DAVIS EXPEDITION FUND

REPORT ON EXPEDITION / PROJECT

Expedition/Project Title:	Asian Gallwasp Project, Taiwan-China Expedition
Travel Dates:	13/03/2011-17/04/2011
Location:	Taiwan and Yunnan Province, China
Group Members:	Frazer Sinclair, Jack Hearn, Konrad Lohse, Chang-Ti Tang
Aims:	To assess gallwasp diversity and collect specimens for species descriptions and molecular analysis.

Outcome (not less than 300 words):- See report.

Asian Gallwasp Project

Taiwan-China expedition 2011

Novel gall-types from *Quercus sessilifolia* in Tawan (left), *Lithocarpus* spp. In China (centre), and *Castanopsis echinocarpa* in China (right).

Photos by Chang-Ti Tang.

Expedition Report May 2011

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Introduction

The Cynipini gallwasps are a fascinating group of insects whose larvae induce complex and often spectacular galls on trees of the Fagaceae family. These galls support rich multitrophic communities and are a valuable ecological model system, having recently featured in studies of biological invasions, phylogeography, and community assembly. The vast majority of the ~1000 known species are associated with trees of the genus *Quercus* in North America and the Palaearctic, but it is becoming increasingly apparent that other genera within the Fagaceae family also support potentially diverse gallwasp communities. In particular, recent research in Japan and Taiwan has led to the formal description of several gallwasp species associated with the Fagaceae genera *Castanopsis* and *Lithocarpus* that are endemic to Eastern and Central Asia. The 'Asian Gallwasp Project' was established in 2009 by postgraduate students at the University of Edinburgh to promote further study of the ecology and taxonomy of Asian gallwasps and their associated communities.

Few gallwasp species (<10) have so far been described from Asian endemic Fagaceae, and the extent of gallwasp diversity in the region remains largely unknown. The inclusion of further Asian gallwasp species in a comprehensive phylogeny of the Cynipini could shed new light on the geographic origin of the tribe, and reveal the evolutionary processes that govern the association between gallwasps and their host plants. The objective of the Asian Gallwasps Project's 'Taiwan-China Expedition 2011' was therefore to assess the diversity of gallwasps on the various Fagaceae taxa within these two countries, and to collect gallwasp specimens for species descriptions and molecular analysis.

Methods

Cynipini gallwasps typically have a cyclic lifecycle, with galls of a sexual generation developing during spring, and galls of an asexual generation developing during autumn each year. Some galls, particularly those of the asexual generations, can persist on a tree long after all resident wasps have emerged, while others fall or are excised from the tree once they have matured. Fieldwork was scheduled specifically to target maturing sexual generation galls, although older galls were also sampled where field dissections indicated that they may still contain wasps.

Cynipini galls occur on various plant organs including leaves, buds, flowers, seeds, stems, and roots. Fagaceae trees were identified in the field, using morphological keys where necessary, and accessible foliage was examined for galls with the aid of extendable pole pruners or rope based canopy access techniques where appropriate. Gallwasp larvae develop within individual chambers inside the galls, and it was possible to distinguish between Cynipini galls and those of other types (i.e. midge or sawfly galls) by dissecting a single gall in the field. Cynipini galls were collected in the field in zip-lock plastic bags, before being transferred to ventilated plastic rearing containers. Collections were sorted into morpho-types based on their external morphology, which is distinctive of a particular generation of an individual species. Morpho-types were either matched with existing records or nominated as a novel gall-type. A photographic record of novel gall-types was maintained, and this shall be published online to aid further studies of Asian gallwasps. Rearing containers were stored in laboratories at the host institutions, and were monitored at three day intervals. All emerging wasps were preserved in 100% ethanol.

Expedition:

Taiwan: March 13th – 31st, 2011

The mountainous sub-tropical island of Taiwan supports a considerable diversity of potential gallwasp host-plants, including members of the Fagaceae genera *Castanea* (2 species), *Castanopsis* (12 species), *Lithocarpus* (15 species), and *Quercus* (46 species). These occur in forests ranging from sea level to over 2500 meters elevation.

The expedition began in Taichung City where the team were hosted at the National Chung Hsing University (NCHU) by Professor Man-Maio Yang. Following a busy schedule that covered much of the length of the island, 13 field-sites were visited between elevations of 400 and 2200 meters (Figure 1a). Invaluable assistance in the field was provided by students from Professor Yang's research group including Shui-Wei Hou, Sheng-Fong Lin, I-Chang Liao, and Wesley Hunting. A total of 76 different gall types were collected, 48 of which had never previously been recorded. Notable findings included 3 new gall-types from *Castanopsis uraiana* at Xiaowulai that were discovered by climbing into the tree canopy using rope access methods, and hundreds of a previously unknown 'fluffy pink leaf gall' on *Quercus sessilifolia* at Erge Mountain (see cover for photo). All collected galls were returned to

Professor Yang's lab for rearing, where they soon yielded a diversity of adult gallwasps, inquilines, and parasitoids. Between fieldwork, time was found to visit Sun-Moon Lake and the 921 Earthquake Museum, and to sample the delights of 'stinky tofu' at the Zhongxiao night market.

Xishuangbanna, China: April 1st – 16th

Xishuangbanna County in Yunnan province lies in the transitional zone between tropical Southeast Asia and subtropical East Asia, and contains some of the largest reserves of pristine rainforest in China. This mountainous region in the foothills of the Himalayas supports an incredible diversity of flora within areas of tropical rain forest, seasonal moist forest, montane evergreen broad-leaved forest, and tropical monsoon forest. Floral inventories for the region include members of the Fagaceae genera *Quercus, Castanopsis, Lithocarpus, Castanea,* and *Trigobalanus*.

After three flights and a night in Hong Kong, the team arrived at the Xishuangbanna Tropical Botanic Gardens (XTBG) where they were hosted by Professor Charles Cannon. During the two week visit, galls were collected within the grounds of XTBG and at several sites within Xishuangbanna and neighbouring Lan Cang County, between 500 and 1700 meters elevation (Figure 1b). Valuable field assistance and botanical expertise were provided by XTBG staff including Mr Lui, and Lui Jing-Xin. A total of 41 gall different gall-types were collected, 37 of which had never been recorded before. Galls were reared in Professor Cannon's laboratory at XTBG with much appreciated assistance from PhD student Warin Harrison. Notable findings included 3 novel gall-types from a single tree of *Castanopsis echinocarpa* at Foufang quarry, all of which produced adult gallwasps within days of collection. Also at this site, there was the unique opportunity to examine a species of the rare Fagaceae genus *Trigobalanus,* although no evidence of gallwasps could be found. To celebrate the end of a successful expedition, the team were thoroughly soaked at the Dai new-year water splashing festival in Menglun.

(a) (b)

Figure 1. Maps of (a) Taiwan, and (b) South Yunnan, China, showing the location of field-sites

Preliminary results:

Cynipini galls were sampled from tree species in each of the genera *Castanopsis, Lithocarpus,* and *Quercus,* in both Taiwan and China (Table 1). The majority of collected gall-types were novel (85/115), and their discovery represents a substantial addition to knowledge of Asian Cynipini. Analysis of the number of gall-types per individual tree species indicated that there was no significant difference in gall diversity between the three genera (analysis of variance, p=0.753). This is somewhat surprising, as almost all currently described Cynipini species are associated with trees of the genus *Quercus.* Approximately 450 species of *Quercus* are known globally, which is comparable to the combined number of *Castanopsis* and *Lithocarpus* species (~120 and 300 respectively). If the true diversity of gallwasps per tree species is even remotely similar across these taxa, as these findings suggest, then Asia is likely to be home to hundreds more undescribed gallwasp species representing a considerable proportion of the tribe.

The monitoring of collected galls is ongoing, and adult gallwasps have so far been obtained from 25 different gall-types (Table 1). Particularly notable are the 6 types from galls on *Castanopsis*, which more than doubles the number of species currently recognised from this tree taxon. Unfortunately no adult gallwasps have yet been obtained from *Lithocarpus* galls, despite 25 different gall-types having been collected. This may reflect particularly high rates

of colonisation by inquilines or parasitoids that cause the death of the gall-former. Alternatively, it was noted that several gall-types had fresh exit holes, and it is possible that the collections were conducted too late in the season for galls from these trees.

Table 1. Summary of gall-types and host tree species recorded in Taiwan and China.

Country	Tree Genus	No. Gall-types	No. Tree species	Mean No. gall-types per tree species	No. Gall-types that produced adult gallwasps
Taiwan	*Quercus*	40	12	3.33	17
	Castanopsis	20	6	3.33	2
	Lithocarpus	15	7	2.14	0
China	*Quercus*	12	8	1.50	2
	Castanopsis	20	7	2.86	4
	Lithocarpus	10	3	3.33	0
Taiwan + China	*Quercus*	51	19	2.68	19
	Castanopsis	39	12	3.25	6
	Lithocarpus	25	11	2.27	0

Further work

Gall rearing shall continue to be monitored by researchers at NCHU and XTBG until October 2011, when it is expected that the majority of adult wasps will have emerged. All adult gallwasp specimens shall then be transferred to the University of Edinburgh, where DNA will be extracted by non-destructive means for a sample of individuals from each gall-type. The DNA will be sequenced for three loci (nuclear 28S and long-wavelength opsin, and mitochondrial cytochrome b), and combined with existing data to generate a phylogeny of the Cynipini tribe. This shall be used to assess; (1) what is the likely geographic origin of the Cynipini tribe, as evidenced by the historic geographical range of the Fagaceae taxon associated with the most basal Cynipini? And (2), what are the relative roles of parallel cladogenesis (i.e. diversification in unison with host-plant) and host-shifting (i.e. switching between distinct host-plant taxa) in the evolution of the Cynipini? The results shall be published in an appropriate evolutionary journal.

Following analysis of DNA sequence data, morphological analysis shall be conducted in collaboration with Dr George Melika, a world renowned expert in Cynipid taxonomy. Formal descriptions of novel species will be published in taxonomic journals, and type specimens shall be deposited in the collections of appropriate institutions in Taiwan and China.

Summary

The objectives of this expedition were to assess the diversity of Cynipini gallwasps in Taiwan and Southern China, and to collect specimens for taxonomic and molecular analysis. Fieldwork was conducted at varied forest sites in both countries and a total of 115 different gall-types were sampled from trees of the Fagaceae genera *Quercus, Castanopsis*, and *Lithocarpus*. As the majority of these gall-types were previously unrecorded, this represents a substantial addition to knowledge of Asian gallwasps. The diversity of gall-types per tree species did not differ between tree genera, suggesting that *Castanopsis* and *Lithocarpus* may host a considerable proportion of the Cynipini tribe, much of which has yet to be described. Specimens of adult gallwasps have so far been obtained for 17 gall-types, including 6 from *Castanopsis*. These shall be transferred to the University of Edinburgh for extraction of DNA, and novel species shall be formally described in collaboration with taxonomic experts. DNA sequence data from a sample of adult specimens shall be combined with existing data to generate a phylogeny of the Cynipini tribe.

Acknowledgements

This expedition was generously supported by grants from the Royal Entomological Society (£1000), the Davies Expedition Fund (£7500), the Royal Geographical Society (£1500), the Gilchrist Educational Trust (£1000), the Weir Fund for Field Studies (£3000), and the James Rennie Bequest (£350). It was hosted by Professor Man-Miao Yang at the National Chung Hsing University, and Professor Charles Cannon at the Xishuangbanna Tropical Botanic Gardens. Logistical support was provided by Miss Yi-Chuan Li and Song Yu, and invaluable assistance with gall rearing was provided by Warin Harrison and Hsim-Yong Chang. The team were joined in the field by Shui-Wei Hou, Sheng-Fong Lin, I-Chang Liao, Wesley Hunting, Mr Lui, and Lui Jing-Xin.

Appendix 1 – Expenditure

A budget of £15785 was available for the Taiwan-China expedition 2011, consisting of various grants and a personal contribution of 10%. The total expenditure as of May 1st 2011 was £15392.48 (see Tables A1.1 & A1.2), leaving a surplus of ~£390. It is planned that this be used towards international flights for Chang-Ti Tang to visit Hungary during November 2011 to begin the formal description of novel gallwasp species in collaboration with Dr George Melika. An itemised record of all expenditure, with receipts, is available on request from Frazer Sinclair (frazer_sinclair@yahoo.co.uk).

Table A1.1. Summary of expenditure, as of May 1st 2011.

Expense type	Expenditure (£)
Training	1804
Equipment	2793.83
Medical	1334.35
International travel	3270.39
Travel and subsistence UK (T & S UK)	825.68
T & S Taiwan	2704.68
T & S Hong Kong	152.99
T & S China	2506.56
Total	15392.48

Table A1.2. Summary of how the various sources of funding were used. Funds awarded to an individual, rather than to the expedition, are indicated by the initials of the recipient.

Source	Training	Equipment	Medical	International travel	T & S UK	T & S Taiwan	T & S Hong Kong	T & S China	Total (£)
Weir Fund (FS)		200.00	200.00	600.00					**1000.00**
Weir Fund (JH)		200.00	200.00	600.00					**1000.00**
Weir Fund (KL)		200.00	200.00	600.00					**1000.00**
James Rennie Bequest (JH)				350.00					**350.00**
Royal Entomological Society	149.80	182.17	60.98	93.04	68.56	224.59	12.70	208.14	**1000.00**
Davies Expedition Fund	1123.52	1366.31	457.35	697.77	514.23	1684.46	95.28	1561.07	**7500.00**
Royal Geographical Society	224.70	273.26	91.47	139.55	102.85	336.89	19.06	312.21	**1500.00**
Gilchrist Educational Trust	149.80	182.17	60.98	93.04	68.56	224.59	12.70	208.14	**1000.00**
Personal contributions	156.17	189.91	63.57	96.99	71.48	234.14	13.24	216.99	**1042.48**
Total (£)	**1804.00**	**2793.83**	**1334.35**	**3270.39**	**825.68**	**2704.68**	**152.99**	**2506.56**	**15392.48**

Appendix 2 - Selected images

Plate A2.1. Searching for galls at Huisun forest, Taiwan (top), using rope canopy access techniques to prune for *Castanopsis* flowers in Taiwan (middle left), rearing galls in the laboratory at National Chung Hsing University, Taiwan (middle right), group photo near Meng Hai, China (bottom). Photos by Chang-Ti Tang.