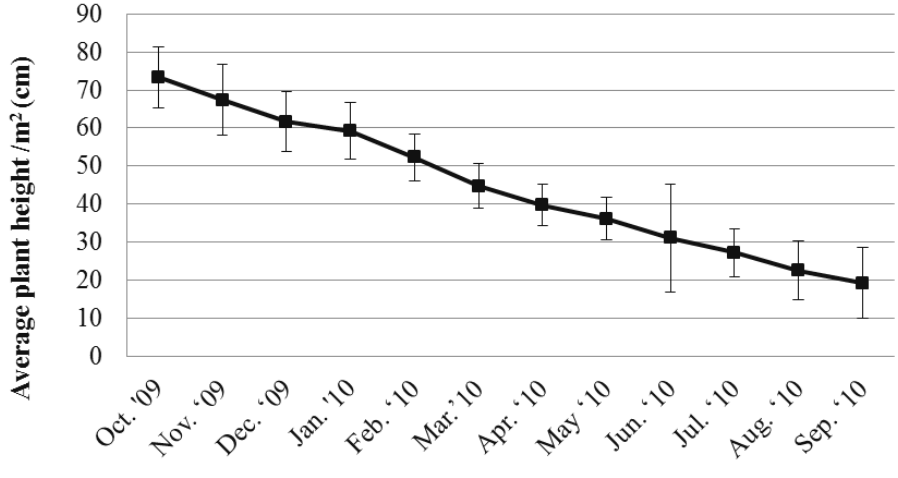


**Figure 3.** Average height of *Chromolaena odorata* plants at selected sites on Guam.

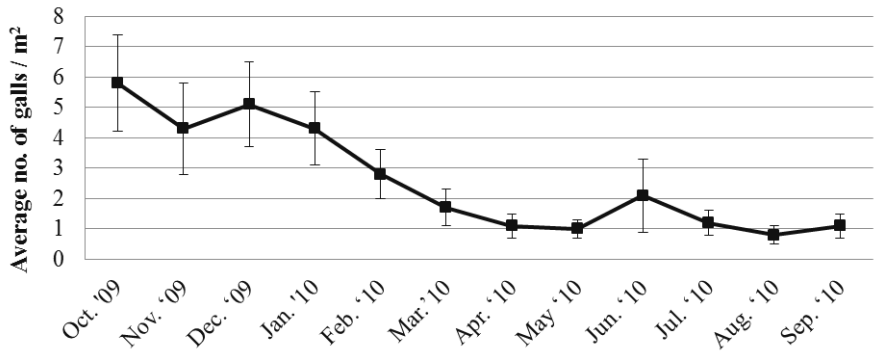


**Figure 4.** Average number of *Cecidochares connexa* galls on *Chromolaena odorata* plants at selected sites on Guam.

2010. The average number of galls formed by *C. connexa* within the sampling area, which is likely one of the factors that contributed to the reduced growth of *C. odorata* (Cruz et al. 2006) also declined during the study (Fig. 4), coinciding with a decline in the number of stems. During the dry season (December through May) plants lose foliage; however, they recover after the onset of the rainy season in June. These data show no recovery of leaf production to the original level.

Populations of *P. pseudoinsulata* were low in number, patchy and sporadic during the study period. Larvae of *P. pseudoinsulata* were found at Mangilao, Dededo and Talofofo for a short period of time but not within the actual study sites. Yellowing of leaves due to insect-induced plant defenses, as well as larval damage, were noted at other locations such as Yigo, Hagatña and Agat. *Pareuchaetes pseudoinsulata* was not, therefore, a contributing factor to the decline in plant growth observed during this study.

Since the establishment of *P. pseudoinsulata* in 1985 and *C. connexa* in 2002 in Guam, the density of infestations of *C. odorata* have steadily reduced. The present findings indicate the rate of decline of *C. odorata* at selected sites during a one-year period. It also documents that *C. connexa* was continuously present throughout the year, while *P. pseudoinsulata* occurred only sporadically, possibly due to insect-induced defenses in *C. odorata* as well as abiotic factors. However, the absence of any significant levels of parasitism of both *P. pseudoinsulata* and *C. connexa* in Guam has probably enhanced their efficacy (Muniappan et al. 2005; Cruz et al. 2006). The population of *C. odorata* has steadily declined since the introduction of two natural enemies. The introduction of additional natural enemies is therefore not warranted.

## ACKNOWLEDGEMENTS

This project was supported by grant 09-DG-11052021-109 Forest Health Protection, Invasive Plants, from the USDA Forest Service. In accordance with federal law and USDA policy, this institution is prohibited from discrimination on the basis of race, color, national origin, sex, age or disability. We thank David Bakke, State and Private Forestry, USDA Forest Service, Vallejo, CA, USA and Anne Marie La Rosa, Institute of Pacific Islands Forestry, USDA Forest Service, Hilo, Hawaii for the useful discussions. This work benefited from the field assistance of Z. T. Cruz and R. Gumataotao, University of Guam.

## REFERENCES

Brower JE, Zar JH, von Ende CN (1998) Field and laboratory methods for general ecology.

Fourth Edition. MCB/McGraw-Hill Companies, Inc., New York

Cruz ZT, Muniappan R, Reddy GVP (2006) Establishment of *Cecidochares connexa* (Diptera: Tephritidae) in Guam and its effect on the growth of *Chromolaena odorata* (Asteraceae). Ann Entomol Soc Am 99:845–850

Muniappan R, Bamba J (2000) Biological control of *Chromolena odorata*: successes and failures. In: Spencer NR (ed) Proceedings of the tenth international symposium on biological control of weeds. Bozeman, Montana, pp 81-85

Muniappan R, Reddy GVP, Lai P-Y (2005) Distribution and biological control of *Chromolaena odorata*. In: Inderjit S (ed) Invasive plants: ecological and agricultural aspects. Birkhäuser Verlag, Basel, Switzerland pp 223-233

Raman A, Muniappan RN, Silva-Krott IU, Reddy GVP (2006) Induced-defense responses in the leaves of *Chromolaena odorata* consequent to infestation by *Pareuchaetes pseudoinsulata* (Lepidoptera: Arctiidae). J Plant Dis Prot 113:234–239

Zachariades C, Day M, Muniappan R, Reddy GVP (2009) *Chromolaena odorata* (L.) King and Robinson (Asteraceae). In Muniappan R, Reddy GVP, Raman A (eds) Biological control of tropical weeds using arthropods. Cambridge University Press, Cambridge, UK, pp 130-162