Biological control of *Chromolaena odorata* in Papua New Guinea (CP/1996/091)

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Project number	CP/1996/091
Project name	Biological control of *Chromolaena odorata* in Indonesia and Papua New Guinea
Collaborating institutions	Australia: Department of Natural Resources and Water, Queensland Indonesia: Universitas Nusa Cendana; SEAMEO Regional Centre for Tropical Biology; Gadjah Mada University; Indonesian Oil Palm Research Institute; Centre de Cooperation Internationale en Recherche Agronomique pour le Développement Papua New Guinea: National Agricultural Research Institute (NARI), formerly the Department of Agriculture and Livestock; Oil Palm Research Association Philippines: Philippine Coconut Authority (Note 11/3/2002—Variation 3—Review of Review recommended an increase in budget and an extension of 3 years in PNG only—the project was no longer active in Indonesia or the Philippines.)
Project leaders	Dr Michael Day, Department of Employment, Economic Development and Innovation, Queensland
Duration of project	1 July 1997 – 31 March 2007
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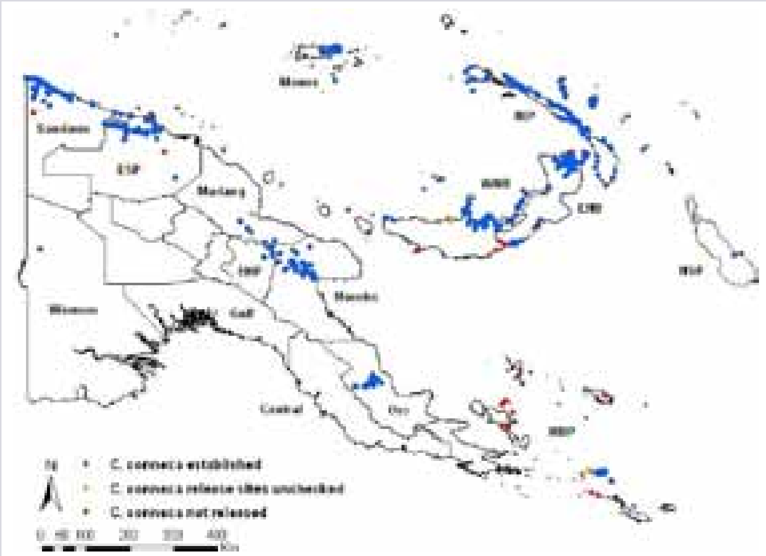
Countries	Papua New Guinea (Indonesia, Philippines)
Commodities	Crops
Related projects	AS2/1991/010, LPS/2003/028



The distribution of chromolaena in Papua New Guinea, showing where the gall fly *Cecidochares connexa* has been released, where it has established and where it is not yet present.

Motivation for the project and what it aimed to achieve

Chromolaena odorata (chromolaena) (family Asteraceae), originally from the Caribbean and northern South America, is one of the world's worst weeds, affecting many tropical countries in Africa and Asia. It is a fast-growing woody shrub, reaching about 3 m tall. It can invade farming lands, lowering farm productivity, and outcompete natural vegetation, reducing biodiversity. In Papua New Guinea (PNG), it invades subsistence farms, smothering crops such as taro, cassava and pawpaw, as well as infesting plantations where it can interfere with the harvesting of coconuts or establishment of oil palm and cocoa. In grazing areas, it can outcompete preferred species, reducing productivity.

The plant flowers prolifically and produces thousands of barbed seeds that can be spread by wind, machinery, animals or on people's clothing and possessions. Chromolaena can be controlled by herbicides or manually but this is usually expensive and time-consuming and its rapid regrowth means that control efforts needs to be repeated frequently.

Biological control (biocontrol) of chromolaena has been suggested since the 1960s, when investigations undertaken by the Commonwealth Institute of Biological Control from 1966–72 identified 225 natural enemies of the weed. Several of these were considered promising for biocontrol and were released in West Africa in the 1970s.

An ACIAR-funded project on the biocontrol of *C. odorata* started in Indonesia and the Philippines in 1991. The rationale of the project was that controlling chromolaena in neighbouring countries to Australia not only helps farmers and increases food security in those countries but also reduces the risk of the weed reaching Australia. In 1991, when the project commenced, chromolaena was not found in Australia. However, it was later discovered in North Queensland in 1994 and became the target of a national eradication project.

Two biocontrol agents, the moth *Pareuchaetes pseudoinsulata* and the gall fly *Cecidochares connexa*, were introduced into Indonesia in 1993 and 1995, respectively, and both established. Following the introduction of these agents into Indonesia, the project was extended in 1998 to include PNG. In PNG, chromolaena was also considered a major weed of subsistence farms and plantations, where it smothered food crops and interfered with harvesting, reducing productivity and income. The impacts of chromolaena in PNG were likely to increase as the weed was spreading rapidly due to logging.

The PNG project aimed to reduce the impact of chromolaena on landholders, by introducing biocontrol agents that were deemed host specific and effective elsewhere. By controlling chromolaena in PNG, it was hoped that time spent on weeding would fall, while food production and income would rise.

The main agency involved in PNG was the National Agricultural Research Institute (NARI), formerly the Department of Agriculture and Livestock. Staff in NARI had been involved in an Australian Agency for International Development (AusAID)-funded project on the biocontrol of water hyacinth in PNG, which was managed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and ended in 1998. Other organisations involved were the PNG Oil Palm Research Association (PNGOPRA), the National Agriculture Quarantine Inspection Authority (NAQIA) and the PNG Department of Conservation (DEC). The last two organisations were involved because they are the organisations that issued the import permits for the biocontrol agents.

Outputs—what the project produced

The main outcome of the project was the control or significant reduction of chromolaena in most provinces of PNG. Areas that were once monostands of chromolaena have been converted back into subsistence farms, and plantations in which chromolaena was the main understorey species are now clear of the weed. This outcome was the result of the primary outputs of the project: (a) knowledge of the extent of the chromolaena problem and its impact of the livelihoods of smallholders, (b) an understanding of effective biocontrol agents and (c) significant capacity built in biocontrol of weeds.

Chromolaena was confirmed at over 700 sites in 13 lowland provinces. Through the results of public awareness campaigns and interviews, chromolaena was found to seriously affect landowners in terms of lost productivity and income and a significant increase in the time spent weeding food gardens. Chromolaena can quickly invade food gardens and its rapid growth can smother a range of crops including taro, cassava, banana and pawpaw. In plantations, chromolaena impeded the harvesting of fallen coconuts, while in grazing lands it outcompeted preferred grasses, significantly reducing stocking rates. Where chromolaena infestations were particularly severe, subsistence farmers had to slash and remove chromolaena almost daily to keep gardens clear of the weed. The increase in time spent weeding had numerous flow-on effects. Some food gardens became smaller because it was not possible to maintain larger food gardens, thus reducing productivity and income by up to 50% and having a significant effect on food security. In addition, there was considerably less time available for other activities such as repairs to houses, or there was a requirement for children to assist with farming, thus removing them from school.

The gall fly *Cecidochares connexa*, an agent for biological control of chromolaena. (Photo: C. Wilson)

Three insects, the moth *P. pseudoinsulata*, the gall fly *C. connexa* and the leaf-mining fly *Calycomyza eupatorivora*, were introduced as biocontrol agents during the project. *Pareuchaetes pseudoinsulata* was released widely but established only in Morobe and Eastern Highlands provinces, where it defoliates chromolaena seasonally. Rearing the moth was labour intensive, and large numbers were required to ensure establishment. Researchers in other countries also reported difficulties in rearing and achieving establishment. As a result, the rearing program was shortened and *P. pseudoinsulata* is not recommended for release in other countries.

The leaf-mining fly *C. eupatorivora* was imported numerous times from South Africa but did not establish. It was thought that PNG was too hot for the insect and it is not recommended for other tropical countries, such as East Timor.

The gall fly *C. connexa* was released at over 350 sites in all provinces where chromolaena occurs and established at nearly 300 sites. It later spread to over 350 additional sites, some of which were 100 km away. At the completion of the project, there were still about 25 sites that needed to be checked for establishment and about 50 sites where the gall fly was never released. Given the high establishment rate (98%) and the high rate of dispersal, it is quite likely that the gall fly is present in many of these areas by now. However, some of the more remote islands in Milne Bay would still require field releases.

Field monitoring of the gall fly found that, as the number of galls increased, branches can die, thereby reducing biomass and flower and seed production. At high gall levels (>50 galls/plant), whole plants can die, thus allowing the re-establishment of food gardens or natural vegetation. Numerous 'before gall fly' and 'after gall fly' photos were taken and have been used in various presentations. Such information is particularly useful for other countries where chromolaena is a problem. Control was reported in nearly 200 sites covering eight provinces, with partial control at many more sites.

Socioeconomic surveys conducted on nearly 200 landowners found that 83% of respondents thought there was much less chromolaena now than before the gall fly was released. About 70% of respondents stated that they were benefiting from the control of chromolaena, with 50% of respondents stating that weeding times were reduced by 50% and that control costs had fallen by 45%. Over 62% thought that crop yield and income increased following the control of chromolaena.

Throughout the project, databases were established to record information on where chromolaena was present, where the gall fly was released and had established, and to where it had naturally spread. Information was also collected on the effect of the gall fly on chromolaena at selected sites and the impact of the project on landholders. The information was useful for reporting and presentations, as well as assisting in planning future releases and other activities within the project.

At the commencement of the project, only one staff member in NARI was experienced in weed biocontrol. However, during the course of the project, numerous staff gained significant experience in the discipline. The project leader left the organisation midway through the term of the project and commenced work for

Kunibert Tibil, District Administrator, Kavieng, New Ireland, holding dead stems of chromolaena with galls. (Photo: W. Orapa) the Fiji-based Secretariat of the Pacific Community where, through his experience in weed biocontrol, he was able to enhance biocontrol throughout the Pacific. The junior scientist took over as the in-country project leader and quickly gained skills in all aspects of weed biocontrol and the importance of good data collection and processing. Labourers employed by the project to assist with releases, field monitoring and collection of agents are now being employed by other projects.

As biocontrol agents were released throughout the country, there was a need for project staff to liaise with provincial officers who had much local knowledge but often had little experience in weed biocontrol. However, towards the end of the project, through working with project staff, these provincial officers were skilled enough to be able to release biocontrol agents they received, then monitor results. This was a huge saving for the project in terms of time and funds. Serendipitously, these provincial officers are also being used in the current project on the biocontrol of mikania, another invasive weed.

Reporting the success of the gall fly on chromolaena was particularly relevant to researchers in other countries where chromolaena was also a problem. The project produced numerous publications, mainly presented at international workshops on the management and biocontrol of chromolaena: one paper was presented in Bangalore, India (1996), two in Durban (2000), two in Cairns (2003), one in Taiwan (2006)

John Bokosou of the National Agricultural Research Institute interviewing a landowner family near Burit, East New Britain, to get their thoughts on chromolaena and the gall fly biological control agent, and how they are affecting their farm. (Photo: M. Day) and one in Nairobi (2010). A paper was also presented at the Australian and New Zealand Biocontrol Conference in Sydney in 2008. Information gained from this project was also included in chapters in two books on weed biocontrol.

A training workshop on biocontrol of weeds, with reference to chromolaena, was held in Lae, PNG, in 2003 and attended by PNG provincial officers, as well as researchers from Solomon Islands. The workshop covered the theory behind weed biocontrol, as well as information on the chromolaena biocontrol agents, with visits to selected field sites to view chromolaena infestations and the effect of the gall fly. The workshop was particularly useful as it provided training for provincial officers not well versed in weed biocontrol. More importantly, it increased awareness of the problems of chromolaena to the researchers in Solomon Islands, where chromolaena is not yet present. A comprehensive manual was produced for the workshop and distributed to the participants. Seminars covering the project were also presented to researchers in several Queensland government departments, the Queensland Entomological Society and at Kasetsart University, Thailand.

As biocontrol agents had to be imported and reared through one generation to remove possible parasites before their field release, post-entry quarantine had to be upgraded and rearing facilities built. A building with several rooms was upgraded so that it could be used as a post-entry quarantine facility. The insect-rearing facilities for biocontrol agents released from quarantine were constructed from an old shed used for rearing ducks. Insect cages were constructed in Australia and sent to PNG. These buildings and cages are now being used by other projects.

Adoption—how the project outputs are being used

Information on the distribution and significance of chromolaena as a weed and its effect on food security in PNG was used by quarantine and DEC authorities when conducting risk assessments on potential biocontrol agents being considered for importation. In all cases, the three agents were considered damaging to chromolaena and safe to release. The information on chromolaena was also used by quarantine authorities in Solomon Islands who now regularly survey the northern islands that neighbour PNG for the weed in an effort to ensure it does not establish in the country.

Information on the distribution of chromolaena and the status of the gall fly is still being used by NARI officers to both check whether the gall fly is present in various regions and conduct opportunistic releases of the gall fly if it is not present. Information on whether chromolaena is being controlled is also being collated. NARI officers, when travelling on behalf of the mikania biocontrol project, are often advised of the status of chromolaena in provinces they are visiting.

Landowners have reported that the gall fly has made a substantial difference and some are still moving the insect around to new areas. Other landowners report that they are now reducing the levels of burning or leaving patches of chromolaena in land not needed for farming to ensure populations of gall fly are maintained.

Jenitha Fidelis of the Cocoa and Coconut Institute collecting information about chromolaena and its biological control from landowners near Burit, East New Britain. (Photo: M. Day)

Information on the effect of the gall fly on chromolaena in PNG has been presented at numerous conferences and workshops and has been published in several proceedings. The information has been used by several organisations overseas. For example, based on the results in PNG, the gall fly was imported into East Timor in 2005. It was also imported into Thailand in 2009, following a visit by researchers from Kasetsart University. Following an international workshop in Kenya in 2010, an application to import the gall fly into that country was submitted.

Infrastructure such as quarantine and rearing facilities built during the project has been utilised by other projects in NARI that require sealed, airconditioned rooms or large, covered areas to maintain plants or insects. The mikania biocontrol project is located at NARI's Lowland Agricultural Experimental Station at Kerevat, East New Britain, but used the facilities built for chromolaena for a short period. Cages built to rear the agents have been utilised for rearing other insects.

Adoption of the project was enhanced by the production and distribution of a brochure detailing the weed and the agents. Several stories were published in two national newspapers and as well as on the radio. During project visits to release or monitor agents, project staff engaged provincial officers and community groups to inform them about the project, its objectives and results. Numerous papers were presented at international workshops and included in published proceedings to inform the scientific community on the success of the chromolaena project.

Despite these efforts, communication within PNG can be difficult, with unreliable phones and frequent power outages. Some places are just very remote. Consequently, the gall fly could not be released in all areas of PNG, but it is hoped, with time, that it will disperse to new places by itself.

Impact—the difference the project has made or is expected to make

The degree of benefits of the project vary with land use and climate. Control or significant reductions of the weed were reported in most provinces where chromolaena was present. Control was reportedly quicker and more complete in some provinces than in others. In New Ireland, which was one of the first provinces to receive the gall fly, very good control was observed and socioeconomic impact studies suggested that the landholders are benefiting from the gall fly's introduction. In other, drier provinces, such as Morobe, control was slower and less complete. In West New Britain, which is considerably wetter than most other provinces, control was not as good and chromolaena remains a problem. This is because the gall fly needs sunny days with temperatures over 30°C to mate. Cloudy, wet days result in lower temperatures and less time for mating. The gall fly failed to establish in Western province, as the only release site was slashed soon after the gall fly was released. However, the gall fly was recently released there again by mikania biocontrol project staff visiting the province.

Provinces aside, 69% of landowners who had chromolaena on their farms have reported some benefits as a result of the gall fly. However, the degree of benefits from the gall fly vary considerably with land use. Subsistence farmers who rely heavily on weeding by physical means such as slashing are probably the greatest beneficiaries in terms of percentage gains. This is in part due to the low inherent incomes and the high degree of manual labour involved in subsistence farming. Surveys found that weeding times were cut by up to 50%, which similarly reduced labour costs. Coupled with reduced time spent weeding, productivity (and therefore food security) and income both increased. As populations of chromolaena were controlled, there was less competition against crops such as taro, cassava, pawpaw and banana. However, the major benefit is apparently that, with reduced time required to maintain food gardens, landholders are able to increase the size of their blocks, thus increasing yield and income.

Commercial farmers also benefited from reduced herbicide costs and thus returned higher profits, while plantation owners were able to access coconut plantations to harvest fallen nuts. Controlling chromolaena in pastures meant that stocking rates could be increased. However, if other weeds were not managed at the same time, they would just replace chromolaena as it was controlled.

Other benefits that were not so obvious were that there were fewer places for snakes and pigs to hide once the chromolaena was controlled and so farmers did not have to erect fences around food gardens to keep out wild pigs. Some farmers reported a reduction in wounds from bush knife cuts, as there was a reduced need to slash chromolaena in food gardens. Chromolaena has a very thick and tough stem which makes slashing harder and also blunts knives quicker, adding to the risk of injuries.

The adoption study team near Matanakalah, New Ireland; L–R: Jenitha Fidelis (Cocoa and Coconut Institute, CCI), John Bokosou (National Agricultural Research Institute, NARI), John Joseph (CCI), Anna Kawi (NARI) and Richard Dikrey (Papua New Guinea Oil Palm Research Association). (Photo: M. Day)

Reduced populations of chromolaena also increased safety for pedestrians. Chromolaena was often found growing along roadsides and is considerably harder to slash than grasses. This meant that villagers often had to walk on the road to and from food gardens, increasing the risk of being hit by motorists.

It is anticipated that the benefits of this project will continue to flow through the community. Biocontrol is a self-sustaining control method, with the gall fly continuously suppressing populations of chromolaena, although both populations may fluctuate with time. It is also anticipated that the gall fly will continue to spread naturally throughout areas where chromolaena is present or into which it may spread. In addition, it is expected that landowners will continually move the gall fly into new areas themselves once they are aware of its benefits.

At a much wider level, organisations in other countries will continue to consider introducing effective agents to control chromolaena as a result of publications or presentations reporting the research conducted in PNG or other countries. Through various international workshops and publications, the news of the outcomes of the project in PNG has resulted in other countries also introducing the gall fly. The gall fly was introduced into East Timor in 2005 and Thailand in 2009. An application has recently been submitted to introduce the gall fly into Kenya. In addition, China, Taiwan and Palau have all expressed interest in importing it.