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Reconnecting the *Cinchona* (Rubiaceae) collections of the "Real Expedición Botánica al Virreinato del Perú" (1777–1816)

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Abstract. During the "Real Expedición Botánica al Virreinato del Perú", 1777–1816, Hipólito Ruiz López (1754–1816), José Antonio Pavón Jiménez (1754–1840), Juan José Tafalla Navascués (1755–1811) and Juan Agustín Manzanilla (fl. 1793–1816) collected economically important specimens of anti-malarial cinchona bark (*Cinchona* spp.). In the 230 years since, these specimens have been dispersed across institutions in Spain, Britain, Germany and Italy. Two major sub-collections of these are found at the Real Jardín Botánico, Madrid, Spain (n = 243), and the Royal Botanic Gardens, Kew, UK (n = 188). The Kew collection arrived in Britain through Pavón and other Spanish botanists selling part of the collections. This study traces the history, trajectory and relationship of the collections between the two institutes.

Keywords. History, Botany, Pharmacy, Medicine, Ruiz & Pavón Expedition.

Resumen. Durante la Real Expedición Botánica al Virreinato del Perú, 1777–1816, Hipólito Ruiz López (1754–1816), José Antonio Pavón Jiménez (1754–1840), Juan José Tafalla Navascués (1755–1811) y Juan Agustín Manzanilla (fl. 1793–1816) recolectaron especímenes de cortezas de quina (*Cinchona* spp.), importante económicamente como antimalárico. En los 230 años transcurridos desde entonces, estos especímenes se han dispersado por instituciones de España, Gran Bretaña, Alemania e Italia. Dos subcolecciones importantes se encuentran en el Real Jardín Botánico, Madrid, España (n = 243), receptor de la colección, y en Royal Botanic Gardens, Kew, Reino Unido (n = 188). La colección de Kew llegó a Gran Bretaña a través de Pavón y otros botánicos españoles que vendieron parte de las colecciones de la Expedición. Este estudio rastrea la historia, trayectoria y relación de estas colecciones compartidas entre estos dos centros de investigación.

Palabras clave. Historia, Botánica, Farmacia, Medicina, Expedición de Ruiz y Pavón.

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INTRODUCTION

For over 300 years, the quinine-containing bark of the *Cinchona* tree was the only effective treatment for malaria in Europe and its colonies. *Cinchona* bark was exported from South America from the 1630s, harvested in its native habitat of cloud forest on the slopes of the Andes (Wallis 2012; Crawford 2016; Walker & Nesbitt 2019). The remote habitat of *Cinchona* trees meant that the plants were poorly understood by European botanists, despite their economic and medical importance. It is therefore not surprising that *Cinchona* trees were a major object of study of Ruiz and Pavón, the principal botanists of the "Real Expedición Botánica al Virreinato del Perú" [Royal Botanical Expedition to the Viceroyalty of Peru] (1777–1816) hereafter referred to as the "Real Expedición" (Honigsbaum 2001; Bleichmar 2008; Crawford 2016).

Most of the original "Real Expedición" collections are kept at the MA Herbarium of Real Jardín Botánico (RJB), Madrid. However, over the 230 years since its return to Spain, the collection, and in particular the *Cinchona* portion, has been partly dispersed across various locations. A major component of the *Cinchona* collection is now at Royal Botanic Gardens, Kew (Economic Botany Collection). This paper traces the history, trajectory and relationship of the *Cinchona* collections of Ruiz and Pavón found today in Madrid and Kew. It forms a case study of the circulation of specimens as circulation of knowledge, an important purpose of museums in the study period (Driver & al. 2021).

Our aim in this study was to identify specimens in Kew and Madrid that would be suitable for chemical and genomic analyses, as part of a wider project on the history and chemical diversity of *Cinchona* (Canales & al. 2020). Historic specimens such as those collected by Ruiz and Pavón are important evidence of past forests, harvesting by local communities, trade networks, and the taxonomic practices of botanists. We wished to understand whether this dispersed *Cinchona* collection could be reassembled in digital format, reconnecting the specimens to their documentation, improving understanding of provenance, and thereby enriching their usefulness as biological and cultural specimens.

Our methodology thus had two components: study of relevant archives and other written materials in order to understand the ways in which specimens circulated between various individual institutions and people, and careful analysis of individual specimen characteristics such as appearance, collection numbers assigned in the field, catalog numbers assigned later, handwriting, and museum labels. We expected that this specimen data would enable correlation of individual specimens with the division and movement of collections through time.

The genus Cinchona

The genus *Cinchona* L. comprises 23 (Andersson 1998) to 24 (Aymard 2019) species, with a recent addition, *C. andersonii* Maldonado (Maldonado & al. 2017). The genus is in the monophyletic Rubiaceae tribe Cinchoneae with *Ciliosemina* Antonelli, *Cinchonopsis* L.Andersson, *Joosia* H.Karst., *Ladenbergia* Klotzsch, *Remijia* D.C., *Stilpnophyllum* Hook.f., *Maguireocharis* Steyerm. and *Pimentelia* Wedd., (Andersson & Antonelli 2005; Manns & Bremer 2010). The *Cinchona* genus and *C. officinalis* L. were first described by Linnaeus (1753: 172) based on descriptions and drawings by La Condamine (de La Condamine 1738). Five new, still accepted, species were described by the end of the eighteenth century: *C. pubescens* Vahl, *C. lancifolia* Mutis, *C. hirsuta* Ruiz & Pav., *C. micrantha* Ruiz & Pav. and *C. nitida* Ruiz & Pav. In Andersson's monograph (1998), c. 330 historic scientific names were distilled down to a couple of dozen. The high number of synonymous names is a consequence of the phenotypic variability of the plant and the historical botanical and pharmaceutical interest in this group, reflected in the confusion, debate and repeated re-organization of the genus by different authors.

Cinchona grows throughout the Andes at altitudes between 500–3000 metres, from the Potosí area (Bolivia) in the south, extending further north as far as the Talamanca range (Costa Rica), and spreading along the Venezuelan coastal range (Andersson 1998). Three main *Cinchona* species, *C. calisaya* Wedd (yellow bark) (including *C. ledgeriana* (Howard) Bern.Moens ex Trimen), *C. officinalis* L. (pale bark) and *C. pubescens* Vahl (red bark), have been cultivated on a regular basis for their pharmacological exploitation, as well as the hybrids with *C. officinalis* (Nair 2010). The type and proportion of alkaloids vary greatly in *Cinchona* species, as well as in populations of the same species, between individuals of different ages and between the oldest and newest leaves and barks (Martin & Gandara 1945; Bruce-Chwatt 1990; Nair 2010). The genera *Ladenbergia* and *Remijia* also contain quinine-type alkaloids (Maldonado & al. 2017).

History of the "Real Expedición"

In the last third of the eighteenth century, the Spanish Government began a scientific programme to collect and record the physical and biological characteristics of its colonies. Between 1760 and 1816, fifty-seven expeditions were launched with these aims in mind ranging from mathematical to the botanic (Steele 1964; Bleichmar 2008, 2012). In the case of scientific "Expediciones", the objective was to collect useful botanical knowledge for the benefit of the nation (Figueroa 2012). Colonial and state infrastructures were made available to the expedition members during their commission, as well as means of transport

(Campo 1993). Administratively, the botanical expeditions were assigned to the Ministry of the Indies, while the scientific supervision of the work was assigned to the First Professor of the Real Jardín Botánico, an institution subordinate to the Chief Minister, and the recipient of the botanical materials collected by these expeditions (García Guillén & Muñoz Paz 2003).

The "Real Expedición Botánica al Virreinato del Perú" (1777–1816) was one of the first "Expediciones*"* organized specifically to study the flora of the colonial territories. Ruiz and Pavón, together with French botanist Joseph Dombey (1742–1794) who left the "Real Expedición*"* in 1784, traveled to the Viceroyalty with the purpose of cataloging the flora of Peru and Chile and publishing the results in a series of illustrated volumes. The "Real Expedición" members were exhorted in their instructions to make a particular study of *Cinchona*, whose medicinal applications made it a recognized economically valuable plant (AJB, Div. IV, 7, 1, f. 5v; Ruiz & al. 1998). The directions also gave guidelines and references for the formation and packaging of the collection, along with specifications for each plant. Numerous types of sample were to be collected, including (where possible), branch or trunk wood with bark adhering, leaves, flowers, seeds, sap, as well as local ethnobotanical names and uses (Steele, 1964, p. 42). There is evidence that in addition to gathering their own barks, Ruiz and Pavón asked the Viceroy of Peru to send samples of barks in commerce to Madrid.

> *"Los botánicos del Perú con el mayor respeto hacemos presente a Vuestra excelencia la necesidad que tenemos de adquirir esqueletos (especímenes de herbario) y demás materiales de la Quina llamada Calisaya, para hacer por ellos la descripción de tan interesante especie... se digne mandar pasar las correspondientes órdenes al Virrey del Perú para que haga acopiar en las Montañas en que se cría dicha Quina calisaya los materiales necesarios de ella, para que por mano de V. E los remita aquel virrey a esta oficina Botánica...."* (Ruiz & Pavón, 23 September, 1803, ACN, 17, 305, f.1).
>
> "The botanists of Peru with the greatest respect we present to Your Excellency the need we have to acquire skeletons (herbarium specimens) and other materials of the Quina called Calisaya, to make the description of such an interesting species... he deigns to pass the corresponding orders to the Viceroy of Peru to have the necessary materials collected in the Mountains in which said Quina calisaya is grown, so that by the hand of Your Excellency that viceroy may send them to this Botanical office..." (Authors' translation of Ruiz & Pavón, 23 September, 1803, ACN, 17, 305, f. 1).

The initial phase of the "Real Expedición" began with the team's arrival in Lima in 1778, and concluded with Ruiz and Pavón's return to Madrid in 1788 with a large shipment of collections. During their stay in South America they sent dried plants, wood samples, botanical descriptions and drawings, and live plants collected in the field in Peru and Chile, to the Ministry of the Indies in Madrid. Live plants and seeds were also sent directly or indirectly to the Real Jardín Botánico (RJB), Madrid. Between 1777 and 1788, there is evidence of four shipments of seeds and specimens of live plants from *Cinchona* being received in 1785, 1786 and 1787, but not all arrived in good condition (Campo 1993). In the RJB Seed (sowing) books, there are references to *Cinchona* seeds in 1785, (AJB, Div. I, LS, 4. f. 71), 1796 (AJB, Div. I, L-S, 13) and 1803 (AJB, Div. I, L-S, 28). The Spanish never established successful cultivation in Spain, preferring to focus on potential sites in South America. However, projects there did not thrive, due to lack of local confidence, preference for other land uses and political instability at home and abroad (González Bueno & Muñoz Garmendia 1993; Crawford 2016).

On their return, Ruiz and Pavón collected the materials they had sent, now scattered among the Secretariat of the Indies. For example, in 1793 they collected herbarium specimens and drawings from the Library of Ministry of Indias, the "Gabinete de Historia Natural", and the RJB (ACN, 13, 205, f. 9). In the latter, there were 18 or 19 boxes of roots, barks and seeds (ACN, 12, 203, ff. 33–36). Ruiz and Pavón initially had no official residence to work on their collections. In 1792 work began in the "Oficina de la Flora" (Peruvian Flora Office) (González Bueno & Rodríguez Nozal 1996), established at the request of the First Professor of the RJB, teacher and mentor of Ruiz, Casimiro Gómez de Ortega (1741–1818) (Steele 1964). The assignment of the "Oficina" to the Ministry of the Indies kept it out of the influence of the RJB both geographically and scientifically, which in the long run had a negative influence on the preservation of the collections. In particular, Ruiz and Pavón had poor relations with the director of the RJB between 1801 and 1804, Antonio José Cavanilles (1745–1804) (Steele 1964). The "Oficina" moved its headquarters on seven occasions, with the consequent danger to collections in each move (García Guillén & Noya Santos 2017).

Beginning with Ruiz's death in 1815 and until the collections entered the RJB in 1831, Pavón made sales of specimens and other botanical materials belonging to the "Real Expedición", mainly to Aylmer Bourke Lambert and Philip Baker Webb. The dispersion caused by these unauthorized sales has been studied by Rodríguez Nozal (1994). Not all the materials would remain in the "Oficina de la Flora". In 1793 Ruiz and Pavón requested that they should be allowed to keep in their own houses duplicates of each plant gathering to allow observations and new corrections, as well as for safety in the event of fire in the "Oficina de la Flora". They also considered this as a reward

for their work (ACN, 12, 203, f. 36). We do not know the answer of the Secretary of the Indies, however we have evidence that Pavón kept a personal herbarium outside the Office, supposedly in his house. Of this 'personal' collection of Pavón, a small part was sold by his son after his father's death, through the intermediation of Mariano de la Paz Graells, director of the RJB at that time, to the Academia de Ciencias Naturales de Barcelona and is currently in the Herbarium BC of the Institut Botànic de Barcelona (Ibáñez & al. 2006). The main part of Pavón's personal herbarium was sold to Edmund Boissier in 1841, probably through the intermediation of RJB Director, Miguel Colmeiro (1816–1901) (Burdet 1985), and is preserved in the Herbarium G of the Conservatoire et Jardin botaniques de la Ville de Genève.

After Ruiz and Pavón's return to Madrid, two "Real Expedición" leaders would remain in South America, Juan José Tafalla, who joined the "Real Expedición" in 1785 and the artist Francisco Pulgar, to whom botanist Juan Agustín Manzanilla, and artists José Gabriel Rivera and Xavier Cortés would be added in 1794 to continue the observations and replace the collections lost in the shipwreck of the San Pedro de Alcántara and the Macora fire in 1784. Between 1798 and 1808, in response to a request by Ruiz and Pavón, Tafalla and Manzanilla made an excursion to the territories of Ecuador in which they collected *Cinchona* (ACN, 16, 289, f. 1). Numerous shipments of barks, seeds, herbarium specimens, and also drawings and descriptions of *Cinchona* were sent during this period between 1785 to 1814, recorded in shipping lists kept in the archives of the Real Jardín Botánico and the Museo Nacional de Ciencias Naturales, Madrid. In 1801, during their stay in Quito, Tafalla and Manzanilla would meet Alexander von Humboldt (1769–1859) and Aimée Bonpland (1773–1858), and also with Francisco José de Caldas (1768–1816), a member attached to the "Expedición Botánica al Virreinato de Nueva Granada" (Royal Botanical Expedition of the New Kingdom of Granada). This "Expedición" was led by José Celestino Mutis (1732–1808) to study, among others, the territory's *Cinchona*, giving rise to a competition between both Spanish expeditions to identify the *Cinchona* species most effective against malarial fevers. Humboldt and Bonpland had met Ruiz and Pavón in Madrid in 1799, before their trip to America, to view the herbarium of the "Real Expedición" (von Humboldt & Bonpland 1814: 48).

All the materials sent by Tafalla and Manzanilla were incorporated into the collection of the "Real Expedición" in Madrid and their origin and authorship were obscured, but they are thought to have contributed a significant number. This is important to bear in mind when evaluating the collections because, as many researchers have pointed out, items collected between 1789 and 1816 have sometimes been attributed to Ruiz and Pavón, resulting in inaccurate collection data (Miller 1970; Pupulin 2012a; Tepe 2018). The specimens, descriptions and drawings corresponding to Tafalla and Manzanilla travels to Guayaquil were identified by Eduardo Estrella (1989). A helpful breakdown of the timeline of the "Real Expedición" and collectors was compiled by Tepe (2018).

Due to the richness and complexity of the flora, Ruiz and Pavón's study took much longer than anticipated. Ultimately, they failed to publish the collection in its entirety, with only three of the eleven planned volumes of the *Flora Peruviana et Chilensis* produced (1798–1802), with two additional pre-publications, *Florae Peruvianae, et Chilensis Prodromus* (1794) and the *Systema Vegetabilium Florae Peruvianae et Chilensis* (1798). The plates of the fourth volume were distributed by Pavón (González Bueno & Rodriguez Nozal 1996; Pupulin 2012a). The ambitious task was affected from 1808 by national and international political instability, as well as the Napoleonic wars in Spanish territory (1808–1814) during which the RJB was occasionally closed (González Bueno & Rodríguez Nozal 2006). After this period, Spain was left economically unstable, with efforts directed towards reconstruction, and scientific projects such as the *Flora Peruviana* lost their urgency and significance.

MATERIAL AND METHODS

Abbreviation list

AJB: Archivo del Real Jardín Botánico de Madrid

ACN: Archivo del Museo Nacional de Ciencias Naturales, Madrid

BC: Herbario del Institut Botànic de Barcelona

BM: British Museum, London

EBC: Economic Botany Collection, Kew

K: Herbarium of Royal Botanic Gardens, Kew

LMA: London Metropolitan Archives

MA: Herbario del Real Jardín Botánico-CSIC, Madrid

MNCN: Museo Nacional de Ciencias Naturales-CSIC, Madrid

NHM: Natural History Museum, London

RBGK: Royal Botanic Gardens, Kew

RGS: Royal Geographical Society Archives

RJB: Real Jardín Botánico-CSIC, Madrid

RPS: Royal Pharmaceutical Society, London

"Real Expedición" material assessed as part of this project included herbarium specimens, wood, bark, and seed samples, and archives relating to *Cinchona* at the RJB and RBGK. An overview of the two institutions' collections by type can be found in Figures 3 and 4. At RBGK, barks and

woods collections from the "Real Expedición" are kept in the Economic Botany Collection (EBC) and the pressed plant specimens are kept in the Herbarium (K).

Closely related non-*Cinchona* species were included in the project study. These include species that were previously classified as *Cinchona,* or were part of the "Real Expedición" *Cinchona* collections. These include 'false-barks', which had close resemblance (but lesser medicinal action), and were found in trade intentionally or unintentionally mixed with *Cinchona* barks. Genera names in the *Cinchona* labels studied in the project include closely related Rubiaceae members: *Joosia*, *Ladenbergia* (syn. *Cascarilla* (Endl.) Wedd.), *Machaonia* Bonpl., *Macrocnemum* P.Browne, *Pimentelia* Wedd., *Remijia, Nauclea* L., and *Uncaria* Schreb., as well as Theaceae genus *Gordonia* Ellis (syn. *Laplacea* Kunth). *Cinchona* in Kew's Economic Botany Collection is cataloged under botanical names assigned during databasing in the late 1980s. For our data tables, updated accepted names (using http://www.plantsoftheworldonline.org/) have been entered, based on the oldest known original names originally assigned by Hipólito Ruiz and José Pavón or John Eliot Howard.

The primary working materials of the project are spreadsheets of the *Cinchona* collections at Kew and Madrid, partly extracted from institutional databases, and expanded through study of the specimens, labels, archives and printed materials. In cases where original labels and lists are transcribed in this paper, e.g. in transcribing old data, we have kept the original spelling, which has alternate versions and inconsistencies. Because of COVID-19, some external archives were inaccessible and therefore the authors have had to rely on communications from other curators or transcriptions in secondary sources. The project data are presented in the supplementary data (https://doi.org/10.6084/m9.figshare.15081633).

RESULTS

Overall, we identified 243 relevant botanical specimens, illustrations and copper plates in Madrid and 188 at Kew (Table 1). Within the Economic Botany Collection at Kew we were able to assign Pavón specimens as arriving via Aylmer Bourke Lambert (1816) and John Eliot Howard (1858).

DISCUSSION

The Madrid Collection

The collection is made up of herbarium specimens, samples of woods and barks, drawings, original handwritten descriptions and a catalog listing species and materials. There are also five copper plates of *Cinchona* illustrations and a copy of José Pavón's manuscript *Nueva Quinología* (dated around 1826), as well as collection inventories, shipments of material from Peru and Ecuador, and other related administrative documents. The biological material is in the MA Herbarium, and the graphic and textual material is in the RJB Archives. Part of the documentation relating to shipments made by the "Real Expedición" and its management is in the archives of the MNCN, Madrid. A breakdown of the biological specimens can be found in Table 1.

Table 1. Breakdown, by type, of *Cinchona* and related genera collections from the "Real Expedición" currently at Kew (EBC and K) and Madrid (MA).

	Royal Botanic Gardens, Kew	**Real Jardín Botánico, Madrid**
	No. of specimens	No. of specimens
Herbarium sheets (including duplicates)	≥ 6 from Pavón (52 from later "Real Expedición")	168
Illustrations	0	3
Copper printing plates	0	5
Bark samples	72	48
Wood samples	35	19
Seed samples	23	0
Total	188	243

The set of *Cinchona* materials is now integrated and dispersed within the wider collections of the "Real Expedición", but was previously kept separate in the "Oficina de la Flora", reflecting the importance that *Cinchona* held for the botanists of the "Real Expedición".

Three stages can be distinguished in the formation of the collection. The first corresponds to the activity of Hipólito Ruiz and José Pavón in Peru between 1778 and 1788, the second, to that developed by commissioners Juan José Tafalla and Juan Agustín Manzanilla, mainly during their stay at the Royal Court of Quito, Ecuador (1799–1805). The third stage relates to study of the material in the "Oficina de la Flora", resulting in publications by Hipólito Ruiz and José Pavón on *Cinchona*. These stages, and the relationships between the different materials, can be distinguished from these inscriptions, labels and the period inventories. The annotations also reveal the connections between the materials, giving a unique and consistent character to the Madrid collection. Authors' translations throughout.

Transfer to the Real Jardín Botánico

An important point in the history of the quinological materials in Madrid is the closure of the "Oficina de la Flora Peruviana" and the transfer of the collections of the "Real Expedición" to the RJB in 1831. This was meant to

be a temporary move, but became the collection's ultimate destination. Previously, the collections of the "Oficina" had been inventoried in 1809, 1821 and 1823. The inventory carried out by the Board of Protection of the Museum on its entry into the RJB detected significant omissions, from that made by Pavón in 1823 (ACN 21, 396, f. 181–183). This highlighted the poor curation practices of Pavón (Ruiz had died in 1816) and led to the cessation of his employment and salary, until he could explain the missing materials. Although the Professors of the RJB, Sandalio de Arias and Vicente Cutanda, warned it was impossible to know exactly what was missing, the inventory showed that at least 712 drawings and four boxes of roots, fruits, barks and seeds, in addition to books like the *Flora Peruviana*, Ruiz's *Quinología* and Ruiz and Pavón's *Suplemento de la Quinología*, were no longer part of the collection (ACN, 21, 396, f. 180).

The inventory also revealed that the samples of dried plants, bark and wood sections from *Cinchona* were inventoried and kept separately from the rest of the collection of materials belonging to the *Flora Peruviana et Chilensis*. In 1823, Pavón cataloged these collections and coordinated the samples, for his future *Cinchona* monograph entitled *Nueva Quinología.* This manuscript *Catalogus omnium Chinchonarum specierum tam editum quam ineditarum* (AJB, Div. IV, 15, 1, 3. See Figure 1a) describes 50 species, classified into two sections, published and unpublished, detailing the material (or lack of collected parts) that corresponds to each one (sheet, drawing, bark and wood), other relevant data, such as description number, drawing number ("icon" or "ic."), as well as observations on vernacular names, properties and the publications for which it was reference material. In other words, these *Cinchona* specimens were reclassified by Pavón in 1823 in a new structure that correlated all the components, including the materials collected by Ruiz and Pavón themselves, and those collected later by Tafalla and Manzanilla. The same catalog can be considered as a work plan for Pavón's unpublished manuscript *Nueva Quinología* (1826) and includes the species that had already been published in the *Flora Peruviana*, *Quinología* (1792) and the *Suplemento de la Quinología* (1801). The coordination of this catalog with the samples, left its mark on the inscriptions that accompany both the barks, wood, descriptions and drawings, data that allows us to recover the order and structure that Pavón gave to the collection.

In addition, an undated list of 40 bark packages and 41 *Cinchona* woods existing in the collection is preserved, organized by number of packages and vernacular name, and two later copies of the list made upon entering the RJB showing the differences (AJB, Div. IV, 15, 3, 14). See Figure 1b.

The transfer of the collections to the RJB did not lead to new research by the professors. Vicente Soriano and Sandalio Arias would excuse themselves, arguing that almost all the new species contained in these collections had been published by Swiss botanist Auguste De Candolle (1778–1841) and that the only professor who could have addressed this work, Mariano Lagasca (1776–1839), was in political exile in London (ACN 21, 396, ff. 29–31). Meanwhile, European interest in the *Cinchona* genus, and its potential cultivation, grew in light of the need of expanding empires for anti-malarial medicine. Several researchers recognized the value of the Madrid collection, including British quinologist, John Eliot Howard, as discussed later in the Kew Collection section. Clements R. Markham (1830–1916) visited the RJB in September 1866, comparing the herbarium collection to trees growing in the new plantations in India. According to his notes, the dried *Cinchona* specimens had remained in the same state in which Pavón had left them (Markham 1866). This continued until the 1870s when the samples of *Cinchona* barks and woods were organized separately from the *Cinchona* specimens of the Herbarium into the RJB's 'Special Collections'. From that time, species descriptions, herbarium, bark and wood, had different histories according to their typology. We will discuss the history of each separately: 1) herbarium specimens, 2) barks, woods and seeds, and 3) descriptions and drawings.

Herbarium specimens

At the time of its entry to the RJB, and according to the inventory of 1831 (AJB, Div. IV, 15, 2, 14), the "Real Expedición" herbarium consisted of ten drawers "containing various plant specimens placed by their classes whose herbarium is tied with their corresponding little boards". There are no in-depth studies on the history of the "Real Expedición" herbarium from its entry into the RJB in 1831. Information on its state in the second half of the 19th century is partial and scattered. Some descriptions are provided by visitors like Markham who describes it as "Herbarium arranged according to De Candolle natural system in a long dirty upstairs room in the garden. The Flora Peruviana of Ruiz & Pavón in folders down the center of the room. Among them, two large bundles of *Cinchona* specimens with tickets in Pavón's own handwriting" (RGS, Special Collections, C.R. Markham, 57. South American notes). The 'room' that Markham describes was specially erected behind the "Pabellón Villanueva" to house these collections in 1831, in the place of two old ponds. On the right side, currently occupied by offices, was located the collection room that housed the general herbarium, the herbaria of the scientific expeditions, and collections of natural products such as barks, logs, gums, resins, and fruits, etc.

Regarding Markham's comment on classification, we believe it refers only to the general herbarium, and that the

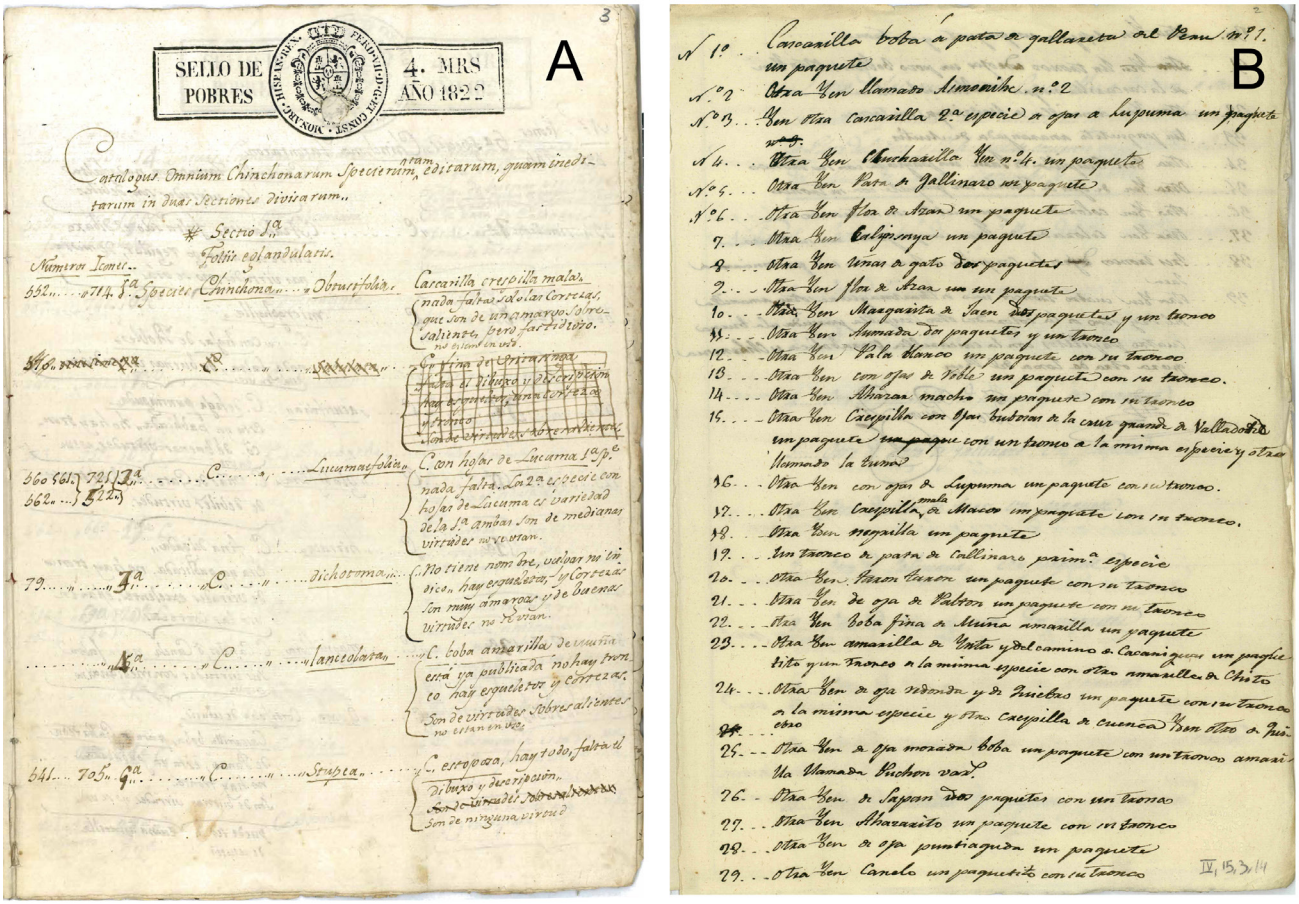

Fig. 1. Images of Pavon's manuscripts: **a,** front page of the *Catálogo de las Chinchonas o cascarillas de todas las especies del Perú y Quito,* 1823, MS. AJB, Div. IV, 15, 1, 3; **b,** a page from the *Lista de muestras de Cascarillas*, [1831], MS. AJB, Div. IV,15, 3, 14. Both written in Pavón's hand.

"Real Expedición" herbarium, like the rest of the "special" herbaria, had little intervention and possibly continued with the Linnaean classification. In 1875, the director of the RJB, Miguel Colmeiro, calculated that the herbarium of the "Real Expedición" of Ruiz and Pavón contained a total of 2,980 specimens, of which 2,859 were phanerogams and 121 were cryptogams (Colmeiro 1875). The systematic identification of the herbarium was not addressed until the 1930s, with its loan to the Herbarium B of the Botanical Garden and Museum of Berlin-Dahlem (AJB, Div. I, 107, 11), where the specimens were given determinations in 1932 by specialists including Diels, Pilger and Krause (Lack 1979). During the project we also located barks (~8) and herbarium specimens (~22) in Florence University, apparently sent by Pavón to botanist Phillip Webb, but further research on these is required.

In the "Real Expedición" herbarium, we can find three types of original labels, see also Figure 2:

1) Pavón labels (Fig. 2a), which can be cross-referenced to the 1823 catalog (Catálogo, 1823, Ms. AJB, Div. IV, 15, 1, 3) and *Nueva Quinología* manuscript (LMA ACC/1037/855), which include species number, scientific name, vernacular name, drawing number ("L. / Lam. / icon / ic..") or the mention that it exists ("c. l" [cum lamina], description number ("N.")), and in some cases, a corresponding reference to the *Flora Peruviana*, to the *Quinology* of Ruiz and *Supplement*, and to the manuscript of *Nueva Quinología* of Pavón ("Kinología"). Forty-nine sheets bear labels that allow us to relate them to 38 of the 50 species listed in the 1823 catalog (1–14; 16–17; 19–21; 23–37 and 39–41). We cross-reference to this London version of the *Nueva Quinología* because it is the original, whereas the Madrid version is a copy.

2) Labels referring to the Tafalla (Fig. 2c) and Manzanilla collection (25 samples), which include: Linnaean class, scientific name, vernacular name, drawing number, description number, location and date of collection. 72% of the specimens from Tafalla and Manzanilla were collected in Loja (formerly known as Loxa, present day Ecuador) in 1805. Pavón added to these labels the species

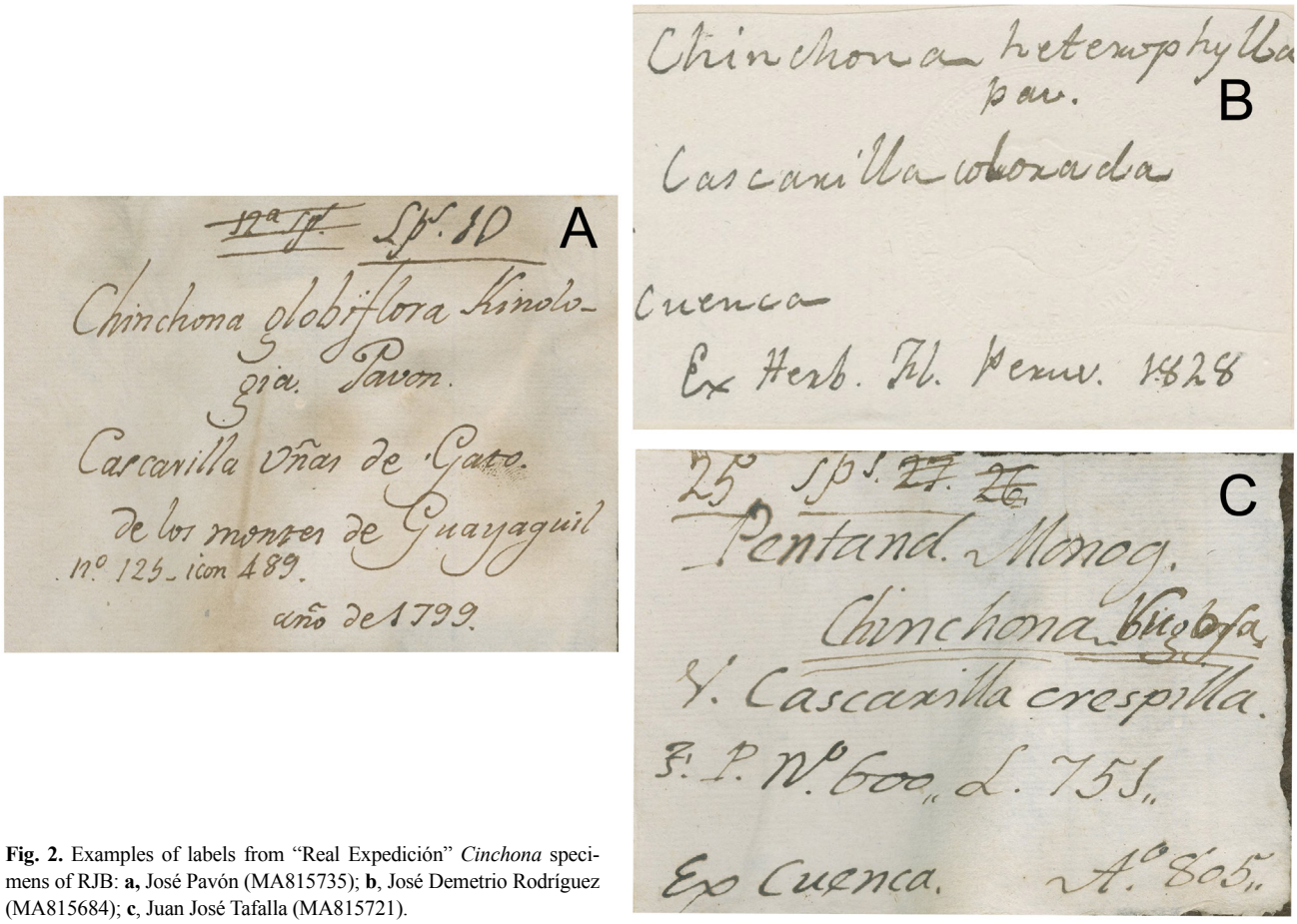

Fig. 2. Examples of labels from "Real Expedición" *Cinchona* specimens of RJB: **a,** José Pavón (MA815735); **b**, José Demetrio Rodríguez (MA815684); **c**, Juan José Tafalla (MA815721).

number from the 1823 *Cinchona* catalog.

3) There are nine specimens with labels (Fig. 2b) that correspond to the work of José Demetrio Rodríguez (1760–1846), added to the "Oficina de la Flora" in 1827 (Álvarez López 1956). We cannot know if Rodríguez removed the original tags to add his own, or if they lacked a tag from the beginning. They all include the scientific name and the phrase "Ex herb. [arium] Fl. Peruv. 1828". Of the 168 specimens, twenty-two coincide with species number 1, 8, 10, 12, 14, 17, 18, 19, 20, 26, 27, 28, 29, 31, 35, 36, 37 and 41 collected in the manuscript, *Nueva Quinología* of Pavón.

Barks, woods and seeds

The 1823 catalog (AJB, Div. IV, 15, 1, 3) and the 1831 list of barks and woods (AJB, Div. IV, 15, 3, 14) indicate that *Cinchona* biological materials were kept separate from the rest of the "Real Expedición" collections both at the "Oficina de la Flora" and at the RJB. In 1831 they were moved together with the herbarium to the 'collections room' of the "Pabellón Villanueva", without receiving more attention from the experts of the RJB. An inventory by Colmeiro was drawn up in 1870 (AJB, Div. 15, 4, 7), in which materials are listed, organized in drawers, grouped by category including barks, woody stems, leaves, herbs, roots, catkins, fruits, seeds. Among them was noted eight packets of *Cinchona* bark. However, the main collection of barks and woods from *Cinchona* would remain separated from the rest of materials of *Flora Peruviana* with its own inventory. In 1875 Colmeiro counted 586 packages, 39 of which included cascarillas or quinas within the special collections of Peru and Chile (Colmeiro 1875). This number of species relative to the barks agrees with that outlined in the 1831 list, (AJB, Div. IV, 15, 3, 14), except one. Colmeiro had a special interest in these collections, and in the "Catálogo de la colección quinológica de J. Pavón" (AJB, Div. I, 96, 4, 11) he marked those he took for his own collection ("I have mine marked with +"), later with a selection of these barks from this and other expeditions, he created a collection under the name "Quinas del Jardín Botánico. 1878" (AJB, Div. I, 14, 2, 11). Ten of these specimens are from the "Real Expedición" and are now preserved in the MAF herbarium of the Facultad de Farmacia of the Universidad Complutense University de Madrid, without any record of how they got there (González

Bueno & Bermejo 1989: 195). Later, Colmeiro presented a "Colección organográfica" of the RJB at the Congress of Americanists held in Madrid in 1881 (Pérez de Guzmán 1881: 307). The collection of cascarillas from the "Real Expedición" is also mentioned in the 1911 guide to the RJB (Gredilla 1911) and some specimens were exhibited in the *Exposición Retrospectiva de Historia Natural* that was held in the "Pabellón Villanueva" del RJB in 1929 (Real Academia 1932: 31).

These collections remained in the "Pabellón Villanueva", and after a long period of decline of the RJB in the 1960s and 70s, they were moved to the new research building. In 1984, Paz Cabello Carro carried out an examination of the drawers of the old "special collections" and recognized in them packages of barks from Peru (AJB. Div. I, 205). The collection of barks was recovered and cataloging began in 2002 (García Guillén & Noya Santos 2017).

At present, we can recognise three groups in the RJB collection:

– 23 original packages and one drawer of barks (total 24). Seventeen of these packages have original Pavón handwritten tags attached that correspond to the catalog he made in 1823 (by species number) and to the list of 1831 (by package number). Furthermore, two packages correspond to the 1831 list and three only carry the package number without further information, so they cannot be related to the list confidently. The labels of four of the packages lack enough data to relate them to either references. The seventeen other remaining packages can be related to the species in the catalog and other materials, and they can be considered as related reference material for Pavón's quinological collection and his *Nueva Quinología* manuscript of 1826, later published by Howard and now in London.

– 23 packages of barks in more modern packaging, with labels and inscriptions made in the second half of the 19th century that copy the original labels, but without including package number or species number, so it is not possible to relate them to the Pavón inventories. These packages correspond to the list of the collection of "Quinas del Jardín Botánico" organized by Colmeiro in 1878 (AJB, Div. I, 14, 2, 11).

– 19 *Cinchona* woods, of which 18 have inscriptions on the cut end, and 16 of them have original tags tied with rope, some are quite damaged, so they have lost data. Even so, we can relate twelve of them to the 1823 catalog and nine to the 1831 list. In four cases we have been able to relate the wood specimen with the bark package and herbarium sheets.

In addition, there are 25 packages of bark whose collection cannot be established due to lack of data, and that have been left out of this study, since they could also belong to the "Real Expedición Botánica al Virreinato de Nueva Granada" [Royal Botanical Expedition to the Viceroyalty of New Granada] (1783–1816), as is the case of MA-CARPO 100334, with the inscription "Quina Baya de Santa Fé". This group is also related to the quinological collection created by Colmeiro in 1878.

Unlike the Kew collection, there are no *Cinchona* seeds found in the Madrid "Real Expedición" collections.

Descriptions and drawings

At some point after the collection's entry into the RJB in 1831, the "Real Expedición" manuscripts were separated from the biological material and integrated into the RJB Archives as reference material. Of the documents related to *Cinchona*, 12 handwritten descriptions of different species are preserved, of which nine were grouped (Descripciones, n.d.). In addition, the two copies survive of the *Nueva Quinología* of Pavón, a copy in Madrid (AJB, Div. IV, 15, 1) and the original in London (LMA ACC/1037/855), the latter of which will be discussed in the Kew collection section.

According to Pavón, 41 drawings were completed to illustrate the *Nueva Quinología,* of which 11 had already been engraved in copper and 30 were still to be engraved (ACN, 21, 396, f. 10). After the official comparison of the material carried out in 1831 with the older Pavón inventories, 712 drawings were reported missing, and we believe that those of *Cinchona* were among those. It cannot be determined what happened to these as they have never been traced. Possibly they were sold by Pavón to unknown buyers. Today only three of these 41 drawings are preserved in the Madrid collection, which were originally among the Herbarium sheets: *Cinchona lucumaefolia* varietas (AJB, Div. IV, 2258), *Cinchona tarontaron* (AJB, Div. IV, 2257) and *Cinchona magnifolia* (AJB, Div. IV, 2256), all annotated with the species number from the 1831 catalog. All three are unpublished and were intended to illustrate the *Nueva Quinología*. Regarding the copper plates, three correspond to the second volume of the *Flora Peruviana et Chilensis* and two are unpublished: *Chinchona uritusinga* ined. (AJB, Div. IV, C, 539) and *Chinchona macrophylla* ined. (AJB, Div. IV, C, 34). As in the case of the drawings, these are the only examples that have come down to us of the eleven engraved copper plates made that, according to Pavón, were intended to illustrate his *Nueva Quinología.*

Connecting the "Real Expedición" sub-collections

Both the *Cinchona* catalog from 1823 and the list of packages from 1831 allow us to associate the reference material that Pavón had prepared for his publication, the *Nueva Quinología*. Herbarium sheets, barks, wood, descriptions

and drawings were organized around two key pieces of information: species number and package number. Through cross-correlation we can attribute other attributes, such as drawing number, and description number. We can now confidently ascribe to the collection that Pavón formed and used to write his *Nueva Quinología* seventeen bark packages, forty-nine herbarium sheets, twelve wood sections, three drawings, and two copper plates (see Supplementary Data table https://doi.org/10.6084/m9.figshare.15081633).

As an example of this, species No. 24 from the *Cinchona* catalog of 1823: "*Cinchona magnifolia*... Flor de Azahar, está ya publicada, nada falta… hay tronco y esqueletos" [Translation: *Cinchona magnifolia*... Flor de Azahar is already published, nothing is lacking... there are wood and herbarium specimens] (AJB, Div. IV, 15, 1, 3, 4v), corresponds to package number 6 in the 1831 list. This gives the following related items, which can be seen in Figure 3:

Bark package: MA780956 (MA-CARPO-100028), see Figure 3a.

Wood: MA944755 (MA-CARPO-100424), see Figure 3b.

Herbarium sheet: MA815853, see Figure 3c.

Drawing: AJB, Div. IV, 2256, see Figure 3d.

This specimen was published in the *Flora Peruviana* (Fl. Peruv. 2: t 196. 1799) and in the *Quinología* (Ruiz 1792: 71), and this set could be considered potential original reference material for *Cinchona magnifolia* Ruiz & Pav.

The Kew Collection

"Real Expedición" botanical specimens of *Cinchona* and related genera are kept in the Herbarium (K) (pressed plants) and the Economic Botany Collection (EBC) (seeds, wood and bark), see Table 1. There are also some prints of *Cinchona* from Ruiz and Pavón's *Flora Peruviana* in the Library and Archives Illustrations Collection (*Cinchona* files).

Herbarium specimens

"Real Expedición" herbarium specimens and illustrations were discovered in Lima by botanist Andrew Mathews (1801–1841) between 1833–1835. He believed them to be those of Ruiz and Pavón, left behind on their return to Spain. The herbarium specimens were then sent to William Jackson Hooker (1785–1865). However, as stated before, these were collected in the latter part of the "Real Expedición", under Tafalla and Manzanilla between 1788–1816 (Miller 1970; Pupulin 2012a; Tepe 2018). At the time of receiving these herbarium samples, Hooker was Professor of Botany at the University of Glasgow, later joining Kew in 1841. After his death, his personal herbarium was absorbed into Kew's, being stamped 'Herbarium Hookerianum, 1867'. Because Mathews had labeled them as 'Ex Herb R&P', and then Hooker had written, 'Mathews, 1833' etc., some of these specimens have been databased by Kew as collected by Mathews or Ruiz and Pavón, but these records are currently being corrected.

A brief assessment of the rest of the herbarium collection of *Cinchona* related species shows at least six specimens that can be confidently assigned to Ruiz and Pavón, two from Lambert's own herbarium. These latter two are attached to the same sheet and are now under the determination of *Macrocnemum roseum* (syn. *Cinchona rosea*), and are labelled 'Herb. reg. Berolinense, Ruiz legit ex. herbario Lamberti' (K001436606/K001436607). Two other specimens labelled 'Herb Pavón', *Macrocnemum roseum,* 1784, with a "Ruiz/Pavón Expedición" label, 1784 (K001436605), *Ladenbergia magnifolia* (syn. *Cinchona magnifolia*), undated, and two *Cinchona purpurea* (K001337111/K001337112), come from the herbarium of Swiss Botanist William Barbey (K001435731). K001436605 is related to RJB specimen MA885880. How these herbarium specimens arrived at Kew is not clear, though Miller suggests that Lambert specimens at Kew are the result of swapping between the 'loyal friends', Lambert and Hooker (Miller 1970, p. 506). There are, in addition, other Lambert *Cinchona* species with unclear origins which may or may not be part of the Ruiz and Pavón collection. We have also seen further *Cinchona* herbarium collections from Ruiz and Pavón's period of collecting in the "Real Expedición" at the Natural History Museum (NHM), London. These were purchased by the British Museum (precursor to the NHM) from the collections of Aylmer Bourke Lambert (see next section).

Because of Covid-19 restrictions, a full assessment of the Lambert-Pavón herbarium, which remained with the British Museum (and now with the NHM, London), was not possible, but there are at least 45 specimens in the *Cinchona* cupboard alone. Some, but not all, of these herbarium labels also match the names of the barks found at Kew, though they are written in a different hand.

Barks, woods and seeds

The EBC specimens are relatively recently acquired from two sources. The first were sent by the NHM (BM herbarium) between 1979–1982, when it was deemed that such *Cinchona* specimens 'had no logical place in our department' (Cornish 2011). These were originally purchased from the estate of British botanist Aylmer Bourke Lambert (1761–1842), who had in turn purchased them from Pavón between 1816–1817. This will be referred to as the Lambert-Pavón collection.

The second accession came from the Royal Pharmaceutical Society (RPS) in 1983 as part of the deaccession of 10,000 "materia medica" items from its Museum (Hudson & Boylan 2013). The donation included a sub-collection of

Fig. 3. Examples of RJB specimens from the "Real Expedición", showing *Ladenbergia macrocarpa* (Vahl) Klotzsch (syn. *Cinchona magnifolia*), species No. 24 according to Pavón's Catalog: **a,** bark samples; **b,** wood sample; **c,** herbarium sheet; **d,** unpublished drawing intended for the *Nueva Quinología.*

Cinchona specimens received from quinologist and pharmaceutical manufacturer, John Eliot Howard (1807–1883). Howard had purchased "Real Expedición" barks and the original manuscript of the *Nueva Quinología*, from a 'botanist in Madrid' in 1858 (Howard 1862, p. ii). The botanist had allegedly bought these either direct from Pavón at the time of his death or shortly after, and offered them to Howard for a cost of 500 duros (RBGK Archives, unsigned, undated manuscript, JEH/1/14). These will be referred to as the Howard-Pavón collection.

An overview of the two collections can be seen in Table 1 and an excel spreadsheet with further details in supplementary data (https://doi.org/10.6084/m9.figshare.15081633).

The Lambert-Pavón collection

Aylmer Bourke Lambert was a British botanist and a co-founder of the Linnean Society. Lambert had wide-ranging interests, including *Cinchona*, publishing works on the genus in 1797 and 1821 (Lambert 1797; Lambert 1821). To further his botanical knowledge, Lambert negotiated with Pavón, in the year of Ruiz's death, to buy the herbarium 'containing nearly all of the plants collected' from the *Flora Peruviana* for £1500. The collection also included bark specimens, woods and mixed fruits and seeds, arriving in batches between 1816 and 1817 (Lambert 1821; Howard 1853; Steele 1964; Miller 1970). Details of the full history of this acquisition and its later sale to institutes after Lambert's death are given by Miller (1970).

The sale appears to have been undertaken in secrecy. Mariano Lagasca was the Professor of the RJB from 1807, and Director from 1815, during which time Pavón, located in the "Oficina de Flora", sold the specimens. Whether Lagasca had known of their sale at the time is not known, but during his exile to London between 1823 and 1834 he visited Lambert's collection. A visitor to Lambert's house around 1827 noted "Whilst we were employed in viewing Count Lambert's treasures, a little man dressed in black entered the apartment; and he cast a glance full of sorrow and indignation upon some packages which belonged to the herbarium of Ruiz and Pavón" and on enquiry discovered this to be Lagasca (Schultes 1830, p. 63). The motivations behind Pavón's decision to sell the collections after the death of Ruiz is not known but rivalry with Lagasca, desire for greater recognition and financial issues may have motivated these sales.

Letters to Lambert from Pavón in Kew's archives, given to William Hooker by a trustee of Lambert's estate (Miller, 1970), evoke this general atmosphere. Pavón appears to be maneuvering himself for greater recognition within the botanical world and his collections provided economic as well as social currency. The letters discuss the sale and include Pavón making proprietorial references to 'my herbarium' (RBGK Archives, Lambert Letters, J.A. Pavón to A.B. Lambert, 25 May 1820, f.153) and contain disparaging comments by Pavón who calls Lagasca 'Sujeto' (subject / this individual) (RBGK Archives, Lambert letters, letter from J.A. Pavón to A.B. Lambert, 9 August 1815, f.107). Pavón later also asks for other favours, such as ordering a gold watch from London (RBGK Archives Lambert Letters, J.A. Pavón to A.B. Lambert, 25 May 1820, f. 153). Lambert also proposed Pavón as a Foreign Member of the Linnean Society, which was eventually achieved in 1820 (Steele, 1964). However, this sale was not without consequences for Pavón; as previously mentioned, the 1831 inventory of the collections found significant losses, and his employment and salary were terminated (Rodríguez Nozal, 1993).

Lambert's purchase included a herbarium of 'numerous specimens, both in flower and fruit, of all the species of the highly interesting genus *Cinchona'* (Lambert & al. 1821, p. 7). He also describes 44 bark samples (Table 2), 36 wood sections (with labels in Pavón's hand), and a collection of *Cinchona* capsules with seeds (Howard 1853). Pavón also sent three lists corresponding to the barks and woods. Lambert published a description of *Cinchona* as well as a list of his bark specimens (names based on Pavón's second list) in the *Illustrations of the genus Cinchona* (Lambert 1821, p. 95). After Lambert's death, the British Museum bought the collection of herbarium and barks (Miller 1970, p. 539). These were later described as the 'largest original collection of *Cinchona* barks in England', and described as being in their original packaging, probably like the Madrid specimens today (Howard 1853, p. 1). Today, the labels on the Kew specimens match the packaging and handwriting of the bark specimens in Madrid but the labels seem to have been cut down to size from the annotations on the larger original wrapping, the author is unknown but possibly

Table 2. *Cinchona* and related genera sub-collections of the Kew Economic Botany Collection, from Pavón via Aylmer Bourke Lambert (1816) and John Eliot Howard (1858).

	Barks	Wood	Seeds	Total
No. of Lambert-Pavón specimens	56	35	23 packets (under 1 accession)	114 (92 accessions)
No. of Howard-Pavón specimens	16	0	0	16
Total	72	35	23 packets (under 1 accession)	130 (108 accessions)

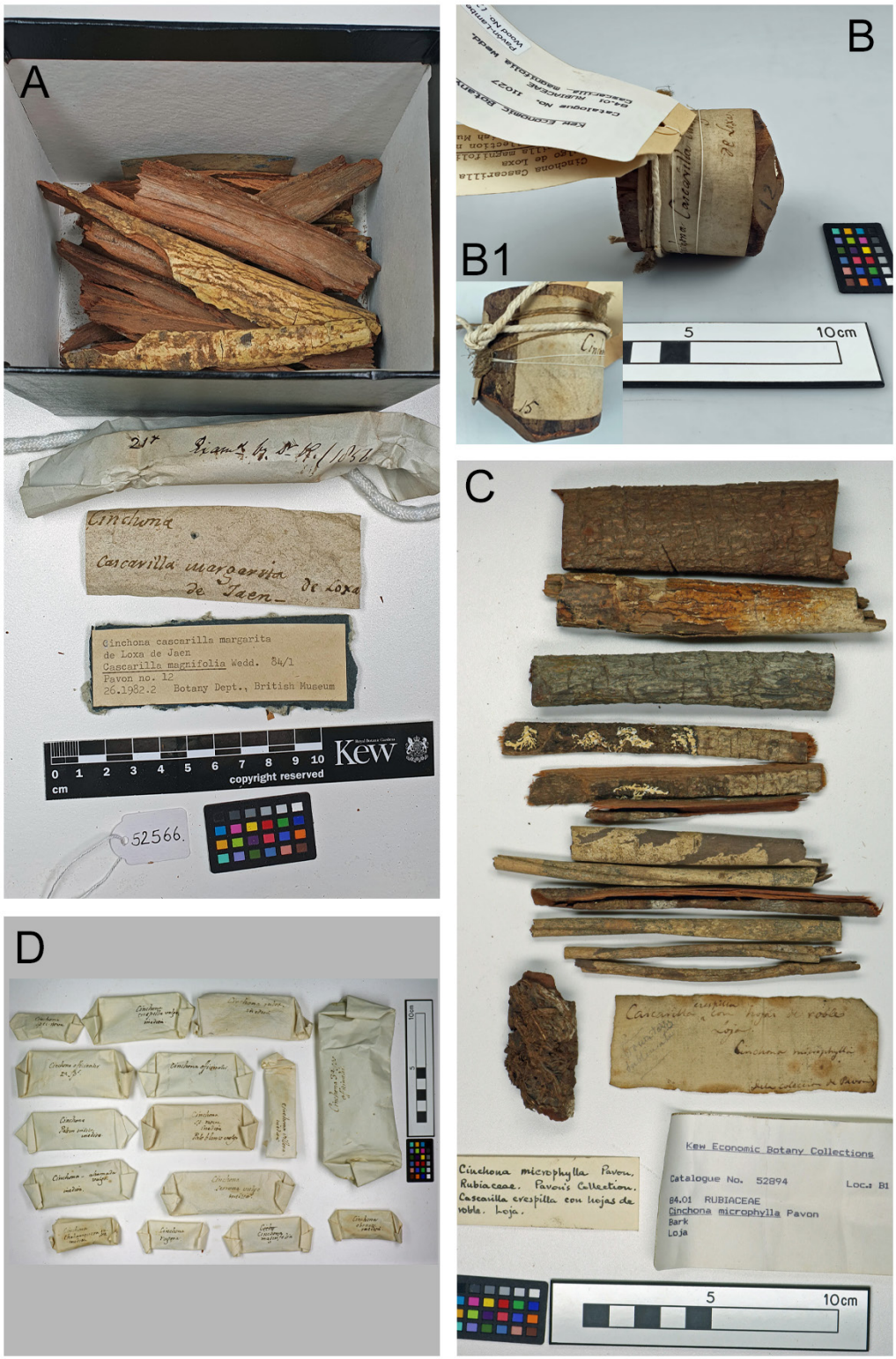

Fig. 4. Clockwise from top left, an example of Lambert-Pavón collection of *Cinchona* L.: **a,** *C. magnifolia* (now *Ladenbergia oblongifolia*) bark ("Cinchona Cascarilla margarita de Jaen de Loxa") with labels in handwriting possibly by Manzanilla (EBC 52566); **b,** wood sample of *C. magnifolia* ("Cinchona Cascarilla margarita de Jaen de Loxa"), with a label matching Pavón's handwriting, and a close-up of Howard's annotation on the label referring to the matching bark specimen (EBC 11027), with (**b1**) close-up of corner label with Howard's addition showing the number of the wood corresponding to Pavón's third list; **c,** Howard-Pavón bark specimen (EBC 52894) of "Cascarilla Crespilla con hojas de roble" (*C. mutisii* syn. *C. microphylla*); **d,** a selection of seed packages in Ruiz' handwriting (EBC 52577).

Manzanilla (Howard 1853, pp. 2–3). An example of these can be seen in Figure 4a

Quinologist and quinine manufacturer John Eliot Howard and pharmacologist Jonathan Pereira (1804–1853) studied the Lambert-Pavón collection with Howard publishing an overview, in the year of Pereira's death, in *An Examination of Pavón's collection of Peruvian barks contained in the British Museum* (with a later appendix) (Howard 1853, 1855).

Howard described the barks as 'almost bewildering otherwise in their unclassified state' and brought his own reference specimens to help analyse and arrange them (Howard 1853, p. 2). Howard noted that 7 of the original 44 barks were missing, but 36 woods remained. Howard created a reference table in the publication to display the relationships of the barks to the woods using the original numbers for the barks as published in Lambert's *Illustrations* and the three lists Lambert also received from Pavón. The numbers for the woods were taken from the ones found written on the stump ends. This numbering has aided the matching up of many of the EBC wood and bark specimens to the Howard and Lambert (Pavón) lists (see supplementary data table https://doi.org/10.6084/m9.figshare.15081633). The 36 woods survive (now at EBC), numbered 1 to 37, with no specimen numbered 34. An example of these can be seen in Figure 4b.

In his table, Howard (1853) mentions more barks than are shown in Lambert's original list of 44, but it is not clear exactly how many barks Howard actually saw in the collection due to the confusing numbering system used in his reference tables (Howard 1853). His system is based on cross-referencing the three different Pavón lists he saw, leading to occasionally overlapping numbers. On the woods, Howard added a small number in the bottom left hand corner that matches the wood to Pavón's 'third list'. The species he assigns them to can be matched to the *Nueva Quinología* (1826) which is also the same as Pavón's 1823 catalog (AJB, Div. IV, 15, 1, 3). Under each species in those lists, common trade bark names can be found which correspond with the barks examined by Howard. In letters kept at Kew from Pavón to Lambert, 53 barks appear to have been sent which may explain some of the difference between the 44 barks listed in Lambert's publication with the amount Howard saw later (RBGK Archives, Lambert letters, letter from J.A. Pavón to A.B. Lambert, 1816, f.115). Howard further explains one reason for this difference, noting: 'there are eight packets, of which no account can be given, except that they appear to have been obtained from the same quarter' (i.e. Pavón's sale to Lambert) (Howard 1853, p. 31). At Kew, there are now 56 Lambert-Pavón barks surviving.

Lambert's purchase included *Cinchona* seeds in paper packages. The original number purchased is not known, but today there are 23 packets accessioned under one number (EBC 52577). Howard does not mention these in his assessment of the collection. These seed packets can be seen in Figure 4c and have the same paper folding technique and handwriting found on other seeds collected by Ruiz and Pavón in the RJB. In Pupulin's examination of the Orchidaceae of the "Real Expedición", the orchid seed packages shown match the paper and folding technique, and the handwriting is thought to be Pavón's (Pupulin, 2012b, p. 180).

It is curious that no *Cinchona* seeds survive in Madrid, leading to the question of why such a valuable resource (with potential for cultivation) was not used by the Spanish. The surviving seeds do not appear in the RJB's seed book listing all those that entered the garden for planting, and hence we know their absence is not because they were planted in the garden. Perhaps Ruiz and Pavón knew the seeds were no longer viable by the time of their return to Spain (*Cinchona* seeds have a short shelf life). Alternatively, they may have become detached from herbarium specimens, as some of the names roughly match those found in the NHM, London, which bear fruiting material.

The Howard-Pavón collection

After studying the Lambert-Pavón collection, Howard felt that '...the subject was left in an incomplete, and therefore unsatisfactory state; and I could not help surmising that there must remain at Madrid further results of the labours of the Spanish botanists which might throw light on the many questions still left in obscurity' (Howard 1862, p. ii). Howard made enquiries and in 1858 purchased a collection of 54 barks and the original manuscript of the *Nueva Quinología* (ca. 1826), in Pavón's hand (Figure 5) 'from a botanist in Madrid' (Howard 1862, p. ii). The Madrid botanist may have been Miguel Colmeiro. Researcher Eduardo Estrella suggests this because Colmeiro published *La botánica y los botánicos de la península hispano-lusitana,* also in 1858, in which he mentions the *Nueva Quinología* manuscript (Colmeiro 1858, p. 48). The manuscript and specimens were kept for a short time by Colmeiro, presumably until 1858 (Estrella 1987). In addition, the barks Howard bought have labels that relate them to the specimens that are now in the faculty of Pharmacy Universidad Complutense, also likely sent there by Colmeiro (see Figure 4d). For an overview of the specimens, see Table 2.

The manuscript Howard purchased, the *Nueva Quinología,* is now held by the London Metropolitan Archives (LMA ACC/1037/855), deposited as part of the Howard family business archives in 1969. On the manuscript folder, a letter is attached, dated 2 February 1858, Hippolyte Bailliere, a scientific book dealer acting as intermediary, informing Howard of the sending of the man-

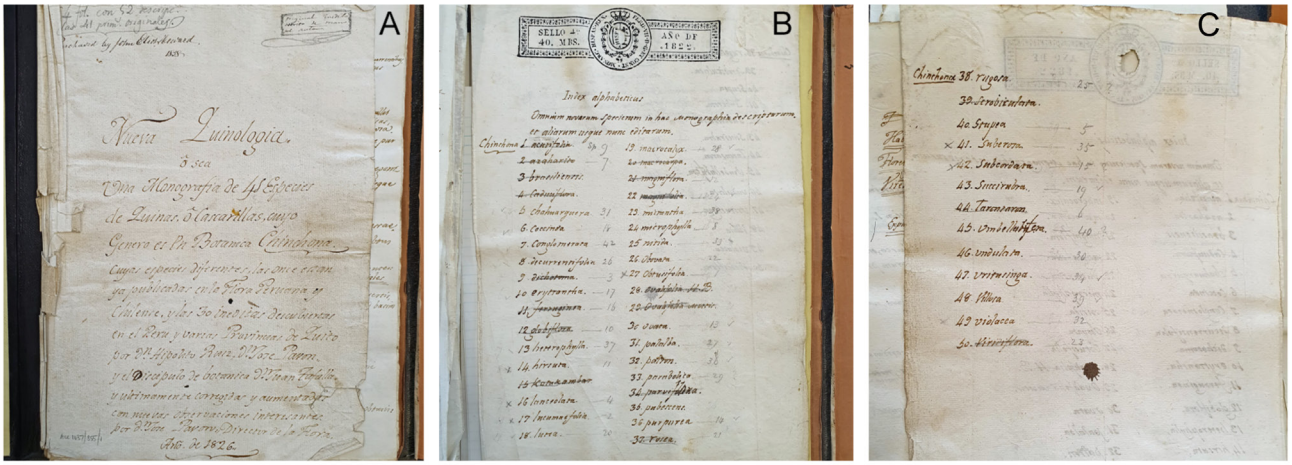

Fig. 5. Images of Pavón's *Nueva Quinología,* 1826: **a,** the front page; **b-c,** the two pages of the index alphabeticus. Copied out in the top left corner, it says '4 fol con 52 descripc. Las 41 prim. Originales', this corrects the description in the text which says 48 species. After this note, in ink it states, 'Purchased by John Eliot Howard, 1858' (in Howard's handwriting). London Metropolitan Archives, ACC/1037/855.

uscript from Madrid. Bailliere also writes that Vicente Cutanda, professor of the RJB, is sending a written list of herbarium species there for information 'but are not to be sold and therefore cannot be got'. An excerpt of the manuscript can be seen in Figure 5.

As Howard was unable to procure the herbarium specimens for himself, he sent the botanical artist, Walter Hood Fitch (1817–1892) to illustrate them from the pressed specimens, in effect replacing the lost Ruiz and Pavón illustrations. These botanical plates, along with microscopical analyses were published in the *Illustrations of the Nueva Quinología of Pavón* (Howard 1862). Some of these original Fitch sketches and illustrations can be found in the archives at Kew, which contain a note from H. Bailliere (to Howard, dated 1 June 1860) regarding them. In the same file is also a series of preliminary pencil sketches and 12 original illustrations created by Fitch from the Madrid herbarium, some of which became plates for Howard's 1862 publication *Illustrations of the Nueva Quinología of Pavón* (file in Kew's Illustrations collection under *Cinchona*, no reference number).

The specimens in the manuscript were listed alphabetically (Fig. 5), but Howard renumbered them in pencil to match Pavón's original species list, matching the 1823 Catalog (AJB, Div. IV, 15, 1, 3). In Howard's published edition of *Illustrations of the Nueva Quinología of Pavón*, he lists the species corresponding to Pavón's list, and then under each species description, he lists barks by trade name. These trade names can also be found in the list of barks and woods he provides in the *Examinations*.

Most of the Howard-Pavón barks are, however, lost to time. In 1952, the collection was redistributed, probably owing to a restructure of Howard's family business, Howards and Sons who acted as caretakers of the collection (Richmond & Stevenson 2003). The RPS Museum had previously received donations of *Cinchona* barks directly from John Eliot Howard throughout his career (Howard 1854; Hudson & Boylan 2013). In January 1952 Howard's collection of 292 trade-collected barks, housed in a walnut cabinet, was accessioned into the Museum. Later in October, another list of specimens was offered to the RPS (Anthony Howard to J.M. Rowson, Pharmaceutical Society of Great Britain, Ref JAEH/GC, 28 October 1952; RPS File 88, *Cinchona* shelves, Economic Botany Collection, Royal Botanic Gardens, Kew). This was a selection of about 600 further barks, including ones sourced from other scientists, but the RPS accepted only 120. This list, with its checked selections by the RPS still exists ('Catalogue of Cinchona bark collection', 1952, London Metropolitan Archive ACC/1037/695). Although the compiler gives the scientific names of the barks, other data such as collectors and dates rarely appear, as the list is an non-expert inventory rather than an historical assessment. Pavón materials are therefore difficult to identify within it. It is clear from the ticked choices that the Society decided to make selections to fill 'gaps' of missing (and thus rare) species rather than accepting the entire collection, probably due to limitations of space. By the 1950s, use of the RPS Museum specimens for education was in any case declining (Hudson & Boylan 2013). This form of decision-making has been noted before in botanical collections, in what was called historically at Kew, 'intercalation' (Cornish 2013, p.248). Within the barks that were chosen, only 16 specimens that can be identified as Pavón barks were retained, likely by chance because they were examples of uncommon species with older, unusual names. Of these, there are 10 *Cinchona*, 4 *Ladenbergia* (syn. *Cascarilla),* 1 *Remijia* and 1 *Pimentelia*

barks. An example of these barks and their distinctive labels, distinct from the Lambert collection, can be seen in Figure 4d. More often than not, curators at the RPS repackaged the barks and the older labels were discarded (possibly due to being affixed to older packaging) and a transcribed label put in their place. When the RPS transferred their entire "Materia Medica" collection to Kew in 1983, they reserved a small collection which included around 33 Howard associated *Cinchona* barks. Of these, there is some evidence around 4 may be Pavón barks, though due to COVID-19 restrictions, the collections were unavailable for access.

Further research has shown that other specimens were sent to the Wellcome Historical Medical Museum (now the Wellcome Collection, on loan to London's Science Museum). In 1958, Anthony Howard donated 79 specimens to the museum, made up of about 30 barks and 50 alkaloid samples (Wellcome Collection; archives of the Wellcome Historical Medical Museum and Library; Cinchona Tercentenary Collections; WA/HMM/EX/C/5). There are also hints that some barks remained with the museum after an earlier exhibition. In 1930, the Wellcome Collection invited Howards and Sons to provide barks for display at their Cinchona Tercentenary Exhibition, marking the approximate tercentenary of the discovery of the anti-malarial drug. Many items were lent, including 84 bark samples from the company's collection and a further 44 Pavón barks, the latter numbered 1059–1102 in the exhibition handbook (Wellcome Institute 1930, pp. 20, 107). Several of the RPS-Howard-Pavón barks now at Kew still retain the exhibition display numbers, confirming they are the same items. For some *Cinchona* samples accessioned into the collection, the accessioner pencilled in '...the source is not stated, I suggest that the exhibits may have been presented by Howards and Sons at the time of the tercentenary' (Wellcome Collection, Museum Accessions Register Vol 31: note found between Accession No.s 46 and 47 but referring to accession no.s 43 to 83/1958, WA/HMM/CM/Acc/51). However, a letter at the time of the Tercentenary Exhibition clearly shows that the Howards and Sons display was only on loan with a request for advanced notice of their return (Wellcome Collection: Tercentenary Exhibition 'H' General Correspondence WA/HMM/EX/C.19: Lloyd Howard to L. Malcolm, Curator, 25 November 1930). Potentially some or all of these barks may have not been returned, remaining in storage and being formally accessioned into the register by 1958. This may have been coincidental to Anthony Howard's donation or triggered by it (Wellcome Collection 'Wellcome Historical Medical Museum and Library Index Cards' 347/1958–427/1958). The Wellcome Collection specimens are now held by the Science Museum and are currently inaccessible. They remain a subject for further research.

Incidentally, the Wellcome Collection also contains other "Real Expedición" items, donated in 1930 to the Tercentenary Exhibition by King Alfonso XIII of Spain. These include three packaging cases with barks, used to transport *Cinchona* materials: one rawhide 'seron', and two wooden & hide 'corachas' (Science Museum, A654763, A655407 and A654761) (Wellcome Institute 1930, p. 17).

It is not known what happened to the remainder of Howard's *Cinchona* bark collection, but it is likely to have been eventually discarded. The London Metropolitan Archives contain the Howards and Sons business archives and may provide an answer, but so far no note has been unearthed. No barks were donated to Kew at this point, and it is not thought to have passed to descendants, with whom the authors of this paper are in communication.

Descriptions and drawings

None of the missing "Real Expedición" images have been found at Kew. Nor have they been identified through preliminary enquiries to the British Museum and the Natural History Museum.

Reconnecting the "Real Expedición" Collections at Madrid and Kew

Under modern collecting protocols a unique numerical reference is assigned to specimens at the point of collection, acting (in combination with the collector name) as a key to associated data such as field notes, seeds, ethnobotanical items and genetic samples. However Ruiz and Pavón, in common with collectors of their time, did not follow this approach. Inventory lists sent to Madrid contain sets of numbers which do not match specimens that followed. Nor was the maintenance of these identification systems always effectively curated after collection, with reorganizations leading to relabeling and renumbering. In addition, not all barks may have been collected at the same time as herbarium specimens, such as the barks derived from commerce sent over after 1803, and it is possible that some of those at Kew include this type (ACN, 17, 305, f. 1).

We have been successful in establishing relationships between some of the different categories of specimens within the Madrid and Kew collections, in particular in linking Madrid specimens to the *Nueva Quinología* manuscript of 1826, and Kew specimens to Howard's 1853 study, but mostly unsuccessful in our original intention, to correlate the specimens held in the two institutes. There are no unique reference numbers which would enable us to match specimens between the two collections. Trade names and species names sometimes match, but these can be misleading. These specimens were not historically handled as 'duplicates' in the modern botanical sense of the word ('multiple specimens from a single herbarium gather-

ing'; Beentje & Williamson 2016, p. 45), rather they were considered exemplars of the same species, used for redistribution, a phenomenon recently noted in Kew's Economic Botany Collection (Cornish & Driver 2019).

In the case of the barks, woods and seeds at Kew, links to Madrid herbarium and illustration numbers have not been found, though in some cases this may be due to them being barks of commerce. It is likely that when these were split from the original Madrid samples, their purpose evolved away from their original collection structure as linked "Real Expedición" bark-wood-herbarium specimens. Instead, once separated they became a discrete set of orphaned reference samples. However, we were able to identify several lists of numbers applied in Madrid and Kew that clarify specimen relationships. In the Kew collections, any numbers associated with specimens are usually consecutive, e.g. if there are 36 barks, they are numbered 1–36 and only relate to that discrete collection. Other associated numbers also refer to other systems. Pavón's species list, discussed in the section on the Howard-Pavón collection, assigns species a number between 1 to 50. Howard additionally renumbered this list in pencil to align it to Ruiz's original list, then organized the barks in the publication under the species classification of British-French quinologist Hugh Weddell (1819–1877). There are frequent overlaps in numbers which cause confusion.

Visual matching of the barks at Kew and Madrid was also attempted though we found it difficult to assess similarity in appearance. The woods at Kew do not match names and circumference/diameter dimensions of the woods in Madrid, and therefore do not seem to have been simply chopped from the ends of the trunks for distribution. The wood specimens at Kew are larger, more uniform and bear different names than those found in Madrid, which may be evidence for Pavón selling the best of the collection to Lambert.

Conclusions and future research

Due to the complex relationships between Spanish botanists, difficulty with the taxonomy of the genus, and unstable politics both in Spain and in its colonies, the collecting, naming and curating of the *Cinchona* materials from the "Real Expedición" was messy, complicated, and ultimately unfinished. The sale of part of the collections by Pavón and later botanists further fragmented the collection. The ultimate logic behind how the Ruiz and Pavón collection was split into parts and sold to other botanists remains unclear. However, we have made significant progress in understanding the organization and numbering systems subsequently applied to the specimens in Madrid and Kew.

Although we found no direct correspondence between the specimens and the collecting itinerary of the "Real Expedición", nor between the specimens in Madrid and Kew, these collections remain an important research resource. The lack of traditional provenance data reinforces the importance of genetic analysis as a means to determine the species and geographical origin of specimens, and as a means to test whether some are true duplicates. Such work would enable a rich, renewed investigation of the collecting and naming practices of the botanists of the "Real Expedición".

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