



The potential for the biological control of *Hedychium gardnerianum*

Annual report 2012

A report of the 4th Phase Research on the Biological Control of
Hedychium gardnerianum

Produced for

Landcare Research, New Zealand and The Nature Conservancy, Hawai'i



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1. Executive Summary

This report details the work undertaken by CABI E-UK in 2011, in collaboration with NBPGR, on the fourth phase of the biological control programme against *Hedychium gardnerianum*, for the consortium of sponsors from New Zealand and Hawai'i.

The research builds on the third phase of work carried out in 2010 in which export of some prioritised natural enemies was finally achieved and formal identifications and investigations into their potential as biocontrol agents were initiated.

- A new collaborative workplan (Phase III) between ICAR and CABI was drawn up in June and the *Hedychium* project (Component B) highlighted as an on-going activity under the package “the study of biological control of invasive plant species and Indian natural enemies”. New permits for survey and collection were obtained from the Department of Forests, Environment & Wildlife Management Sikkim (DFEWM) as well as ICAR permissions to survey and the National Biodiversity Authority notified accordingly.
- A survey was undertaken in July by Djami Djeddour and Corin Pratt from CABI E-UK. Meetings were held with DFEWM range officers and scientists in Sikkim to discuss the project and future collaboration. Courtesy meetings were also held with the Kanchenjunga conservation committee before repeat surveys in the National Park.
- Natural enemies were once again well represented on all *Hedychium* species and exports of the *Puccinia* rust on *H. gardnerianum*, of the damaging Chloropid fly, *Merochlorops dimorphus*, the *Tetratopus* weevil, leaf feeding Lepidoptera (*Camadena* spp. and Zygaenid spp. were made for host range initiation and further identifications by international experts. Whilst some preliminary tests were undertaken, a combination of non-synchronous emergence of adults (dipteran and lepidopteran), parasitism and resulted in limited numbers of individuals, so rearing attempts were unsuccessful.
- The 13th International Symposium on Biological control of Weeds held in Hawaii in September provided an excellent opportunity to promote the project through an oral presentation in the theme on “Prospects for weed biocontrol in Pacific Islands” but also during a specific *Hedychium* workshop. Key discussions were held to investigate ways in which the project could be

tailored to meet the needs of additional stakeholders and as a result of discussions proposals have been submitted by ARC-PPRI for funding from Working for Water, an important National funder. A meeting in the UK was also held to help identify potential sponsorship from the Azores.

- The UK's national *Hedychium* collection has been a useful source of plants and genetic material. Samples of a number of species were sent to Landcare's molecular team for characterisation and preliminary results indicate that the *Hedychium gardnerianum* from the invasive ranges may in fact be a hybrid which could have implications on agent selection.
- Increased funds have been secured for 2012/13 to continue the research and make progress with the host range testing. The project will be managed by Corin Pratt with support from Dick Shaw whilst Djami Djeddour is on maternity leave.
- Components of the work in the next phase will consist of:
 - Renewed collaborations in India
 - Further surveys to Sikkim and potential scientist recruitment
 - Rearing and research into the life cycles of selected agents
 - Continued prioritisation of agents through host range studies
 - Agreeing the test plant list for Hawaii and sourcing/propagating plants
 - Continued project promotion and stakeholder lobbying



2. Recommendations

The International Symposium on the Biocontrol of Weeds in Hawaii provided a unique opportunity to raise awareness of the project and identify additional stakeholders. The project's export restrictions in the early phases had meant that progress was initially slow but as collaborations in India and administrative protocols become more routine, surveys and export are becoming less of a challenge. Natural enemies continue to be well represented on all *Hedygium* species and with the commitment of adequate funds early in the year by sponsors and other stakeholders, a greater number of surveys can be accommodated as well as more concrete collaborations in Sikkim to facilitate observations and collections of different lifestages of natural enemies in the field across the season. The taxonomic ambiguity of the target *Hedygium* species in the invasive range needs further study as this could impact on agent selection and specificity requirements. Approval of the test plant list for Hawaii remains outstanding and must be addressed as a priority for host range testing and plant sourcing to be carried out accordingly.



3. Acronyms and Abbreviations

ACF	Assistant Conservator of Forests
CCF	Chief Conservator of Forests
DARE	Department of Agricultural Research and Education
DFEWM	Department of Forests, Environment and Wildlife Management
DFO	Divisional Forest Officer
FERA	Food and Environment Research Agency (exec. agency of DEFRA)
FTA	Fast technology for Analysis of Nucleic Acid
HVNP	Hawaii Volcanoes National Park
ICAR	Indian Council of Agricultural Research
ISBCW	International symposium on the biological control of weeds
KCC	Kanchenjunga Conservation Committee
MTA	Material Transfer Agreement
NBPGR	National Bureau of Plant Genetic Resources
TNCH	The Nature Conservancy of Hawaii

Acknowledgements

The researchers and authors of this report very much appreciate the continued support of its sponsors, Landcare Research and TNCH.

We gratefully acknowledge NBPGR for their assistance in the administrative aspects of survey and export whilst our sincerest thanks go to Mrs Usha-Lachungpa of DFEWM for facilitating the issue of new permits for surveys in Sikkim and the CABI India team for all their support. Thanks also to the members of the Kanchenjunga Conservation Committee for their assistance, to Dr. Von Tschirnhaus for his taxonomic guidance and to Gary Houlston and team of Landcare for their molecular analysis. Special thanks also go to Andrew Gaunt for hosting repeat visits to his collection and for his generous contributions of plant material.



4. Phase 4 Detail

4.1 Background

This report details the fourth phase of work conducted on the biological control *Hedychium gardnerianum* during 2011.

4.2 Aims and Achievements

The aims of the phase 4 research were:

- To renew/continue collaboration agreements with NBPGR (Delhi) and DFEWM (Sikkim) and obtain permits to survey and collect
- To source and propagate approved test plant list for New Zealand and agree test plant list for Hawaii
- To undertake survey to Sikkim and export agents/host material (July)
- The identification, rearing and culturing of agents in India/UK
- Research into lifecycles/infection parameters and host specificity of selected agents (India/UK)
- Further prioritisation of agents for full host range testing
- Project promotion and follow up of opportunities for additional consortium funding at ISBCW in Hawaii (September)
- The use of molecular diagnostic results, where possible, to help inform/narrow geographical focus of surveys
- The compilation of the annual report with recommendations for future work based on the findings of phase 4

Table 1: Aims and Achievements (Milestones in bold)

AIMS	ACHIEVEMENTS
Renew/continue collaboration agreements with NBPGR and DFEWM	Project continuation under CABI –ICAR MoU was approved by the competent authority until December 2011 . Collaborations with DFEWM were renewed and scientific staff earmarked for potential future field assistance/training
Obtain permits to survey and export	New application documents to survey/ collect specimens in Sikkim and transport them to Delhi containment facilities were successfully obtained from DFEWM. Survey and export were approved by ICAR/NBPGR and the National Biodiversity Authority informed.
Survey to India	Survey to Sikkim was undertaken from 14th -23rd of July 2011
Project promotion/profile raising/ and fund seeking	Oral presentation made and dedicated workshop held at 13th ISBCW in Hawaii . Opportunities for consortium expansion followed up; meetings held with Azores stakeholder and promotional flyer produced
Host range testing initiation	Choice feeding tests carried out with <i>Tetratopus</i> weevil and Zygaenid moth larvae. <i>Merochlorops dimorphus</i> rearing and rust culturing attempted.
Identification of natural enemies collected	Identifications made by NHM Museum and Bielefeld University experts, Germany.
Molecular characterisation of plants	FTA samples from the National <i>Hedychium</i> curator in the UK and from the native and invasive ranges were sent to Landcare for characterisation and preliminary results obtained
Shipments and propagation of test plants	Shipments of seeds were received from New Zealand and test plants sourced from the UK/France and grown in propagation for HR
Compilation of progress and final reports	Progress report was submitted in November 2011 and final report in February 2012

4.3 Administration

Personnel

CABI-UK

Djami Djeddour, Project manager, was accompanied by **Corin Pratt**, Project scientist for the July survey. Dr **Dick Shaw**, senior entomologist and invasives coordinator, continued to provide expertise and support for the project in the UK as required. UK Centre Director, Dr **Sean Murphy** provided managerial backstopping support in administrative negotiations.

CABI-India

Dr Ravinder Khetarpal, Country Director (India) and **Lalit Saini**, General Manager helped to coordinate extensions to the collaborative initiative with ICAR and provided logistical and administrative support for the survey.

ICAR

Dr. T.P. Rajendran, Assistant Director General (Plant Protection), ICAR, responsible for authorizing survey and the new phase of collaborative project activities.

NBPGR

Dr. P. C. Agarwal, Head of Plant Quarantine Division managing staff associated with the project: **Dr. Kavita Gupta**, Senior entomologist, facilitated export process and identifications in India and responsible for cultures deposited at NBPGR.

DWFEM

Mrs Usha Lachungpa, Senior Research Officer at the DFEWM and point of contact for facilitating applications for survey and issue of permits following senior authorisation from the Chief Wildlife Warden (**Mr. N. T. Bhutia**) and Director of Research (**Mr. T. D. Rai**). Also met and discussed the project with range Officer **Mr. Ongden Lepcha** and newly recruited Assistant Conservators of Forest, **Ms. Smita Shilal** and **Ms. Karma Choden** who may take more active collaborative roles in the future.



Fig.1. Corin Pratt examines *Hedychium* stems in India

Collaboration -India

ICAR/NBPGR

Revisions were made to the overarching collaborative work plan (Phase III) between CABI and ICAR, which continues to include the *Hedygium* project activities under Component 2: Collaborative Research and Studies on the Biological Control of Invasive Plant Species and Indian Natural Enemies. In July 2011, the competent authority approved the survey activities and notified the National Biodiversity Authority as required. A project extension was subsequently approved until December 2011 and another extension letter was provided in January 2012 for ICAR approval, along with provisional work plans for the project to continue until December 2013 to better facilitate future continuation.

Export of insects previously prioritised for further study and deposited in the national collection were exported to the UK and any newly encountered species left with NBPGR staff for rearing and subsequent identification. Molecular samples in the form of FTA squashes were also exported to the UK.

Although the material transfer agreement now covers a number of prioritised species, the procedure for getting export approval of any new species still follows a strict protocol: duplicate sets of specimens must be collected/reared such that one is available for deposition and identification at IARI and one is held at NBPGR for verification at the time of export. Export itself can only be approved once the Export facilitation committee and DARE have given the go ahead to the IARI identifications. This process remains frustrating since it can often rely on successful rearing of immature phases of a species by NBPGR staff which is not always guaranteed.

DFEWM and KCC

New format permit forms were required for survey in Sikkim and the process was once again facilitated by Mrs. Usha Lachungpa. The permits were approved by the Chief Wildlife Warden and signed off by the Director of Forest (Research, Education and Extension) (see Appendix III for terms and conditions). A pre-survey meeting was held with Ms. Karma Choden Bhutia who had recently joined as Assistant Conservator of Forests (ACF) and Mr. Ongden Lepcha, Range officer, at the Gangtok headquarters to discuss the project progress and future needs. Ms Bhutia has an MSc in Entomology and was pursuing her PhD before the opportunity arose to join the DFEWM. As she is from South Sikkim and knows the area well it is anticipated that she could provide valuable support to the project in the future and join in the surveys to receive training.

A brief meeting was held with the head of the KCC and approval given to collections and survey in the Kanchenjunga National Park where some of the best natural populations are to be found.

Collaboration -New Zealand, molecular work

Following the approval for export of plant squashes at the end of 2010, twenty eight FTA card samples of *Hedychium* spp were sent to Gary Houliston, Landcare Research in March 2011 (see Annual report 2010) from various locations in Sikkim and including FTA samples from Hawaiian *Hedychium gardnerianum* (from Waikamoi Preserve, East Maui) and other *Hedychium* spp. sourced from UK nurseries (provenance unknown).

During the survey in July, fresh samples of *Hedychium* material were collected on FTA and sent on and more *Hedychium* squashes were made from the UK national collection and sent in November 2011 to provide a larger sample size of material from the introduced and native ranges. Material was also requested from South Africa at the time of the biocontrol Symposium and FTA cards and protocol were sent to our contact in the Azores, Dr Mónica Moura, Assistant Professor and Curator of the Azorean Flora DNA Bank (Dec 2011) for collections there.

Molecular results

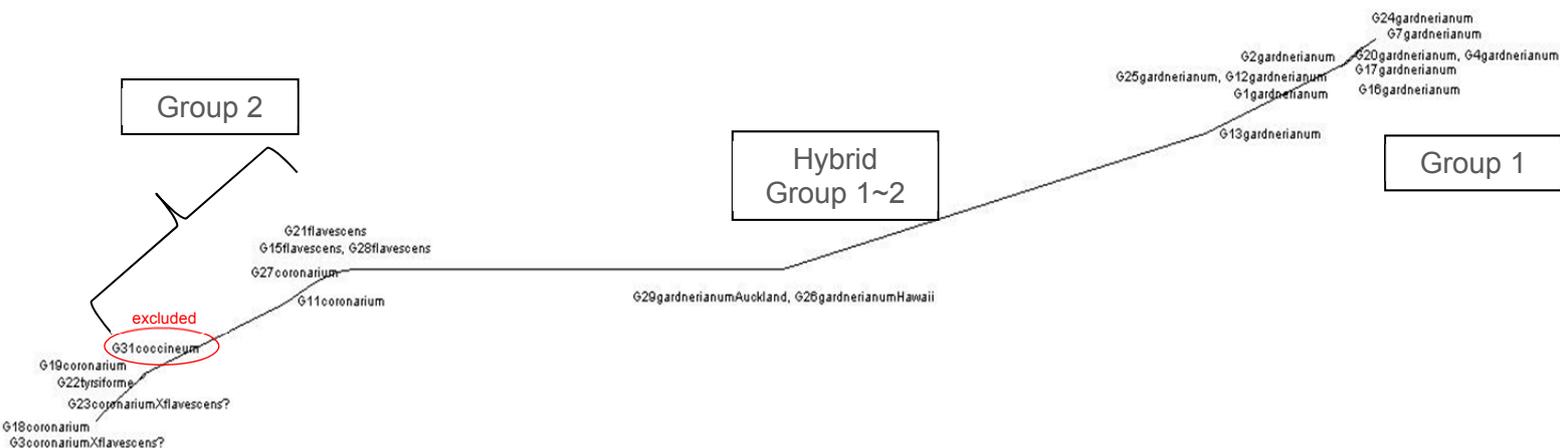


Fig.2. Schematic representation of the molecular sequencing of select groupings of *Hedychium* samples (Courtesy of G. Houliston, Landcare Research)

Despite a small sample size for the “naturalised” *Hedychium*, the molecular fingerprinting results throw up some interesting preliminary results; **Group 1**-the *H.*

gardnerianum from India falls into a good grouping (all identical ITS sequences: G1, G4, G7, G12, G13, G16, G17, G20, G24); **Group 2** although difficult to tell apart genetically, *H. flavescens* / *H. coronarium* / *H. thyrsiforme* also form a group. Rather surprisingly however, the two “invasive” samples (from NZ and Hawaii), appear to be hybrids between **groups 1 and 2**:

H. “gardnerianum” from NZ and Hawaii is heterozygous¹ at three base positions –a diagnostic for *H. gardnerianum* from India and group 2. In group 2, all are the same except for some heterozygous base positions at non-informative sites (G27, G11, G18, G19, G23, G3, G22). *H. flavescens* (G15, G21, G28) only differs from the others by one consistent heterozygosity at a single site (i.e. these are all incredibly similar). These commonalities indicate possible hybridisation between the two main groups. This assumption is based on one gene region only however and since sample size was limited for the “introduced” group, further samples from the invasive ranges will need to be sequenced to confirm this. Other samples including *H. coccineum* were all very different from the rest, but still *Hedychium*.

The Bishop Museum’s on-line resource of collections provides some information on *Hedychium gardnerianum* plants, but no confirmed source of introduction, within the Hawaiian Islands. A specimen from 1930 collected by A.F. Judd (Fig. 3) includes the note “*Hedychium* ...probably a hybrid, from Malay States)”. Judd also collected a specimen that has been listed *under H. gardnerianum* in 1937, so these plants, whatever their origin, were becoming common enough to gain the notice of collectors during the 1930’s. Further samples from the Azores, Hawaii and South Africa have been requested of contacts and should be forthcoming in 2012. Furthermore, Gary Houlston has indicated that



Fig.3. Herbarium voucher from Hawaii

checking material with a chloroplast marker to try to identify the maternal parent, and to check if the cross is consistent in one direction, may provide clues as to which

¹ Zygosity refers to the similarities of alleles, where alleles are one of two or more forms of a gene or a genetic locus (generally a group of genes) for a trait in an organism. If both alleles are the same, the organism is homozygous for the trait. If both alleles are different, the organism is heterozygous for that trait.

theory to chase. This parallel research is increasingly important as the molecular make-up of the target weed and any inherent hybridisation will have implications on agent selection and specificity requirements.

Southeast Asia is thought to be the centre of present Zingiberaceae distribution and species diversity. Fossil Zingiberaceae have been recorded in strata of the late Cretaceous and early Tertiary from Europe, North America and India. "The family was probably common to very early Laurasia and West Gondwanaland" (Raven & Axelrod, 1974). As the climate of Europe and North America became cooler, the Zingiberaceae gradually disappeared, but in Southeast Asia, which was less influenced by glaciation, the Zingiberaceae continued to develop (Telin, 1994).

The traditional taxonomy of *Hedychium* spp. was largely based on morphology such as the bracts arrangement, number of flowers per bract and petal colour etc, however in recent years phylogenetic characterisation carried out with many Chinese species has shed further light on relationships using SRAP (sequence-related amplified polymorphism) markers. A number of key papers have been published in Chinese looking at the role of phylogenetic relationships in parental selection. There are 29 species distributed in the tropical and sub-tropical regions of China and genus is well known for its medicinal, culinary and horticultural attributes (Gao *et al.*, 2008).

Hedychium spp. continue to pose taxonomic and typification problems. The research into the molecular phylogenetics of *Hedychium* species is fast evolving and Hu & Lui (2010) corroborated the work of

Tom Wood (unpublished-Pers. Com.) showing that the Chinese species *H.*



Fig.4. *Hedychium* species in Madeira courtesy of A. Gaunt (FERA)



Fig.5. An illustration of *Hedychium speciosum* in Wallich's *Plantae Asiaticae rariorae* of 1832

bijiangense is identical to *H. gardnerianum*. In addition, the epithet *H. gardnerianum* (Sheppard ex J. B. Ker Gawler, Bot. Reg. 9: t. 774 (1823)) which is considered to be valid and synonymous with the earlier *H. speciosum* (N. Wallich, Flora indica 1: 13 (1820)) may no longer stand. Wallich's *Hedychium speciosum* dates from 1820 in Roxburgh's Flora indica (<http://www.botanicus.org/page/784350>) and so one would assume that as Sheppard's description of the species in "Hort. Liverpool" was made three years later, *H. speciosum* should take precedence, over *H. gardnerianum* according to the rules of priority. The relative merit of a nomenclatural change would need to be established however.

More on this will potentially be published in the journal *Taxon* in the next year or so by Tom Wood (Pers. Com.) and further information can be obtained at: http://www.users.globalnet.co.uk/~drc/hedychium_gardnerianum.htm

With over 100 horticultural varieties bred worldwide and interspecific crossing occurring in the field the confused taxonomy and nomenclature of *Hedychium* species is illustrated by the plant called *H. gardnerianum* in the Portugese archipelago of Madeira (right) which appears to be an entirely different *Hedychium* (e.g. *H. flavum* or a cross at the very least-A. Gaunt, Pers. Com.).

Collaboration- UK

Two visits were made in June and November to the collection held by Andrew Gaunt, the national curator of *Hedychium* species in Chichester, UK, both for propagation material and for FTA sampling.

<http://www.chichestergingers.co.uk/index.html>

A list of all species and cultivars held can be found in Appendix IV.



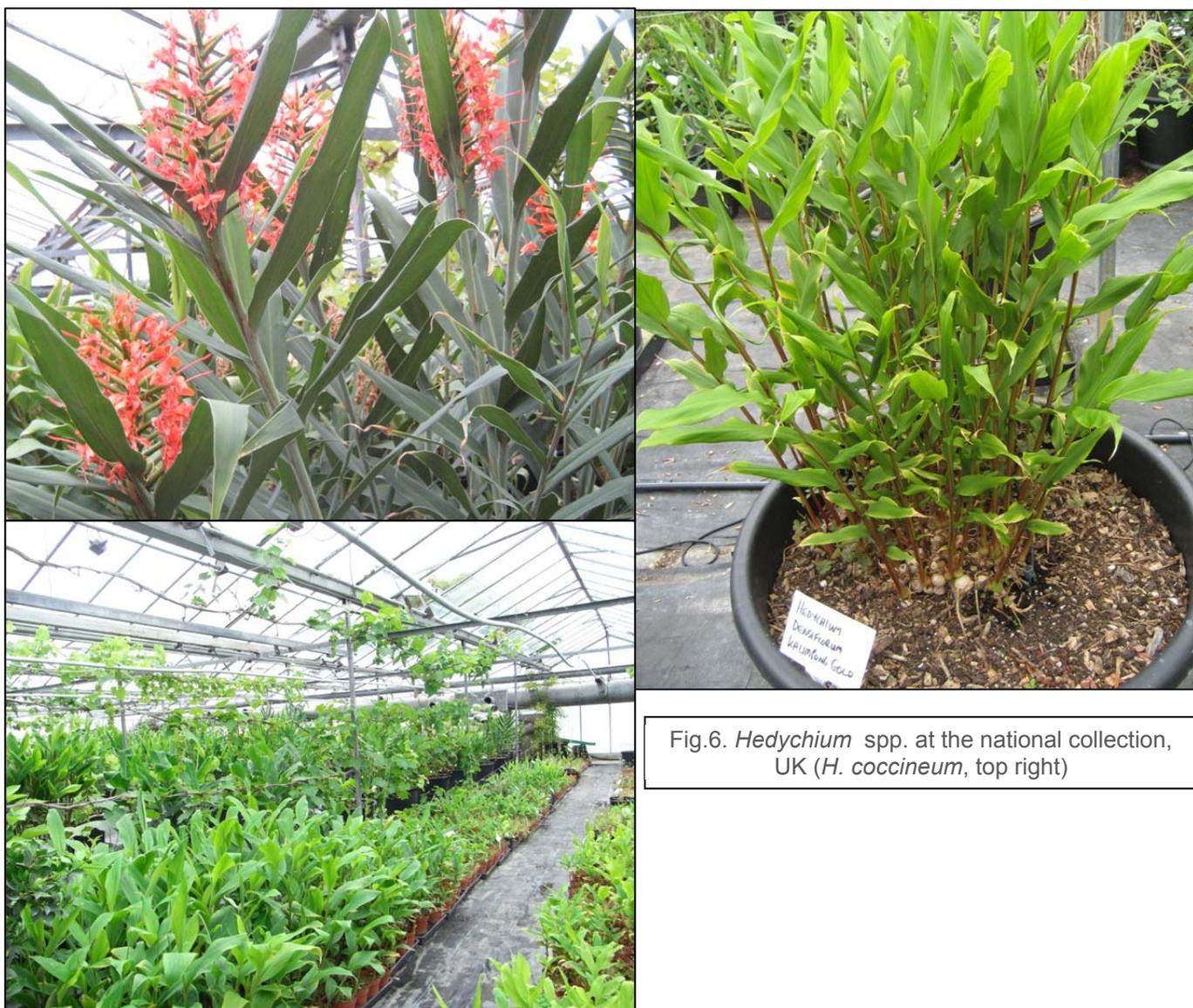


Fig.6. *Hedychium* spp. at the national collection, UK (*H. coccineum*, top right)

4.4 Outputs

Workshop and Presentations

The XIII International Symposium on Biological Control of Weeds (ISBCW 2011) was held on the Kohala Coast of Big Island, Waikoloa, Hawaii from September 11th-16th 2011. Djami Djeddour and Dick Shaw participated and the conference provided a good opportunity to meet sponsors and discuss the research.

The ISBCW is a quadrennial international gathering of scientists and managers working in biological control of weeds. It's a forum which has long provided a unique and important opportunity for international colleagues to share experiences, research and plan future collaborations. The meeting in Hawaii also provided a great opportunity to review a century of biocontrol in the Pacific and discuss emerging issues as well as past and present activities in invasive plant management across the globe.

Djami Djeddour presented an overview of the project so far (“Can wild gingers ever be tamed? The search for natural enemies hots up”) and facilitated a workshop on Wild gingers. The workshop was a chance for anyone with an interest in wild gingers to find out more about the research to date and how it



Fig.7. Djami Djeddour presenting at the XIII ISBVW in Hawaii

could be tailored to meet the needs of more stakeholders. Identifying potential opportunities to grow the consortium was at the heart of discussions and representatives from Hawaii’s Department of Land and Natural Resources, The Nature conservancy, Pacific Cooperative Studies Unit coordinating group on alien spp. and Department of Agriculture as well as scientists from Landcare Research New Zealand and Agricultural Research Council in South Africa (PPRI) attended to provide their insight into the spread of the weeds, public perceptions of the problem and offer advice on likely test plant list requirements, particularly in the light of possible conflicts of interest a biological release may face from the public and horticultural trade in Hawaii. The general consensus was that in areas of dense monocultures, chemical and mechanical control are neither feasible nor environmentally sound and that in Hawaii management is largely confined to outlier populations to try to prevent further recruitment and spread. It was agreed that public awareness campaigns and highlighting the negative impacts that these plants have on all the Hawaiian Islands should be a concerted mission and pre-emptive strategy to any biocontrol release. Details of the project were forwarded to all those in attendance to take forward to potential sponsors. Further discussions were held about the test plant list for Hawaii with Neil Reimer from the Hawaii Department of Agriculture and Tracy Johnson from USDA but a definitive list has yet to be agreed.

Promotion

- A promotional flyer (below) was produced to take to Hawaii and to use for general promotion at conferences and meetings and awareness raising among potential stakeholders.





Wild ginger
– *Hedychium* species

what is wild ginger?

Popular, fragrant and showy herbs growing from fleshy rhizomes, wild gingers (*Hedychium* spp.) belong to the Zingiberaceae family (which also includes root ginger, turmeric and cardamom) and were introduced into Western civilisation in the 1800s as exciting new ornamentals from tropical Asia and the Himalayas. Three species in particular, namely *Hedychium gardnerianum* (Kahili ginger), *H. flavescens* (yellow ginger) and *H. coronarium* (white ginger) have escaped cultivation to become troublesome colonisers of native forests in Hawaii, New Zealand, Australia, South Africa, Brazil and across many Pacific islands. Within the EU, the Macaronesian archipelagos of the Azores and Madeira (Portugal), the Canaries (Spain) and La Réunion (France) are also invaded. *H. gardnerianum* has been nominated as one of the world's 100 worst invaders by the Invasive Species Specialist Group of the World Conservation Union.

why is it a problem?

The biogeographical isolation which characterises so many Oceanic islands makes them especially susceptible to biological invasions and it is on these, with their unique, endemic and vulnerable species, that invasive *Hedychium* species pose the greatest threat. Introduced to Hawaii sometime before 1940, Kahili ginger was first collected in housing areas in Hawaii Volcanoes National Park (HVN) in 1943 but by the mid-1990s, populations had become established in the surrounds at high densities. Today it has naturalised on all islands in Hawaii, forming highly shade-tolerant, dense monotypic stands in mesic sites along streams and under closed rainforest canopies. Colonies cover entire hillsides with dense rhizomes crowding out other plants and preventing regeneration. Succession and bird dispersal of the bright red seeds spreading invasions further. The smothering of indigenous vegetation can alter the structure and function of whole ecosystems, often displacing rare and specialised communities.



an effective and sustainable solution

Classical biological control has the potential to offer effective, economic and sustainable control of this invasive weed. It involves the deliberate release of specialist natural enemies – mainly insects and fungi – from the weed's native range. The aim is to reduce the abundance of a weed in its introduced range below an ecological or economic threshold. Classical biological control can be a **highly effective and cost-efficient** approach to control invasive weeds especially those in water. Biological control of weeds, has been implemented for over a century all over the world on more than 1,400 occasions.

prospects for biological control

With funding from a consortium of sponsors from New Zealand and Hawaii, surveys in kahili ginger's native range in the East Indian Himalayan foothills were initiated in 2007; subsequent annual surveys have allowed consolidation of the inventory of natural enemies across the seasonal growth cycle of the plants and importantly, export of biological material has been secured through collaborations at government level in India. Surveys to Sikkim State in particular, where *H. gardnerianum* grows as a common understorey herb, revealed all stages to be subject to high herbivora as well as pathogenic pressure. A number of potential agents have been prioritised for study and these include a ubiquitous shoot mining Chironomid fly found to affect over 60% of plants and causing "dead heart" symptoms, aborted flowering and plant stunting. Other possibilities include a striking weevil damaging *Hedychium* seeds, leaves and stems in the field, as well as a host of leaf feeding Lepidoptera and a *Rucicola* rust sp. on kahili seedlings which is rarely seen. Surveys in 2011 and approval of a test plant list for New Zealand mean that host range testing has been initiated and the test plant list for Hawaii is currently under review.

what CABI can do:

Having offices in India, and a long history of collaboration with governmental institutes within both countries, CABI is well placed to carry out research on the biological control of invasive *Hedychium* species. We can:

- Conduct field surveys to collect the natural enemies described, and search for other potential agents;
- Import natural enemies and biological material from India using established collaborations;
- Compile a country-specific test plant list for the screening of potential biocontrol agents;
- Evaluate the host specificity of both plant pathogens and invertebrate biocontrol agents.

This is an opportune time for stakeholders to join the established consortium – collaborating institutes are in place, export permissions approved and 2011 will see the initiation of host range tests with prioritised agents. Molecular characterisation of various *Hedychium* species is ongoing in New Zealand to compare the Indian species with invasive forms and may lend further geographic focus to future surveys. International involvement in these early stages would be of long term benefit if the threats to unique ecosystems are to be addressed. We are now looking for partners and funding to tackle this important weed.

get involved

If you are interested or would like to know more, please contact: Djami Djeddour (d.djeddour@cabi.org). For other weed biological control projects CABI works on, please visit our webpage at www.cabi.org

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KNOWLEDGE FOR LIFE

Fig.8. Promotional flyer for the project

- A meeting was held in November 2011 with Assistant Professor Mónica Moura, Curator of the Azorean Flora DNA Bank @ AZB, working in the Department of Biology, University of the Azores whilst she was on sabbatical at the Natural History Museum to investigate potential funding avenues and Azorean PhD opportunities linked with the project .
- Discussions with Andrew McConnachie (ARC-PPRI) during and subsequent to the Hawaii Symposium highlighted the problem of *H. gardnerianum* in the province of KwaZulu-Natal, South Africa. As a result, a request for funding has been submitted to Working for Water (PPRI's national & main project funder) for a contribution to the consortium over a 3 year period. A decision is expected in March 2012.



5. Surveys

5.1 India

The sites previously established as being the most consistent in terms of natural enemy pressure and the most natural were once again visited in 2011, across North, South, East and West Sikkim. A total of twelve sites were sampled over the ten day survey period, devoting particular attention on repeat visits to the protected Kanchenjunga National Park and the Himalayan Zoological Park. Details are listed in Appendix I.

Seeds and young seedlings were collected direct from parent plants (Fig. 10) at one site where the seeds had germinated before detaching from the parent plant. *Hedychium gardnerianum* plants were found as seedlings, fruiting/seeding plants and any intermediate stages in between (Fig. 9). As the survey coincided with the monsoon, the forests were lush and many species were found in flower which had not been so previously (Figs. 11 & 12).



Fig.9. *H. gardnerianum* plants at different stages



Fig.10. "Viviparous" *H. gardnerianum*, seeds germinating on parent plant



Fig.11. *H. coccineum* (poss hybrid)



Fig.12. Clump forming *Cautleya spicata* plants (Zingiberaceae)

Night and day temperatures were recorded in Gangtok (18°C-25°C) in order to inform the settings for CE rooms for subsequent host range studies.

5.2 Hawaii

A mid symposium tour of Hawai'i Volcanoes National Park enabled us to see the *H. gardnerianum* infestations first hand and subsequent trips to the north of the Island and Akaka Falls State Park provided endless views of *H. coronarium* and *H. flavescens* monocultures.



Fig.13. Park ranger points to *H. gardnerianum* stands in Hawaii Volcanoes National Park

5.3 Plant propagation

Seeds from New Zealand were received in July and a good stock of the representative test plants is now being grown in CABI's propagation glasshouse. With the exception of *Alpinia purpurata* (purchased from French nurseries), all plants are relatively easy to source from the UK and *Hedychium* plants and rhizomes available all year round from the National collection.

As the test plant list for Hawaii has not been agreed yet, plant sourcing has been restricted to the New Zealand needs, although some overlap is expected. Seeds from Hawaii are to be sent in 2012 but in the meantime, propagation from rhizome division for the Hawaiian *H. gardnerianum* has worked well.

The *Hedychium* plants maintained in the NBPGR containment facilities for rearing purposes did not fare well and more rhizome and seed material will need to be collected for propagation in India in 2012.



6. Natural enemies

The following section provides information on the fungal pathogens and arthropod natural enemies collected from *H. gardnerianum* in 2011. Insect/fungal specimens were once again sent for formal identifications by respective experts in the Natural History Museum, Bielefeld University and at CABI E-UK.

In addition to the species described below, a number of miscellaneous insect species were also found which have not been detailed. These include a leafminer on *H. gardnerianum*, found feeding in a seedling leaf but which died in transit and leaf miners on *H. coronarium* deposited at NBPGR for rearing.

6.1 Fungal natural enemies

Fungal natural enemies continued to be under represented on *Hedychium* hosts despite the perpetually damp and moist conditions afforded by the monsoon rains. The rust pathogen on *H. gardnerianum* seedlings was observed at the same site as previously found and formally identified.

Rust Fungus : *Puccinia roscoeae* Barclay
[Basidiomycota: Teliomycetes:

Uredinales: Pucciniaceae]

Reference: Paul Sydow & Hans Sydow (1904) *Monographia Uredinearum seu specierum omnium ad hunc usque diem descriptio et adumbratio systematica: 1. The genus Puccinia* (Monograph of the

Uredinales: all species currently known, described and systematically listed) 4 vol. pp. 1 – 972.

“Soridis teleutosporiferis hypophyllis, maculis pallidis insidentibus, minutis, subconfluentibus; uredosporis immixtis ovatis, sparse echinulatis, aurantiacis, 28=18 ; teleutosporis oblongis, apice rotundatis v. lenifer acutiusculis, incrassatis, medio leniter incrassatis, basi plerumque rotundatis, levibus, brunneis, ca. 32=15-17; pedicello brevi.”

Based on morphology, the rust on *H. densiflorum* (?) and *H. gardnerianum* seedlings has been identified as *Puccinia roscoeae*, described from leaves of *Roscoea alpina* (Zingiberaceae) from Shimla (Western Himalayas). (Descr. List Uredineae Simla II: 237 (1889).

This rust has also been reported from a number of Zingiberaceae hosts (Farr & Rossman, 2012): *Camptandra yunnanensis* Loes., a synonym of *Caulokaempferia yunnanensis* (Tai, 1947), *Cautleya cathcartii* from China and the Himalayas, *Cautleya lutea* from India, *Globba hookeri*, *Globba clarkei* Bak. (Sydow & Mitter, 1933) and *G. racemosa* from India and Nepal respectively, on *Hedychium acuminatum* and *H. spicatum* from India and the Himalayas respectively. Other *Roscoea* species are also reported hosts: *Roscoea auriculata*, China; Himalayas, *Roscoea intermedia*, Yunnan, China; *R. purpurea* from Nepal, China and Himalayas (Sydow, Mitter & Tandon, 1937); *Roscoea tibetica*, China; *Roscoea yunnanensi*,: China, Himalayas.



Fig.14. *P. roscoeae* uredinia on *H. gardnerianum* seedling

R. alpina, like other species of *Roscoea*, grows in cold mountainous regions and it is likely that this rust's wide reported host range will be narrowed through specialization or specificity of different pathotypes on certain genera and maybe even species as is seen with a number of other *Puccinia* species.

Attempts to inoculate seedlings from New Zealand and India with the very limited spore material were unsuccessful but it is possible that viability of spores decreases the longer the leaves are pressed. Priority will be given to collecting as many live rusted plants as possible for export to try to establish specificity, virulence and infection parameters.

6.2 Arthropod natural enemies

DIPTERA

CABI Ref Hed11-1001/1022 (As Hed10-1035-See identification in 2010 report by Dr M. Von Tschirnhaus, Bielefeld University, Germany)

Identification

Merochlorops dimorphus Cherian 1991 (Chloropidae: Oscinellinae)



Fig.15. Mature larva of *M. dimorphus*



Fig.16. Pupa of *M. dimorphus* in *H. gardnerianum* shoot tip



Fig.17. Potential exit hole



Fig.18. Adult *M. dimorphus* in pop-up rearing cage

Habit/host range

This fly continued to be ubiquitous on *H. gardnerianum* plants and was not found on other *Hedychium* species. The typical stunting symptoms and flower aborting were again observed (Fig. 19). Most were collected as larvae (young and mature) in stems for export to the UK and no adults were seen in the field. As adults emerged on the road, a makeshift rearing cage was set-up with *H. gardnerianum* young plant as host for



Fig.19. Stunted *H. gardnerianum* plant with *M. dimorphus* in tip

oviposition but no egg laying or mating was observed.

Whilst a number of shoot mining Chloropid flies have been investigated for biological control of weeds (e.g. *Platycephala planifrons* against *Phragmites australis*, Häfliger *et al*, 2005) many Chloropids are Inquilines and only feed saprophagously on shoots already damaged by other herbivores. No traces of other herbivores have been found in the stems but Sciarid flies (*Prosciara* species) have been found to emerge from “dead heart” stems and



Fig.20. *M. dimorphus* larva moving into cut tip

determining that *Merochlorops dimorphus* is the causal agent is important. To this end, an on the road experiment was carried out using a mid- stage *M. dimorphus* larva, which was inserted into a fresh, cut stem of *H. gardnerianum* to investigate primary feeding, if any (Fig. 20). A leading hole was formed using a sterilised needle and the larva entered the shoot willingly and was sealed in with damp tissue paper and tape. A control stem was also set up and hole made to compare physical



Fig.21. *M. dimorphus* pupa in cut tip

damage symptoms after a comparable time period. After 12 days, the stems were carefully dissected.

The stem with larva was blackened and mushy inside with evidence of frass and the larva had pupated (Fig. 21). The pupa did not hatch however but the pre-emergent adult could be seen inside. The control stem had also turned black and mushy inside as the tissue had necrosed (Fig. 22)

This experiment will require tweaking and replication as it was carried out on the road rather opportunistically but the evidence of frass and further development of the larva bodes well.

Rearing

This fly is proving difficult to rear. Despite collecting 60-80 stunted stems for dissection once in the UK, adult emergence was once again frustratingly asynchronous such that a maximum of only 8-10 flies were ever exposed to mature and young *H. gardnerianum* plants from New



Fig.22. Control stem

Zealand and Hawaii in large and small cages with honey feeders. After a week of exposure to the plants, the flies were relocated onto fresh material and all plants exposed to the *Merochlorops* subsequently checked for signs of egg laying/larval feeding but none were found. Destructive examination of exposed plants after 4 weeks showed no evidence of mining or egg laying either. The pending issue of the invasive *H. gardnerianum* being a potential hybrid further complicates things and the possibility remains that the fly is too specific and will only attack the “pure” *H. gardnerianum* found in India. This also merits further investigation so seeds, plants/rhizomes from India will be collected in large numbers to test this theory further.

Some chloropid larvae move into the soil on hatching from eggs laid on the shoot base near the soil and enter shoot buds, hibernating close to the growing point to be lifted in spring. Little is known about the life history of *M. dimorphus* and further observations in the field across the season are required to ascertain life habit and facilitate rearing in quarantine.

It would also be worthwhile confirming whether the Sciarid flies are definitely secondary invaders, feeding on decayed plant material. For instance as with so many saprophagous chloropids, they may infest the plant with specific bacteria (passed from the mother to the egg, then invading the larval salivary glands and from there

with the mouth hooks into the plant tissue) which become their host food. The larval filter apparatus can be studied by Professor von Tschirnhaus for instance to see if it has the sieve for filtering the bacteria.

Biocontrol potential

Remains high.

Other Chloropidae-updated identifications

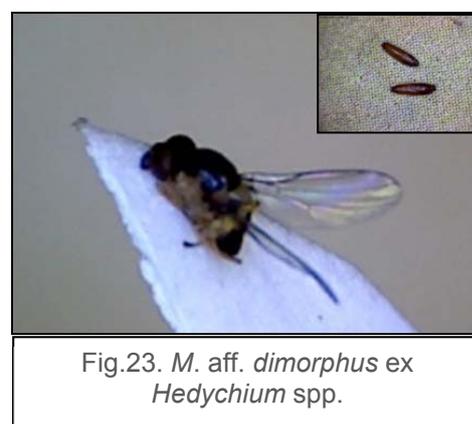
A number of tentative identifications covering a complex of gregarious Diptera were made by the Natural History Museum in late 2010 which were subsequently sent to the Chloropid expert, Dr. von Tschirnhaus, in Germany for confirmation. The following are updates and corrections to the 2010 report.

CABI Ref: Hed10-1036c ex *H. gardnerianum* (identified by Nigel Wyatt, NHM) and **Hed10-1027a ex *H. flavescens***

Identified in 2010 as *Chloropsina* sp. (Chloropinae : Chloropidae) these have subsequently been identified as ***Merochlorops* sp. n.1.(aff. (similar to) *dimorphus*)**

CABI Ref Hed09-143b previously tentatively identified as *Rhodesiella* sp.? collected from a *H. gardnerianum* shoot (as gregarious pupae), subsequently identified as ***Neoloxotaenia gracilis*** (de Meijere, 1908) Chloropinae.

The species identified from edible ginger, *Zingiber officinale* as *Thressa* sp. nr. *spuria* (Chloropinae) have since been confirmed as *Thressa* sp. but belonging to one of the three species : *punctifer* de Meijere, *anderssoni* Narchuk and *apicalis* de Mejeire. The only keys available are in the Russian language however and since some *Thressa* species are sexually dimorphic both sexes would be needed to make accurate identifications.



LEPIDOPTERA

Identifications by Martin Honey (NHM)

CABI ref: Hed11-1031 and Hed11-1037

Camadena acutipennis (Moore 1888) and *Camadena vespertilionis* (Moore 1888),
Thyrididae,



Fig.25. *C. acutipennis* ex *H. gardnerianum*



Fig.26. *C. vespertilionis* ex *H. coronarium*

As reported in the 2010 annual report, little is known about the biology of these picture wing leaf moths and Thyridid specimens are rare in museum collections. They alone make up the Thyridoidea superfamily, which is sometimes included in the Pyraloidea (although not supported by cladistic analysis).

Camadena acutipennis is a repeat identification of Hed10-1057, and was again collected from *H. gardnerianum* in West Sikkim. *Camadena vespertilionis* is a new identification however and was collected from *H. coronarium*.

These are listed as synonyms in the NHM LepIndex <http://www.nhm.ac.uk/research-curation/research/projects/lepindex/search/index.dsm> but a note by Michael Shaffer, the authority on the superfamily, confirmed that they were in fact good species.

These similar looking leaf-folder moths (and their larvae) are fairly ubiquitous on *Hedychium* spp. and the characteristic folding of leaves has been observed on other Zingiberaceae hosts so the fact that there may be different species is of great interest as it may reveal a degree of specificity.

The folding pattern looks to differ slightly on the different host species (Figs. 28 & 30) with rounded cuts and straight cuts at the margins but these can be variable depending on larva number per leaf and leaf/larva size.



Fig.27. *C. acutipennis* larva on *H. gardnerianum*



Fig.28. *C. acutipennis* leaf folding on *H. gardnerianum*



Fig.29. *C. vespertilionis* larva on *H. coronarium*



Fig.30. *C. vespertilionis* leaf folding and emerged adult on *H. coronarium*

Potential

This ubiquitous folder may in fact be a complex more host-specific species within the *Camadena* genus and will be collected from as many hosts as possible for further identifications and to establish host range and specificity within the *Hedychium* genus.

Identification (CABI ref: Hed11-1023 & Hed11-1047) by Martin Honey, NHM

These specimens proved a challenge for the taxonomist to identify. Described as another species of the genus *Artona* (Zygaenidae: Procridinae), it is likely to be a close ally to *A. chorista* Jordan 1907, which itself may be a species complex, but it is in fact almost certainly an **undescribed species of Zygaenidae**, and could even be from the genera *Amuria* or *Pseudoamuria* or *Pseudoarbudas*. NHM taxonomists believe that the type series of *Artona chorista*



Fig.31. Undescribed Zygaenid moths ex *H. flavescens*/*H. coronarium*

represents more than one species. This is recognised as a difficult group; there are several undescribed species, none of which belong to real '*Artona*'. The latter is more or less restricted to many species with yellow spots or stripes whose larvae feed on Poaceae (bamboo etc.). The species with habitus similar to *Artona chorista* (as with this species) form a group related to *Amuria* and *Pseudoamuria*. Perhaps it is possible to assign most of them into these two genera. The larvae of most of these species feed on Zingiberaceae, Musaceae etc. The 2010 report detailed another Zygaenid, *Artona flavipuncta*, from *H. gardnerianum* and preliminary host range had revealed feeding on *A. zerumbet* in choice tests.

Larval host range

Larvae of this undescribed moth were found on *H. coronarium* (Ref: Hed11-1036) (Fig. 32) on the Darap road site and *H. flavescens* (?) (Ref: Hed11-1047) (Fig. 31) in the Himalayan Zoological Park (HZP) causing extensive damage and skeletonising whole leaves. As the DNA work revealed however, identifications of the *H. flavescens/ coronarium* group can be quite difficult because they are very similar and in the HZP, a number of *H. gardnerianum*, *H. flavescens* and *H. coronarium* cohabit so hybridisation or misidentification of host could be a possibility. The larvae were not found on adjacent *H. gardnerianum* however and these plants are unmistakable. In addition to field host range observations, multiple choice tests were carried out in the lab on larvae collected from the HZP.



Fig.32. Gregarious feeding larvae on *H. coronarium*



Fig.33. Larvae on *H. flavescens* (?) in field

Single choice tests (see Appendix II)

Single choice tests carried out on the road with larvae ex *H. coronarium* (Ref. Hed-1036) and given a choice of *H. coronarium* and *H. gardnerianum* showed a preference for *H. coronarium* after 4 days of testing.

More extensive choice tests were done with Hed11-1047 larvae ex. *H. flavescens* (?) once in the UK with a view to sustaining tests against as many test plants as possible until the larvae pupated and then setting up all emerging adults in choice arenas for oviposition and rearing. No choice tests were not carried out so as to maximise numbers of adults for rearing but unfortunately no egg laying was achieved and several individuals were parasitised, further impacting on population available for studies (see Hymenoptera section). Also due to limited numbers of larvae available to test and wanting to maximise the preliminary assessment of host range of larvae before pupation, larvae pre-exposed to host choices for a week were reused in new tests without starvation. This pseudoreplication is clearly not ideal and future host range studies with greater numbers of young larvae will hopefully be able to follow individuals through to pupation in sustained single choice tests, in parallel with no choice larval tests and the multiple choice oviposition preferences of adults once hatched.

Single larvae were placed in small petri dishes with a choice of cut leaf from the test plant list (*Canna indica*, *Musa acuminata*, *Zingiber zerumbet*, *Alpinia zerumbet*, *Cucurma longa* and *H. gardnerianum* ex NZ) with *H. flavescens* as control in each case. Leaf pieces were replaced when either choice leaf material was completely or nearly all consumed and a score of 0, t, 1, 2, 3,4 or 5 allocated depending on extent of feeding where t=trace feeding and given a value of 0.5 for averaging purposes.

Results (Appendix II)

With the exception of *Alpinia zerumbet* where preference appeared to be equal to that for the control, the larvae showed a preference for their field host over other species. Ten adults emerged from pupae in total over a 2 week period and were set up in a multiple choice oviposition cage but no mating or egg laying was observed and so rearing was unsuccessful.

These tests are by no means definitive and represent a preliminary investigation into host range; larval feeding in the latter stages may have been influenced by imminent pupation and the feeding observed on the non-hosts needs to be tested in a no choice scenario to see if it will sustain development and if adults will oviposit on them in choice tests.

Potential

Since the *Artona* genus may be a species complex and there appear to be different species on the different *Hedychium* hosts, it is likely that some degree of specificity exists, as has been indicated in the literature. These gregarious feeders cause substantial foliar damage to their hosts despite parasitism (Hymenoptera) and warrant comprehensive investigation.

Other Lepidoptera-potential unknown

Ref Hed11-1011-Unidentified Lepidoptera larva (Fig. 34), likely Tortricid, feeding well on *H. gardnerianum* and producing web on leaf as seemed close to pupation. Found to be parasitized (see Hymenoptera).



Fig.34. Green larva found feeding on *H. gardnerianum*-pre-pupal

HYMENOPTERA

Ref: Hed11-1011a parasitoid of Hed11-1011 lepidoptera

(identified by Gavin Broad of NHM)

Clinocentrus excubitor (Haliday) (Braconidae: Rogadinae).

As this is almost certainly a species complex, this will most probably not be the true *excubitor*. This species was described from Western Europe, and this Indian specimen is more extensively red. However, it looks very similar structurally and *C. excubitor* has been recorded, apparently reliably, from Vietnam. *Clinocentrus* are usually parasitoids of Tortricidae, Pyralidae and Crambidae, groups with concealed larvae, with *C. excubitor* having been reared, probably reliably, from some tortricids (*Graphitarmata margarotana* and *Eucosmomorpha*). As with all rogadines, they distinctively mummify the host larva, in *Clinocentrus*, when the host is a prepupa. Each species only attacks a narrow range of closely related host species, and the 'pupa' it was reared from is actually the mummified skin of the host caterpillar.



Fig.35. Parasitoid
Clinocentrus excubitor

Hed11-1047a (identified by G. Broad)

This microgastrine braconid seems to be **an undescribed species of *Dolichogenidea***. These, like other microgastrines, tend to be very host specific. There don't seem to be any Oriental species of *Dolichogenidea* that have been reared from procradines, although there are some species of other genera (*Protapanteles* and *Microgaster*). This Indian species has an unusually short ovipositor, like *Dolichogenidea aethiopicus* from Africa, which has also been reared from a zygaenid. However, *D. aethiopicus* is rather different, as well as being on the wrong continent.



Fig.36. Undescribed
Dolichogenidea parasitoid
ex undescribed Zygaenid
lepidopteran

COLEOPTERA

CABI Ref: Hed11- 1015

Identification

Tetratopus sp. (Curculionoidea, Dryophthoridae, Rhynchophorinae, Sphenophorini)

This weevil was found on *H. gardnerianum*, *H. flavescens* and *H. coronarium* in the field at the Himalayan Zoological Park as well as one individual on another unidentified Zingiberaceae (*Cautleya* sp.?) near an *H. gardnerianum* stand.

Approximately 20 adults were exported to the UK and set up in cages in multiple choice tests in order to try to establish host range and egg laying. Weevils were allowed to feed for a week before moving remaining individuals into new multiple choice cages.

Multiple choice tests

Weevils were often seen aggregated around the exposed rhizomes of test plants (Fig. 37) but no eggs were laid and the culture died out after a month.

Results (Appendix II)

This weevil appears to have a fairly broad host range within the Zingiberaceae. Whilst a great deal more feeding was observed on *Hedychium* species and the adults have not been observed on Cardamom but are consistently found associated with *Hedychium* spp. in the field, heavy damage was observed in the lab on *Zingiber zerumbet*, *Alpinia zerumbet* (variegata) and *Cucurma longa* (turmeric). No feeding or minor probing only was observed on *Musa acuminata* (banana) and *Canna indica* respectively.



Fig.37. *Tetratopus* sp. feeding on *H. flavescens* rhizomes



Fig.38. *Tetratopus* sp. feeding on *Alpinia zerumbet*



Fig.39. *Tetratopus* damage on *H.gardnerianum* from New Zealand (left) and Hawaii (right)

Potential

Host range seems to be quite broad but further studies are needed to establish oviposition preferences of adults and no choice survival. Field observations suggest oligophagy but successful rearing of these weevils is key to progress. Early field surveys may help reveal egg laying strategy.

Other Coleoptera-potential unknown

The black weevil with the characteristic rostrum found feeding on *H. coronarium* and *H. gardnerianum* in 2009 (Ref Hed10-1040) was identified by Richard Thompson of NHM as ***Baris* sp. indet.**, - this species was not represented in the NHM collection (Curculionidae, Baridinae) so nothing is known about its biology or host range.



Fig.40. *Baris* sp. indet.

A similar weevil but with yellow spotting on its abdomen (ref: Hed 11-1021) was found on *H. coronarium* in 2011 in the Himalayan Zoological Park. This weevil has been identified as ***Baris bispilota*** Hope (Curculionidae, Baridinae) with a distribution range of Sikkim and Bengal but no information could be provided about its host range.



Fig.41. *Baris bispilota*

Ref: Hed11-1002

This single orange flea beetle was found on the first day of survey feeding on *H. gardnerianum* and continued to feed well in a tube on this host until its death. Roger Booth of NHM identified it as ***Sphaeroderma* sp.** (Coleoptera, Chrysomelidae, Alticinae) but could not match it to any named specimens in the collection so the identification could not be taken further.



Fig.42. *Sphaeroderma* sp.
flea beetle on *H. gardnerianum*



7. Future Research

In early 2012, Landcare Research and TNCH confirmed funding for the 5th phase of the project and at the time of writing, confirmation of further funds from South Africa's ARC-PPRI was still pending. The research in 2012 will be focused on host range testing and establishing the potential and specificity of insects and pathogens. Two surveys will be carefully planned to maximise collection of all priority species and the recruitment of a semi-permanent entomologist in Sikkim will be investigated to allow closer monitoring and eventual regular shipment of agents. The potential hybridisation issue surrounding the *H. gardnerianum* from the invasive ranges needs elucidation as it may impact on host specificity trials. Additional invasive range material will be sourced for study.

Specific components of this phase will consist of:

- Renewed collaboration/workplans with NBPGR/Sikkim's DFEWM
- Hawaiian test plant list approval and shipment, sourcing and propagation of species
- Two surveys to Sikkim and export of agents/host material (June and September/October)
- Identification, rearing and culturing of agents in India/UK
- Research into lifecycles/infection parameters and host specificity of selected agents (India/UK)
- Comprehensive host range testing of at least 2 agents
- Project promotion and follow up of opportunities for additional consortium funding at appropriate meetings
- Further use of molecular diagnostics, where possible, to help inform/narrow geographical focus of surveys
- Annual report compilation



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9. Appendices

Appendix I – Site details

Appendix II – Host range

Appendix III – Survey permit T&C

Appendix IV – List of *Hedychium* spp. and cultivars held in National collection, UK

APPENDIX I

SITES

Date	Site	Altitude (m)	Detail
14.07.11 (14-1)	Below Temi village		<i>H. coccineum</i> plants growing at edge of road
14.07.11 (14-2)	State Biodiversity park	1983	Large 40m stands of H.g roadside, planted and forest edge. Rust on seedlings and chloropid fly present
15.07.11 (15-1)	Himalayan Zoological Park (nr. Gangtok)	1900	H. flav, H. cor and H. gar populations; stunted/aborted tips collected, chloropid larvae, <i>Tetratopus</i> weevil and lep folder damage. Leaf miners on Hcor
16.07.11 (16-1)	Amlatin village Damthang to Tendong Hill	2130	H. gar population lower than usual. Some chloropid stunting, other vegetation regenerating
16.07.11 (16-2)	Tarku – Ravangla road	850	Pops. of planted H. cor and H.gar near Cardamom; <i>Tetratopus</i> weevils and brown and orange chrysomelid damage
17.07.11 (17-1)	Chemchey	2100	H. gar planted roadside, chloropid larvae+ pupae, flowering plants
18.07.11 (18-1)	KNP, Yuksam Kanchenjunga national Park	2055-2200	H. gar natural-collected stems with chloropid pupae and larvae + <i>Camadena</i> sp. on Hg
19.07.11 (19-1)	Yuksam road, Chinchia village	-	Ginger crop grown under corn. Newly planted due to landslide, no nat. enemies of interest
19.07.11 (19-2)	Pelling-Darap road		H. cor planted; <i>Camadena</i> leaf folding lep and gregarious Zygaenid
19.07.11 (19-3)	Darap road	1850	H. gar planted, leaf folder lep
19.07.11 (19-4)	Pelling-Darap road	1600	H. gar roadside, <i>Tetratopus</i> weevil on other Zingiberaceae/ <i>Cautleya</i> ?
20.07.11 (20-1)	KNP, Yuksam Kanchenjunga national Park	2055-2200	Leaf folder <i>Camadena</i> on Hgar. Collected many stems.
21.07.11 (21-1)	State Biodiversity park	1983	Collected 1 small rusted seedling and seeds for propagation
23.07.11 (23-1)	Himalayan Zoological Park (nr. Gangtok)	1900	<i>Tetratopus</i> weevil, gregarious (Zygaenid) on H. flav.

APPENDIX II-Host Range Tests

Single Choice Host range - Undescribed Zyganidae (2/8/11)

CABI ref Hed11-1047

Day	Rep	Canna indica	H.flav	Turmeric	Hf	Banana	Hf
1	1	0	3	0.5	1	0	2
1	2	0	0.5	0	2	0	2
1	3	0	4.5	0	1	0	5
1	4	0	5	0	3	0	5
1	5	0	2	0	4.5	0	1
1	6	0	3			0	1
1	7	0	3.5			0	5
3	1	1	4	4	4	0	5
3	2	0	5	0	4	0	2
3	3	0.5	3	3	4	0	5
3	4	0	5	3	4	0	5
3	5	0	4	3	5	0	1
3	6	0	4			0	5
3	7	0	5			0	1
6	1	1	1	4	3	0	5
6	2	0	0	0	1	0	4
6	3	0	5	2	1	0	0
6	4	0	4	3	1	0	5
6	5	0	2	4	5	0	4
6	6	0	2			0	3
6	7	4	4			1	5
avg day 3		0.2	4.3	2.6	4.2	0.0	3.4

Red numbers indicate pupation

Single Choice Host range - Undescribed Zyganidae (8.8.11)

Day	Rep	Zingiber zerumber (var)	H.flav	HG nz	Hf	Alpinia zerumbet	Hf
1	1	0	0.5	0	0	0	4
1	2	0.5	3	0	0	3	0
1	3	0	1	0	0	2	0.5
1	4	1	5	0.5	0.5	0	0
1	5	0	0	0	0	0.5	2
1	6	0	0.5	0	2	0	0
1	7	0	0	0	3	0	2
3	1	0.5	3	0	3	3	4
3	2	3	3	0	3	5	4
3	3	0.5	4	0.5	2	5	3
3	4	4	5	0	5		
3	5	0	5			3	2
3	6	0	4	0	4	1	2
3	7	0	0			0	2
7	1	2	3	2	4	0	0
7	2			3	5	0	0
7	3	0	2	3	4	0	0
7	4	0	0	2	3		
7	5	5	5			0	0
7	6	5	5	0	1	4	3
7	7					0	0
	avg day 3	1.1	3.4	0.1	3.4	2.8	2.8

Tetratopus sp. Host range tests

Multiple choice- 20 adults			
Date	Test plant	Reps	Observation
28.7.11	H.gardnerianum ex Hawaii	3	Feeding damage to stem, leaves and rhizomes , deep holes and plants wilted
	Cucurma longa	1	>30 feeding holes in stems, trace feeding on leaves
	Alpinia zerumbet (variegata)	1	probe holes on all leaves, >20 feeding holes on stems
Multiple choice- 19 adults			
2.8.11	H. gardnerianum NZ	1	Comprehensive feeding, plant snapped as result of stem damage
	Canna indica	1	Little feeding, 20-25 probing scars
	H. flavescens	1	Heavy feeding on leaves, stems and rhizomes, plant dead
	Zingiber zerumbet (variegata)	1	Stem and leaf damage comprehensive
	Cucurma longa	1	Heavy feeding on 90 % of leaves, stem damage from base to tip, plant killed
Multiple choice- 16 adults			
9.8.11	H. flavescens	1	Plant decimated, stem chewed and severed
	H. coronarium	1	Base of stem almost chewed through, damage to rhizomes
	H. gardnerianum ex nz	1	Rhizomes, stem leaves chewed and secondary fungal/bacterial rot as a result
	Cucurma longa	1	Stem damage feeding holes
	Canna indica	1	no feeding
Multiple choice-8 adults			
17.8.11	Canna indica	1	No damage
	H. gar ex Hawaii	1	>10 feeding holes in stem only
	Musa acuminata	1	No damage
	H. coronarium	1	>50 feeding holes in stem from base to tip, plant wilted
	Zingiber officinale	3	>35 feeding holes in stem, plant wilted

APPENDIX III

Sikkim Research Permit T&C

Terms and Conditions for Research Permit holder

- (i). Research permit holder shall liaise with concerned DFOs before starting fieldwork for proper coordination of field work and any assistance and inform the area DFO on completion of field works before leaving the field.
- (ii). The Research permit holder shall not be entitled to collect the endangered species/ rare threatened species/ high valued plant except when permitted to do so by officer or authorized authority.
- (iii). The Research permit holder shall not be entitled to collect the natural seeds/ propagule without the prior approval of State Government.
- (iv). Research Permit holder shall not be entitled to patent anything related to wild diversity of Sikkim without the approval of Government.
- (v). Any action detrimental to the forest areas and wildlife is cognizable under the Sikkim Forest Water Courses and Road Reserve (Preservation and Protection) Act, 1988, Biodiversity Act, 2002, Wild Life (Protection) Act, 1972 and Environment (Protection) Act, 1986.
- (vi). The applicant/s shall abide with all the conditions prescribed by the rules and regulations of Central and State Government for the time being in force in the State of Sikkim.
- (vii). Researcher/s team will adhere to Do's and Don'ts in regards to the protection of biodiversity of the region and will be energy sufficient regarding provision of cooking, water, etc. No camp fires allowed.
- (viii). Access and Benefit Sharing Mechanism is adopted as per the State Government approval.
- (ix). No finding/ information related to the allowed research work shall be published without the prior consent of State Government /competent authority.
- (x). Researcher shall declare the project / Research cost in the Application Form I at the time of application.
- (xi). All the finding /information should be submitted to the soft copy and hard copy at the Research Sector.
- (xii). The Beneficiary shall ensure that fee or any other levy according to law/ rules/ regulations in force within the State of Sikkim, are deposited with the competent authority as per prescribed mode and procedure.
- (xiii). Director of Forest reserves the right cancellation of Research permit without assigning any reason thereof.

APPENDIX IV-List of *Hedychium* spp. and cultivars in UK National collection (©A. Gaunt, Fera)

As of Oct. 2011	235 Total
Affin Ellipticum	Crug Farm Plants, Griffith's Crossing Caernarfon, Gwynedd LL55 1TU www.crug-farm.co.uk
Anne Bishop	Aloha Tropicals, 1247 Browning, Court, Vista, California 92083 USA
Apricot	Aloha Tropicals, 1247 Browning, Court, Vista, California 92083 USA
Aurantiacum Himalayan	Himalayan Orchid Exports, Chilauney Botey, Relli Valley, Pundung Khasmahal, Kalimpong 734301, Dist Darjeeling, W. Bengal, India www.himalayanplants.org via Shopwhyke Nursery, Oving, Chichester, West Sussex PO20 2BL
Auranticum	Mulu Nurseries, Burford House, Tenbury Wells, Worcestershire, WR15 8HQ www.mulu.co.uk
Auranticum 'Rainforest Red backed'	The Living Rainforest / Trust for Sustainable Living, Hampstead Norreys Berkshire RG18 0TN www.livingrainforest.org
Ayo	Stokes Tropicals, P.O. Box 9868, New Iberia, LA 70562, US www.stokestropicals.com
Baykoran	Peter Cooke, Derby, Derbyshire peterfcooke@ntlworld.com
Beni-Oran	Aloha Tropicals, 1247 Browning, Court, Vista, California 92083 USA
Beni-Sakigake	The Yokohama Nursery Co. Ltd, 15 Karasawa Minami-Ku Kanagawa, 232-8587, Japan.
Betty Ho	Aloha Tropicals, 1247 Browning, Court, Vista, California 92083 USA
Big Betty	Plant Group Co Ltd, 30/3 Wichitsongkram Road, Ampoe Kathu, Puket 83120, Thailand www.plant-group.com
Brandie Saito	Montoso Gardens, PO Box 692, Maricao, Puerto Rico, 00606 USA www.montosogardens.com
Brevicaule BSWJ7171	Crug Farm Plants, Griffith's Crossing Caernarfon, Gwynedd LL55 1TU www.crug-farm.co.uk
Bright Yellow	Louisiana Nursery, 5853 Highway 182, Opelousas, LA 70570 USA
C P Raffill	John Jearrad, Cornwall T:07546 561041 www.johnjearrad.co.uk
Carneum	Peter Menzel, Hauptstrasse 134, 53489 Sinzig-Bad Bodendorf
Carnival	Plant Delights Nursery, USA www.plantdelights.com
CC4729	John Jearrad, Cornwall T:07546 561041 www.johnjearrad.co.uk
Chrysoleucum	The Europa Nursery, PO Box 17589, London, E1 4YN www.europa-nursery.co.uk
Cinnabar	Gingers Of Texas, 355 County Road 2288, Cleveland, Texas 77327 www.gingersoftexas.com
Clown Suit	Tom Wood, Nurseryman, PO Box 100, Archer, Florida 32618, USA www.oldcity.com order site: www.gingersgalore.com
Coccineum angustifolium	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL www.kobakoba.co.uk
Coccineum angustifolium Peach	Louisiana Nursery, 5853 Highway 182, Opelousas, LA 70570 USA
Coccineum	Chessington Garden Centre, Leatherhead Road, Chessington, Surrey

Coccineum angustifolium Peach	Louisiana Nursery, 5853 Highway 182, Opelousas, LA 70570 USA
Coccineum auranticum	John Jearrad, Cornwall www.johnjearrad.co.uk
Coccineum auranticum Flaming torch	Plant Delights Nursery, USA www.plantdelights.com
Coccineum Bangledeshi Orange	Plant Group Co Ltd, 30/3 Wichitsongkram Road, Ampoe Kathu, Puket 83120, Thailand www.plant-group.com
Coccineum BSWJ 5238	John Jearrad, Cornwall www.johnjearrad.co.uk
Coccineum Disney	Taro and Ti, Hawaian Foods and Tropical Plants, 7150 Orange Way, Lakeland, Fl 33810 USA www.taroandti.com
Coccineum Form 4	John Jearrad, Cornwall www.johnjearrad.co.uk
Coccineum Ganesh	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL www.kobakoba.co.uk
Coccineum Orange	Louisiana Nursery, 5853 Highway 182, Opelousas, LA 70570 USA
Coccineum Orange Brush	John Jearrad, Cornwall www.johnjearrad.co.uk
Coccineum Tara	Mulu Nurseries, Burford House, Tenbury Wells, Worcestershire www.mulu.co.uk
Coccineum Tara Red	Peter Menzel, Hauptstrasse 134, 53489 Sinzig-Bad Bodendorf
Coccineum Thai Orange	Plant Group Co Ltd, 30/3 Wichitsongkram Road, Ampoe Kathu, Puket 83120, Thailand www.plant-group.com
Consanguinem	Himalayan Orchid Exports, Chilauney Botey, Relli Valley, Pundung Khasmahal, Kalimpong 734301, Dist Darjeeling, W. Bengal, India www.himalayanplants.org via Shopwhyke Nursery, Oving, Chichester, West Sussex PO20 2BL
Corelli	John Jearrad, Cornwall www.johnjearrad.co.uk
Coronarium	Chessington Garden Centre, Leatherhead Road, Chessington, Surrey KT9 2NF
Coronarium 'Thai White Ginger'	Plant Group Co Ltd, 30/3 Wichitsongkram Road, Ampoe Kathu, Puket 83120, Thailand www.plant-group.com
Coronarium Andromeda	Mulu Nurseries, Burford House, Tenbury Wells, Worcestershire, WR15 8HQ www.mulu.co.uk
Coronarium Gold Spot	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL www.kobakoba.co.uk
Coronarium maximum	John Jearrad, Cornwall www.johnjearrad.co.uk
Coronarium urophyllum	Ballyrogan Nurseries, The Grange, Ballyrogan, Newtownards, County Down, Northern Ireland, BT23 4SD
Coronarium x Ellipticum	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL www.kobakoba.co.uk
Coronarium x Gardnerianum 'St Martins'	Springwood Nursery, Kevin Clift, Proprietor 5 Southview Drive, Uckfield, E. Sussex TN22 1TA England Email: kevin@springwoodnurserysussex.co.uk www.springwoodnurserysussex.co.uk
Coronata Crema	Montoso Gardens, PO Box 692, Maricao, Puerto Rico, 00606 USA www.montosogardens.com
Cylindricum	Peter Menzel, Hauptstrasse 134, 53489 Sinzig-Bad Bodendorf
Daniel Weeks	Plant Delights Nursery, USA www.plantdelights.com

Dave Case	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL www.kobakoba.co.uk
Densiflorum	Winchester Growers, Winnall Down Farm, Fair Lane, Winchester, SO21 1HF
Densiflorum Himalayan	Himalayan Orchid Exports, Chilauney Botey, Relli Valley, Pundung Khasmahal, Kalimpong 734301, Dist Darjeeling, W. Bengal, India www.himalayanplants.org via Shopwhyke Nursery, Oving, Chichester, West Sussex PO20 2BL
Densiflorum Assam Orange	Mulu Nurseries, Burford House, Tenbury Wells, Worcestershire, WR15 8HQ www.mulu.co.uk
Densiflorum EN562	John Jearrard, Cornwall www.johnjearrard.co.uk
Densiflorum Kalimpong Gold	John Jearrard, Cornwall www.johnjearrard.co.uk
Densiflorum Kalimpong Yellow	John Jearrard, Cornwall www.johnjearrard.co.uk
Densiflorum LS&H 17393	John Jearrard, Cornwall www.johnjearrard.co.uk
Densiflorum Sorung	John Jearrard, Cornwall www.johnjearrard.co.uk
Densiflorum Stephen	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL www.kobakoba.co.uk
Densiflorum Tara	Plant Delights Nursery, USA www.plantdelights.com
Devon Cream	John Jearrard, Cornwall www.johnjearrard.co.uk
Double Eagle	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL www.kobakoba.co.uk
Dr Moy	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL www.kobakoba.co.uk
Dynasty	Louisiana Nursery, 5853 Highway 182, Opelousas, LA 70570 USA
Elatum	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL T: 01458 210607 F: 01458 210650 www.kobakoba.co.uk
Elizabeth	Mulu Nurseries, Burford House, Tenbury Wells, Worcestershire, WR15 8HQ www.mulu.co.uk
Ellipticum	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL www.kobakoba.co.uk
Ellipticum ‘ Elliptium’	Plant Group Co Ltd, 30/3 Wichitsongkram Road, Ampoe Kathu, Puket 83120, Thailand www.plant-group.com
Ellipticum (red Bract)	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL www.kobakoba.co.uk
En-Rei	The Yokohama Nursery Co. Ltd, 15 Karasawa Minami-Ku Kanagawa, 232- 8587, Japan.
Essgee	Pascal Bartkowski, Tropique Production, Chemin du Tuc, 40990 Herm. tropiqueproduction@orange.fr
Esstee	Pascal Bartkowski, Tropique Production, Chemin du Tuc, 40990 Herm. tropiqueproduction@orange.fr
Fake Tara	John Jearrard, Cornwall T:07546 561041 www.johnjearrard.co.uk
Ferrectil	Gingers Of Texas, 355 County Road 2288, Cleveland, Texas 77327 www.gingersoftexas.com
Filagree	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL www.kobakoba.co.uk
Flavescens	Mulu Nurseries, Burford House, Tenbury Wells, Worcestershire, WR15 8HQ www.mulu.co.uk

Flavum	Chessington Garden Centre, Leatherhead Road, Chessington, Surrey KT9 2NF
Flavum 'Chryso'	Plant Group Co Ltd, 45 Moo 2, Loyung, Tanguatung, Phangnag, Thailand, 82140 www.plant-group.com
Flavum Hybrid	Beeches Nursery, Village Centre, Ashdon, Saffron Waldon, Essex CB10 2HB www.beechesnursery.co.uk
Forrestii	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL www.kobakoba.co.uk
Forrestii (Diels)	John Jearrad, Cornwall www.johnjearrad.co.uk
Forrestii (Hort)	John Jearrad, Cornwall www.johnjearrad.co.uk
Forrestii 'Paksong'	Plant Group Co Ltd, 45 Moo 2, Loyung, Tanguatung, Phangnag, Thailand, 82140 www.plant-group.com
Four Way	Louisiana Nursery, 5853 Highway 182, Opelousas, LA 70570 USA
Frilly White	Louisiana Nursery, 5853 Highway 182, Opelousas, LA 70570 USA
Gahili	Aloha Tropicals, 1247 Browning, Court, Vista, California 92083 USA
Gardnerianum BSWJ 7155	John Jearrad, Cornwall www.johnjearrad.co.uk
Gardner Waters	Plant Group Co Ltd, 30/3 Wichitsongkram Road, Ampoe Kathu, Puket 83120, Thailand www.plant-group.com
Gardnerianum	The Europa Nursery, PO Box 17589, London E1 4YN
Gardnerianum 'Bhutanese Kahili'	Plant Group Co Ltd, 30/3 Wichitsongkram Road, Ampoe Kathu, Puket 83120, Thailand www.plant-group.com
Gardnerianum Himalayan	Himalayan Orchid Exports, Chilauney Botey, Relli Valley, Pundung Khasmahal, Kalimpong 734301, Dist Darjeeling, W. Bengal, India www.himalayanplants.org via Shopwhyke Nursery, Oving, Chichester, West Sussex PO20 2BL
Gardnerianum 'Thai Kahili'	Plant Group Co Ltd, 30/3 Wichitsongkram Road, Ampoe Kathu, Puket 83120, Thailand www.plant-group.com
Gardnerianum BSWJ 2524	John Jearrad, Cornwall www.johnjearrad.co.uk
Gardnerianum compactum	Plant Delights Nursery, 9241 Sauls Road, Raleigh, North Carolina USA www.plantdelights.com
Gardnerianum Typ. Menzel	Peter Menzel, Hauptstrasse 134, 53489 Sinzig-Bad Bodendorf
Gardnerianum Pallidum	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL www.kobakoba.co.uk
Gardnerianum x coronarium Great Dexter	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL www.kobakoba.co.uk
Gardnerianum x coronarium tresco	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL www.kobakoba.co.uk
Giant White Thai	Plant Group Co Ltd, 30/3 Wichitsongkram Road, Ampoe Kathu, Puket 83120, Thailand www.plant-group.com
Giant Yellow Hybrid	Aloha Tropicals, 1247 Browning, Court, Vista, California 92083 USA
Giffithianum	Winchester Growers, Winnall Down Farm, Fair Lane, Winchester, SO21 1HF
Glacum	Gingers Of Texas, 355 County Road 2288, Cleveland, Texas 77327 www.gingersoftexas.com
Gold Flame	www.kobakoba.co.uk

Gold Spot	The Europa Nursery, PO Box 17589, London, E1 4YN www.europa-nursery.co.uk
Gold Spot Himalayan	Himalayan Orchid Exports, Chilauney Botey, Relli Valley, Pundung Khasmahal, Kalimpong 734301, Dist Darjeeling, W. Bengal, India www.himalayanplants.org via Shopwhyke Nursery, Oving, Chichester, West Sussex PO20 2BL
Golden Butterfly	Gingers Of Texas, 355 County Road 2288, Cleveland, Texas 77327 www.gingersoftexas.com
Golden Glow	Stokes Tropicals, P.O. Box 9868, New Iberia, LA 70562, US www.stokestropicals.com
Golden Heart	Peter Menzel, Hauptstrasse 134, 53489 Sinzig-Bad Bodendorf
Gracile	The Europa Nursery, PO Box 17589, London, E1 4YN www.europa-nursery.co.uk
Gracile glaucum	John Jearrad, Cornwall www.johnjearrad.co.uk
Gracilis	Aloha Tropicals, 1247 Browning, Court, Vista, California 92083 USA
Great Dixter	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL www.kobakoba.co.uk
Greenii	Plant Group Co Ltd, 30/3 Wichitsongkram Road, Ampoe Kathu, Puket 83120, Thailand www.plant-group.com
Greenii Himalayan	Himalayan Orchid Exports, Chilauney Botey, Relli Valley, Pundung Khasmahal, Kalimpong 734301, Dist Darjeeling, W. Bengal, India www.himalayanplants.org via Shopwhyke Nursery, Oving, Chichester, West Sussex PO20 2BL
Greenii 'Thai Red'	Plant Group Co Ltd, 30/3 Wichitsongkram Road, Ampoe Kathu, Puket 83120, Thailand www.plant-group.com
Griffithianum	Winchester Growers, Winnall Down Farm, Fair Lane, Winchester, SO21 1HF
Hardy Exotics 1	Hardy Exotics Nursery, Gilly Lane, Whitecross, Penzance, Cornwall. TR20 8BZ. contact@hardyexotics.co.uk
Hasseltii	John Jearrad, Cornwall www.johnjearrad.co.uk
Horse Feathers	Plant Group Co Ltd, 45 Moo 2, Loyung, Tanguatung, Phangnag, Thailand, 82140 www.plant-group.com
Horsfieldii	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL www.kobakoba.co.uk
Jungle Yellow	Louisiana Nursery, 5853 Highway 182, Opelousas, LA 70570 USA
Kahili Ann	Aloha Tropicals, 1247 Browning, Court, Vista, California 92083 USA
Kahili White	Aloha Tropicals, 1247 Browning, Court, Vista, California 92083 USA
Kai Yang	Gingers Of Texas, 355 County Road 2288, Cleveland, Texas 77327 www.gingersoftexas.com
Kanogie	Plant Delights Nursery, 9241 Sauls Road, Raleigh, North Carolina USA www.plantdelights.com
Kewense	Mulu Nurseries, Burford House, Tenbury Wells, Worcestershire, WR15 8HQ www.mulu.co.uk
Kinkaku	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL www.kobakoba.co.uk
Kong	Gingers Of Texas, 355 County Road 2288, Cleveland, Texas 77327 www.gingersoftexas.com
Kong Maxi	Taro and Ti, Hawaian Foods and Tropical Plants www.taroandti.com

Lemon Beauty	Gingers Of Texas, 355 County Road 2288, Cleveland, Texas 77327 www.gingersoftexas.com
Lemon Sherbet	Aloha Tropicals, 1247 Browning, Court, Vista, California 92083 USA
Longicornutum	The Living Rainforest / Trust for Sustainable Living, Hampstead Norreys Berkshire RG18 0TN www.livingrainforest.org
Lucky Pink	Louisiana Nursery, 5853 Highway 182, Opelousas, LA 70570 USA
Luna Moth	Mulu Nurseries, Burford House, Tenbury Wells, Worcestershire, WR15 8HQ T: 01584 811592 F: 01584 810673 www.mulu.co.uk
Luna Moth Maxi	Taro and Ti, Hawaiian Foods and Tropical Plants, 7150 Orange Way, Lakeland, Fl 33810 USA T: 8778895088 f:8778895088 www.taroandti.com
Lutea	Burncoose Nurseries, Gwennap, Redruth, Cornwall TR16 6BJ www.burncoose.co.uk
Maiko	Aloha Tropicals, 1247 Browning, Court, Vista, California 92083 USA
Maximum	www.kobakoba.co.uk
Maximum BSWJ8261	Peter Menzel, Hauptstrasse 134, 53489 Sinzig-Bad Bodendorf T: 02642-45603
Maximum HWJ810	Crug Farm Plants, Griffith's Crossing Caernarfon, Gwynedd LL55 1TU www.crug-farm.co.uk
Momo Hikari	Gingers Of Texas, 355 County Road 2288, Cleveland, Texas 77327 www.gingersoftexas.com
Moy giant	Plant Delights Nursery, USA www.plantdelights.com
Multiflora White	Montoso Gardens, PO Box 692, Maricao, Puerto Rico, 00606 USA www.montosogardens.com
Mutant	The Europa Nursery, PO Box 17589, London, E1 4YN www.europa-nursery.co.uk
Mutant Thai	Plant Group Co Ltd, 30/3 Wichitsongkram Road, Ampoe Kathu, Puket 83120, Thailand www.plant-group.com
Nagdhara Dainty Pink	Pascal Bartkowski, Tropique Production, Chemin du Tuc, 40990 Herm. tropiqueproduction@orange.fr
Nagdhara Yellow	Pascal Bartkowski, Tropique Production, Chemin du Tuc, 40990 Herm. tropiqueproduction@orange.fr
Nikasha Cho	Beeches Nursery, Village Centre, Ashdon, Saffon Walden, Essex, CB10 2HB www.beechesnursery.co.uk
Orange	Louisiana Nursery, 5853 Highway 182, Opelousas, LA 70570 USA
Orange Brush 4 row	Peter Menzel, Hauptstrasse 134, 53489 Sinzig-Bad Bodendorf
Orange Crush	Peter Menzel, Hauptstrasse 134, 53489 Sinzig-Bad Bodendorf
Oto Himi	Aloha Tropicals, 1247 Browning, Court, Vista, California 92083 USA
Palani Hybrid	Aloha Tropicals, 1247 Browning, Court, Vista, California 92083 USA
Palani Thai	Plant Group Co Ltd, 30/3 Wichitsongkram Road, Ampoe Kathu, Puket 83120, Thailand www.plant-group.com
Pale Yellow	Montoso Gardens, PO Box 692, Maricao, Puerto Rico, 00606 USA www.montosogardens.com
Peach	Plant Group Co Ltd, 30/3 Wichitsongkram Road, Ampoe Kathu, Puket 83120, Thailand www.plant-group.com
Peach Delight	Plant Delights Nursery, USA www.plantdelights.com
Pink	Plant Group Co Ltd, 30/3 Wichitsongkram Road, Ampoe Kathu, Puket 83120, Thailand www.plant-group.com
Pink Delight	James Scoggins, 4081 Kingsley Street, Clermont, Florida 34711

Pink Flame	www.kobakoba.co.uk
Pink Hawaii	Gingers Of Texas, 355 County Road 2288, Cleveland, Texas 77327 T: 281-592-5067 www.gingersoftexas.com
Pink Hybrid	www.mulu.co.uk
Pink Sparks	www.kobakoba.co.uk
Pink V	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL T: 01458 210607 F: 01458 210650 www.kobakoba.co.uk
PJ218	Fir Tree Farm Nursery, Tresahor, Constantine, Falmouth, Cornwall TR11 5PL www.cornwallgardens.com
Raffilli	Cotswold Garden Flowers, 1 Waterside, Evesham, Worcestershire, WR11 6BS (Nursery at Sands Lane Badsey)
Roxburghii	Peter Menzel, Hauptstrasse 134, 53489 Sinzig-Bad Bodendorf
Palydosum	Peter Cooke, Derby, Derbyshire petercooke@ntlworld.com
Pradhan	Fir Tree Farm Nursery, Tresahor, Constantine, Falmouth, Cornwall TR11 5PL www.cornwallgardens.com
Pradhanii	Mulu Nurseries, Burford House, Tenbury Wells, Worcestershire, WR15 8HQ www.mulu.co.uk
Rubrum	Pascal Bartkowski, Tropique Production, Chemin du Tuc, 40990 Herm. tropiqueproduction@orange.fr
Salmon	Gingers Of Texas, 355 County Road 2288, Cleveland, Texas 77327 www.gingersoftexas.com
Shamsheri	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL www.kobakoba.co.uk
Sherry Baby	Montoso Gardens, PO Box 692, Maricao, Puerto Rico, 00606 USA www.montosogardens.com
Sherry Baby	www.rareexpectations.com USA
Shurei	Montoso Gardens, PO Box 692, Maricao, Puerto Rico, 00606 USA www.montosogardens.com
Sikkim Yellow	Pascal Bartkowski, Tropique Production, Chemin du Tuc, 40990 Herm. tropiqueproduction@orange.fr
Species aff. gardenerianum	Peter Menzel, Hauptstrasse 134, 53489 Sinzig-Bad Bodendorf
Species Menzel	Peter Menzel, Hauptstrasse 134, 53489 Sinzig-Bad Bodendorf
Spicatum	Mulu Nurseries, Burford House, Tenbury Wells, Worcestershire, WR15 8HQ T: 01584 811592 F: 01584 810673 www.mulu.co.uk
Spicatum 'Angel Wings'	Aloha Tropicals, 1247 Browning, Court, Vista, California 92083 USA
Spicatum 'Liberty' BWJ8116	Crug Farm Plants, Griffith's Crossing Caernarfon, Gwynedd LL55 1TU www.crug-farm.co.uk
Spicatum 'White Wings'	Aloha Tropicals, 1247 Browning, Court, Vista, California 92083 USA
Spicatum 'White Wings' sub 'White Gold'	Plant Group Co Ltd, 30/3 Wichitsongkram Road, Ampoe Kathu, Puket 83120, Thailand www.plant-group.com
Spicatum acuminatum	Louisiana Nursery, 5853 Highway 182, Opelousas, LA 70570 USA
Spicatum BSWJ 8115	John Jearrard, Cornwall www.johnjearrard.co.uk

Spicatum CC1705	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL www.kobakoba.co.uk
Spicatum Dudh Kosi Valley	www.johnjearrard.co.uk
Spicatum Himalayan Lipstick	www.johnjearrard.co.uk
Spicatum PJ218	www.johnjearrard.co.uk
Spicatum Red Back	www.johnjearrard.co.uk
Spicatum Salween Valley	www.johnjearrard.co.uk
Spicatum Sichuan BWJ8116	www.crug-farm.co.uk
Spicatum Singalila BSWJ 2303	www.crug-farm.co.uk
Spicatum TH1278	www.johnjearrard.co.uk
Spicatum TH1417	www.johnjearrard.co.uk
Stenopetalum BSWJ7155	www.crug-farm.co.uk
Syu-Rei	The Yokohama Nursery Co. Ltd, 15 Karasawa Minami-Ku Kanagawa, 232-8587, Japan.
Tac Moto Hybrid	Aloha Tropicals, 1247 Browning, Court, Vista, California 92083 USA
Tahitian Flame	Tom Wood, Nurseryman, PO Box 100, Archer, Florida 32618, USA www.oldcity.com order site: www.gingersgalore.com
Tai Alpha	Plant Delights Nursery, 9241 Sauls Road, Raleigh, North Carolina, 27603, USA www.plantdelights.com
Tai Conch Pink	James Scoggins, 4081 Kingsley Street, Clermont, Florida 34711
Tai Emperor	James Scoggins, 4081 Kingsley Street, Clermont, Florida 34711
Tai Empress	James Scoggins, 4081 Kingsley Street, Clermont, Florida 34711
Tai Gold Crown	Peter Menzel, Hauptstrasse 134, 53489 Sinzig-Bad Bodendorf
Tai Golden Goddess	James Scoggins, 4081 Kingsley Street, Clermont, Florida 34711
Tai Mammoth	Plant Delights Nursery, 9241 Sauls Road, Raleigh, North Carolina, 27603, USA www.plantdelights.com
Tai Monarch	Plant Delights Nursery, 9241 Sauls Road, Raleigh, North Carolina, 27603, USA www.plantdelights.com
Tai Pink Princess	Plant Delights Nursery, 9241 Sauls Road, Raleigh, North Carolina, 27603, USA www.plantdelights.com
Tai Pink Profusion	James Scoggins, 4081 Kingsley Street, Clermont, Florida 34711
Tai Queen	Aloha Tropicals, 1247 Browning, Court, Vista, California 92083 USA
Tai Savannah	Plant Delights Nursery, 9241 Sauls Road, Raleigh, North Carolina, 27603, USA www.plantdelights.com
Tai Spirit	Aloha Tropicals, 1247 Browning, Court, Vista, California 92083 USA
Tai Sunlight	Plant Delights Nursery, 9241 Sauls Road, Raleigh, North Carolina, 27603, USA www.plantdelights.com
Tangarine	Aloha Tropicals, 1247 Browning, Court, Vista, California 92083 USA
Telstar 4	Hardy Exotics Nursery, Gilly Lane, Whitecross, Penzance, Cornwall.
Thrysiforme	www.mulu.co.uk
Thrysiforme Thai pincushion'	Plant Group Co Ltd www.plant-group.com

Tresco	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL www.kobakoba.co.uk
Tropic Bird	JungleSeeds, PO Box 45, Watlington SPDO, Oxfordshire OX49 5YR www.jungleseeds.co.uk
Verity	Jungle Seeds, PO Box 45, Watlington SPDO, Oxfordshire OX49 5YR www.jungleseeds.co.uk
Villosum	Mulu Nurseries, Burford House, Tenbury Wells, Worcestershire, WR15 8HQ www.mulu.co.uk
Wardii	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL www.kobakoba.co.uk
White Butterfly	John Jearrad, Cornwall www.johnjearrad.co.uk
White Clover	Plant Group Co Ltd, 45 Moo 2, Loyung, Tanguatung, Phangnag, Thailand, 82140 www.plant-group.com
White Starburst	Aloha Tropicals, 1247 Browning, Court, Vista, California 92083 USA
Yellow Fever	Louisiana Nursery, 5853 Highway 182, Opelousas, LA 70570 USA
Yu-Bae	The Yokohama Nursery Co. Ltd, 15 Karasawa Minami-Ku Kanagawa, 232-8587, Japan.
Yunnan TH1418	Beeches Nursery, Village Centre, Ashdon, Saffron Waldon, Essex CB10 2HB www.beechesnursery.co.uk
Yunnanense	Mulu Nurseries, Burford House, Tenbury Wells, Worcestershire, WR15 8HQ www.mulu.co.uk
Yunnanense L633	KobaKoba, 2 High Street, Ashcott, Bridgwater, Somerset, TA7 9PL www.kobakoba.co.uk
Yunnanense TH1278	John Jearrad, Cornwall www.johnjearrad.co.uk
Yunnanense TH1417	John Jearrad, Cornwall www.johnjearrad.co.uk

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