REPORT

A rediscovery of Alfred Russel Wallace’s fern collection from Borneo at the Cambridge University Herbarium

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Alfred Russel Wallace spent eight years in South-East Asia studying the biodiversity of the region in the course of visits to Malaysia, Singapore and Indonesia. His collections, extensively and scrupulously acquired in the Malay Archipelago, include zoological specimens such as insects, birds, reptiles and mammals. In addition, Wallace collected botanical and ethnological material. The bulk of his zoological collection is deposited in the Natural History Museum, London, and other specimens are to be found in a variety of British museums, for example insects in the Oxford University Museum of Natural History, and in private collections. Wallace’s collection is made up primarily of insects (of which he obtained nearly 110,000 specimens), birds (8050 specimens), mammals and other vertebrates (410 specimens), marine and land shells (7500 specimens) and plants.1

Wallace tried, with remarkable success, to collect specimens in perfect condition and with several duplicates.2 Owing to the immense number of samples, his collection has not received the attention it deserves. Moreover, even though most of his collection is in the Natural History Museum, the fact that it was sold to several buyers means that it has been difficult to study it in its entirety.3

Wallace is acknowledged as the founder of biogeography as a scientific discipline. It is in recognition of this that the boundary between the Oriental and Australian regions, Wallace’s Line, bears his name. He was an extraordinary observer and a prolific writer who published more than 10 books on natural history. He collected in areas where few or no Europeans had set foot before and was the first European to observe birds of paradise alive in their natural habitat. His enormous accumulation of data and field notes on species distribution and morphological variation enabled him to address questions on the evolution, as well as the distribution, of species in South-East Asia. The biogeographic approach is still valid today, with importance for the study of organism diversity and distribution in the region.4

Wallace’s plant collection is divided between the Royal Botanic Gardens, Kew (herbarium identification code K), and the Cambridge University Herbarium (identification code CGE). Part of the collection at K consists of palm samples collected by Wallace in the Amazon in 1848. Most of what he collected there was destroyed when his ship sank in the mid-Atlantic Ocean on his voyage back to England in 1852; fortunately Wallace and the crew were picked up 10 days later by a passing cargo ship.5

This paper describes the materials from Wallace’s collection that are deposited at CGE, consisting of fern specimens from the Malaysian part of Borneo, Sarawak. I accompany

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my account with a complete inventory of the collection and a species list. I give geo-references for the samples, with their approximate coordinates, information that sheds new light on Wallace’s work in the Malay Archipelago and his interpretation of fern biogeography. With attention focused on Wallace following the 2013 centenary of his death, the rediscovery is a welcome new resource for our understanding of his contribution to the study of terrestrial and epiphytic ferns in Borneo. General biogeographical conclusions, based on information from his collection, still have value today. Wallace’s knowledge of fern diversity is also evident in several letters that he exchanged with British naturalists and friends concerning the distribution and population abundance of numerous European fern species.6

THE FERN COLLECTION

The CGE was moved to the Sainsbury Laboratory in Cambridge in 2011. During this relocation a review of the historic collections was conducted, resulting in important new discoveries. The internationally important Lindley collection was found to contain many of the Wallace specimens described here. John Lindley (1799–1865) was Secretary of the Horticultural Society (later Royal Horticultural Society) from 1830, and his herbarium, like those of many taxonomic botanists, was assembled as a research tool throughout his active working life. In his later years, Lindley suffered from the effects of long-term financial difficulties, poor health and rapidly failing memory. When it became clear that he was no longer fit to work on them, he and his family sought to realize the financial value of his library and plant collections. He died before they could all be sold, but they ultimately raised £1400 for his creditors. The Royal Botanic Gardens, Kew bought his orchid specimens, while most of his herbarium, 58 000 sheets, was purchased for £300 by Cambridge University in 1866. The collection is rich in types and representative specimens published by Lindley (especially in the Botanical Register), along with material from across the globe collected by many of the leading botanical explorers of their day. David Douglas (North America), Joseph Hooker (India, Antarctica), Thomas Mitchell (Australia) and Richard Spruce (South America) are among those represented in the collection. Lindley’s herbarium also contains many important duplicate types of specimens that were destroyed in Berlin during World War II. An examination of the ferns in the CGE collection resulted in the rediscovery of Wallace’s samples from Borneo, and further samples were found in the separate, non-Lindley fern material from South-East Asia. Three important specimens were deposited in the CGE type section.

In total, 41 Wallace fern vouchers were found, representing 33 species belonging to 22 genera and 17 fern families (table 1). A sample belonging to the genus Asplenium has not been identified. All the samples are in very good condition. Since their rediscovery they have been placed in new folders and transferred to a separate single collection in the Herbarium, with the exception of the type specimens. A photograph of each voucher has been digitized and will soon be available on the CGE website. Of the 33 species only 16 had previously been identified, three of them being recognized as type specimens of Haplopteris and the tree ferns Cyathea; the remaining 17 included in the Lindley collection had never been studied by any botanist since the collection was purchased in 1866. The vouchers are not damaged, and all the samples have complete lamina, leaves, stipe and root systems. This perfect state of conservation makes the collection extremely valuable for current taxonomic study. The availability of the dataset through the
Table 1. List of species from Wallace’s fern collection from Borneo. (Numbers in parentheses after the scientific names show the number of specimens for each species. Ecology shows the type of forest or the altitudinal belt where the species occur.)

<table>
<thead>
<tr>
<th>Barcode/ID</th>
<th>Family</th>
<th>Species</th>
<th>Habit</th>
<th>Distribution</th>
<th>Ecology</th>
</tr>
</thead>
<tbody>
<tr>
<td>CGE 12738</td>
<td>Aspleniaceae</td>
<td>Asplenium tenerum Forst.</td>
<td>terrestrial</td>
<td>Asia, Pacific</td>
<td>0–800</td>
</tr>
<tr>
<td>CGE 12733</td>
<td>Aspleniaceae</td>
<td>Asplenium affine Sw.</td>
<td>terrestrial</td>
<td>Africa, Asia</td>
<td>0–2000</td>
</tr>
<tr>
<td>CGE 12734</td>
<td>Aspleniaceae</td>
<td>Asplenium sp.</td>
<td>terrestrial</td>
<td>Asia, Pacific</td>
<td>0–2000</td>
</tr>
<tr>
<td>CGE 12731</td>
<td>Cyatheaceae</td>
<td>Cyathea wallacei (Mett.) Copel.</td>
<td>terrestrial</td>
<td>Borneo lowland forest</td>
<td>300–1500</td>
</tr>
<tr>
<td>CGE 12708</td>
<td>Cyatheaceae</td>
<td>Cyathea latebrosa (Wall. Ex. Hook.) Copel.</td>
<td>terrestrial</td>
<td>Asia, Malaysia 0–1500</td>
<td>0–900</td>
</tr>
<tr>
<td>CGE 12722</td>
<td>Davalliaceae</td>
<td>Davallia repens (L. f.) Kuhn</td>
<td>epiphytic, epilithic, sometimes terrestrial</td>
<td>Africa, Asia, Pacific</td>
<td>0–2500</td>
</tr>
<tr>
<td>CGE 12729</td>
<td>Davalliaceae</td>
<td>Davallia parvula Hook. &amp; Grev.</td>
<td>epiphytic</td>
<td>Asia, Pacific 0–900</td>
<td></td>
</tr>
<tr>
<td>CGE 12713</td>
<td>Davalliaceae</td>
<td>Davallia heterophylla Sm.</td>
<td>epiphytic, epilithic</td>
<td>Asia, Pacific 0–900</td>
<td></td>
</tr>
<tr>
<td>CGE 12719</td>
<td>Davalliaceae</td>
<td>Histiopteris incisa (Thunb.) J. Sm.</td>
<td>terrestrial</td>
<td>Asia, Pacific 0–2500</td>
<td></td>
</tr>
<tr>
<td>CGE 12718</td>
<td>Davalliaceae</td>
<td>Syngramma alismifolia Pr. J. Sm.</td>
<td>terrestrial</td>
<td>Malay lowland forest</td>
<td></td>
</tr>
<tr>
<td>CGE 12727</td>
<td>Schizaeaceae</td>
<td>Schizaea dichotoma (L.) Sm.</td>
<td>terrestrial</td>
<td>Madagascar, Polynesia</td>
<td>0–1000</td>
</tr>
<tr>
<td>CGE 12724</td>
<td>Tectariaceae</td>
<td>Tectaria palmata var. platanioides (Mett.) Copel.</td>
<td>terrestrial</td>
<td>Borneo lowland forest</td>
<td>0–380</td>
</tr>
<tr>
<td>CGE 12723</td>
<td>Tectariaceae</td>
<td>Tectaria ternata (Baker) Copel.</td>
<td>terrestrial</td>
<td>Borneo lowland forest</td>
<td>0–300</td>
</tr>
<tr>
<td>CGE 12717</td>
<td>Vittarioideaceae</td>
<td>Antrophyum plantagineum (Cav.) Kaulf.</td>
<td>epiphytic</td>
<td>Malaysia, Australia lowland and mid-mountain</td>
<td>0–3150</td>
</tr>
</tbody>
</table>
CGE website will make it possible for scientists to use this historic resource for a number of purposes. The lowland forest of the island of Borneo has been severely deforested in the past two decades, and the data from the collection will be useful in the study of changes in species distribution, the impact of climate change and red list assessments. The presence and distribution records of species from over 150 years ago are crucially important, as a source of data that can be compared with species richness and distribution in our own day.

**Past and Future Contributions to the Knowledge of the Fern Flora of Borneo**

For some decades now, natural history museums have embarked on the task of digitizing their historic collections. Digitized herbarium vouchers and historic records are a valuable resource. In biodiversity assessments they help us to predict the effect of habitat loss, species invasion and climate change, but accurate geo-referencing is needed if vouchers are to become useful for conservation. In identifying the single or multiple origins of the samples, several approaches have been used. First, books, articles and letters written by Wallace and herbarium catalogues have been studied as sources that throw light on the section related to ferns. Second, a study has been conducted of the Lindley collection, in which some of the vouchers are deposited. Combining these sources of information, it has been possible to identify the precise locality where Wallace performed his collecting.

Here two points should be stressed. First, the specimens were all collected in a single locality. Wallace was not interested in ferns alone but also in widely defined taxonomic groups of animals and plants. His goal was clearly to obtain a broad overview of biological diversity, including fern diversity, by examining one clearly defined area. In his book *Malay Archipelago* he wrote:

I returned to the mountain [in 1855, after spending Christmas in Kuching with Sir James Brooke] with Charles and a Malay boy named Ali, and stayed there three weeks for the purpose of making a collection of land-shells, butterflies and moths, ferns and orchids. On the hill itself ferns were tolerably plentiful, and I made a collection of about forty species.

With a fair degree of accuracy we can conclude that the plants were collected on the mountain ‘Bung Muan’, with coordinates approximately 1.26° N 110.13° E, near Peninjau village, at a distance of 40 km from Kuching (Sarawak), where Sir James Brooke lived. The locality is an isolated mountain formed of a basalt/granite pluton (exposed on the flanks of the summit) erupting through sandstone. On this mountain Sir James Brooke had a hut that Wallace used as a field station. Today the local community maintains a trail in the forest on the ‘Gunung Muan’ named after Wallace and James Brooke (Peter Boyce, personal communication).

With a view to describing local biodiversity, Wallace collected fern species characterized by broad morphological and ecological variability. This is the second important aspect of this set. It is relevant here that European knowledge of fern species diversity in South-East Asia and morphological variability among the different genera and families was very limited at the time. It was therefore important to make available to naturalists a collection of different genera and species that reflected this variability. Another consideration was that a wide morphological diversity of a single taxon such as ferns was particularly easy
to sell at a time when in Britain the collection of dried and living fern specimens was very much in fashion.

The collection provides further information on the ecology of the area where Wallace gathered his specimens. Of the 33 species collected, two have a pantropical distribution, and five species are distributed between Africa and Asia. Twelve species are distributed across the East Asian region (China, Indochina and the Malay Archipelago), and seven species have a more restricted distribution limited to the Malay Archipelago. The remaining five species are endemic to Borneo. In Wallace’s day, knowledge of species distribution was poor, and the possibility of his being familiar with the endemic status of these five species was remote. The ecology of the ferns in the collection is divided between terrestrial and epiphytic, respectively 19 and 16 (table 1). Most of the species have lowland mid-elevation distribution ranges, whereas seven species are widely distributed at altitudes from sea level to 2500 m.
The species exhibit wide ecology adaptation and morphological variability. Most of the species have forest ecology, for example *Diplazium cordifolium* Bl., a common terrestrial species found on the forest floor. *Tectaria palmata* (Mett.) Copel var. *platanifolia* (Mett.) Holttum and *Tectaria ternate* (Baker) Copel are two ground floor forest species, 50 cm tall and able to form a ground layer in forests, commonly along streams. Two vouchers are represented by tree ferns, *Cyathea latebrosa* (Wall. Ex. Hook.) Copel. and *Cyathea wallacei* (Mett.) Copel. One of the species collected by Wallace was new to science and was named after him by G. H. Mettenius and subsequently republished by E. B. Copel. The holotype of *Cyathea wallacei* (Mett.) Copel. is deposited at K, the CGE specimen being a duplicate isotype (figure 1). Wallace was fascinated by the magnificent beauty of tree ferns. As he wrote in *Tropical Nature*, 'Some are as small as mosses, others have huge fronds eight or ten feet long, while in mountainous districts the most elegant of the group, the tree-ferns, bear their graceful crowns on slender stems.

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![Figure 2. The widely distributed species *Schizaea dichotoma* (L.) Sm., with its distinctive morphological characteristics. The species occurs in sandy terrain near rivers or the sea. Herbarium voucher CGI12727. (Reproduced by courtesy of the Cambridge University Herbarium.) (Online version in colour.)](image)
twenty to thirty, or even fifty feet high’ (p. 47), and ‘then magnificent tree ferns sending off their feathery crowns twenty feet from the ground delight the sight by their graceful elegance’ (p. 63).

Three species, *Dipteris conjugata* Reinw., *Histiopteris incisa* (Thunb.) J. Sm. and *Lygodium circinnatum* (Burm.) Sw. (figure 1), are common along forest margins, forest gaps and forest paths. These three species, although easily observable in disturbed areas, were probably not common herbarium specimens in Europe, certainly less common than they are today. On his travels in South-East Asia, Wallace would frequently have observed these species, and he collected two or more samples of each, presumably because of their morphological peculiarity and their interest for European naturalists or fern lovers. Another morphologically peculiar species is *Schizaea dichotoma* (L.) Sm. (figure 2), widely distributed from Madagascar to Australia, from lowland up to 1000 m; ecologically the species is often recorded on sandy ground close to the sea or rivers. Despite its common frequency, the species has unique morphological traits.
Epiphytic species constitute nearly half of the collection. *Haplopteris pumila* Fee and *Haplopteris hirta* Fee are type specimens, deposited at CGE. The genus name *Haplopteris* has been recently adopted to encompass all Asian species previously placed in the genus *Vittaria*. The epiphytic *Haplopteris* species have long linear leaves, up to 70 cm, the sori at the margin of the leaves giving them a unique morphological trait (figure 3). Although the genus is particularly common in South-East Asia, it still calls for thorough up-to-date taxonomic revision. Delimitation between the species is particularly difficult, and revision may reveal that many international herbaria hold *Haplopteris* species new to science. Other important epiphytic families are represented by the Polypodiaceae, with the genera *Selliguea* and *Pyrrosia*, and Davalliaceae with the genus *Davallia* (figure 4). These epiphytic species are particularly rich and abundant, giving the tropical forest canopy its well-known luxuriant aspect. Many species of these genera are nowadays commonly grown in botanical gardens and marketed to gardeners.

Figure 4. The epiphytic species *Davallia repens* (L.f.) Kuhn with leaves dissected in different grade. Herbarium voucher CGI12735. (Reproduced by courtesy of the Cambridge University Herbarium.) (Online version in colour.)
Samuel Stevens, Wallace’s agent in London,\(^{15}\) advertised the Wallace collection in the *Kew Miscellany* in 1857. He described it as ‘Wallace’s Borneo Ferns, 30 to 40\(^*\), at 50 shillings per 100’, \(*\)Among which are some species of great rarity and beauty.’\(^{16}\) The value of the collection in modern currency was approximately £500. As I have indicated, we can confirm that the collection was made up of 41 specimens, and even though some species were common in tropical East Asia, they were indeed of ‘great rarity’ on the British collectors’ market. In conclusion, the rediscovery of Wallace’s fern collection at CGE adds significantly to our understanding of his botanical activity in Borneo. The presence of three type specimens in the collection highlights once again the importance of historic herbaria for taxonomic study. In a broader perspective, historic herbarium specimens and the labels that go with them have the potential for comparisons between the distribution of species in earlier centuries with their distribution in our own day and hence for informing current studies of climate change.

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**NOTES**

6. Wallace Letters Online project; see [http://www.nhm.ac.uk/research-curation/scientific-resources/collections/library-collections/wallace-letters-online/database.html?d-4074490-p=1&includeTranscriptContent=on&keyWord=fern](http://www.nhm.ac.uk/research-curation/scientific-resources/collections/library-collections/wallace-letters-online/database.html?d-4074490-p=1&includeTranscriptContent=on&keyWord=fern).
11 Baker, *op. cit.* (note 1).
15 Baker, *op. cit.* (note 1).