



ARCHLAB Access report

Project Title:

TEXTILES, TRADE AND TASTE: PORTUGAL AND THE WORLD

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Sub-Project: "The Red Road of the Iberian Expansion: Cochineal and the global dye trade"

Institution: CHAM, FCSH-UNL & UAç

Other researchers

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Sub-Project: "Imperial Colours: The impact of the Portuguese Expansion on Chinese silk production (16th to 17th centuries)"

Institution: CHAM, FCSH-UNL & UAç

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Sub-Project: "New Carpets for New Markets: Production and Consumption of Indo-Persian Carpets, 16th and 17th centuries"

Institution: CHAM, FCSH-UNL & UAç

Date of ARCHLAB Access by the funded researcher

Date of Access at **Netherlands Cultural Heritage**: 25/7/2011 to 29/7/2011

Date of Access at **National Gallery of London**: 1/8/2011 to 2/8/2011

Date of Access at **British Museum**: 3/8/2011 to 5/8/2011

Background to the Project

The ARCHLAB Transnational Access, provided by the European Consortium CHARISMA project, grants the opportunity for carrying out research in the archives and laboratories of associated advanced facilities centres, from European Museums and Cultural Heritage Institutions. The possibility of being in touch with archives and researchers, from these European institutions, was very significant for the project TEXTILES, TRADE AND TASTE, PORTUGAL AND THE WORLD (TTT), under development at the CHAM, FCSH-UNL & UAç. The main aim of this project is the interdisciplinary study of historical textiles, by involving the work of a dozen of researchers from History, Chemistry and Conservation areas in Portugal. It currently comprises several sub-projects, which are especially focused on the historical and chemical study of ancient textiles, dating from 16th and 17th centuries.

The contact between TTT and CHARISMA projects was recently accomplished through the ARCHLAB Transnational Access, representing an important contribution for the development of Ana Serrano's PhD thesis, "The Red Road of the Iberian Expansion: Cochineal and the global dye trade". The invaluable visit to the Netherlands Cultural Heritage Agency (RCE), the National Gallery of London (NGL) and the British Museum (BM) allowed the exclusive contact with reports and databases concerning cochineal insect dyes and their analytical characterization in historical works of art, which is accomplished by specialized researchers at the advanced facilities from these institutions. This ARCHLAB Transnational Access grant revealed to be fundamental to acknowledge the research made on cochineal dyes until now, as it permitted a more definitive construction of the phases of this sub-project, which is described in detail below.

Cochineal Insect Dyes

Of all natural red dyes, cochineal insects (Figure 1) have always been an important commodity for world cultures, as they provided the most brilliant and enduring reds in dyed textiles. Indeed, there was great demand for them in fine luxury textile dyeing centres (Figure 2), especially because they were very difficult to acquire, and the dyeing processes were both complex and costly [1-5].

According to historical sources, until the medieval period, cochineal insects (*Porphyrophora hamelii* and *Porphyrophora polonica*), were mainly collected in Central Europe and Central Asia. These were used locally, or traded to the most important dyeing centres, such as Venice, where the most exquisite textiles were dyed with crimson hues, obtained from cochineal or kermes insects [1-2, 4-5, 7-9].



Figure 1 - Cochineal insects from *Porphyrophora polonica* species. **Figure 2** - Brocaded velvet from Turkey, Bursa, dated from 16th/17th century and belonging to Calouste Gulbenkian Museum (I.N.1388A). The red background was dyed with *P. polonica* [10].

With the Iberian Expansion, at the beginning of the 16th century, the Spanish created a commercial monopoly on American products, which included several new dyestuffs that would revolutionize traditional practices in Europe, and later, in Asia. Among them, a new species of cochineal (*Dactylopius coccus*), domesticated on cactus plants by the native populations of Mexico, was discovered by the Spanish to possess a much higher colorant content than kermes or the other cochineal insect species from the Americas, Europe or Asia. The economic importance of this particular insect to the Spanish Empire is attested by the historical sources which refer to it as being so profitable that it represented the most valuable product traded by the Spanish, after silver, during the 17th century. Indeed, in the second half of the 16th century, domesticated cochineal was already requested in the most important European centres of textile production and, from the beginning of the 17th century, the insect arrived in Middle Eastern and Asian markets by way of major trade routes, by land or by sea (Figure 3) [1, 3-4, 7-9, 11-13]. Previous publications have asserted that this dyestuff was swiftly adopted in Europe, and almost completely replaced all other insect sources of red, by the end of the 16th century, and that a similar process occurred when it was traded to Asia [3-5, 7, 12-15]. While this assertion is reasonably well documented for Europe, historical sources confirming the presence of American cochineal in Asian markets are rare. Hence, identifying the precise cochineal species used in Asian textiles would constitute important evidence for tracing the global impact of this dyestuff.

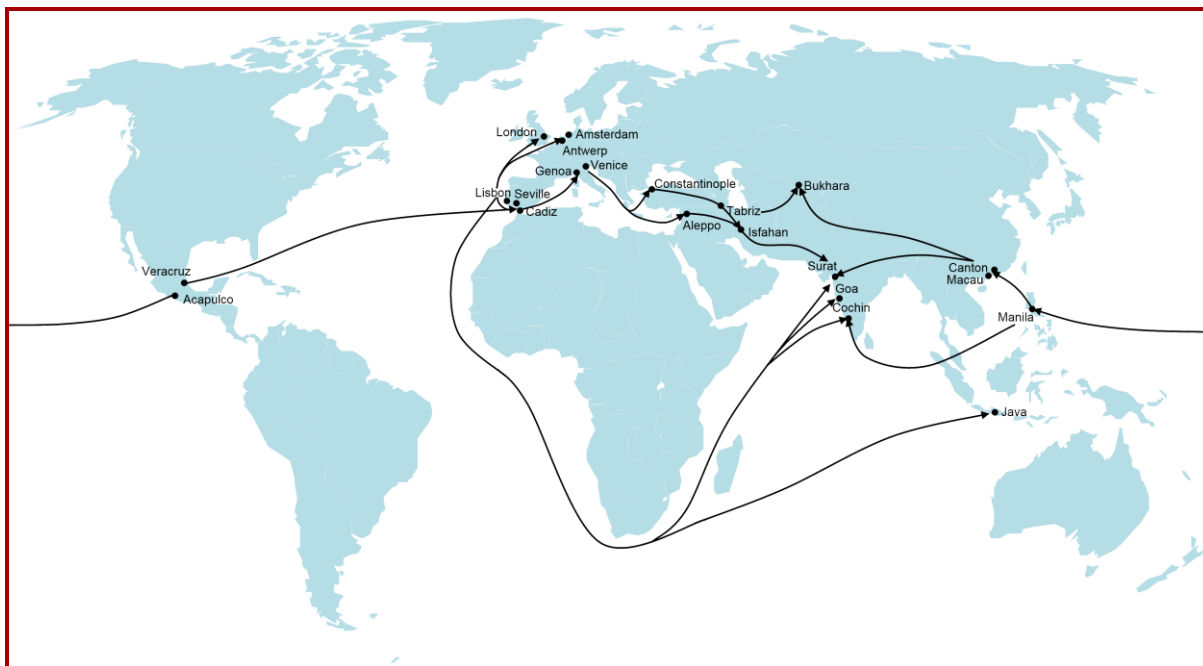


Figure 3 - Representative map of the major trade routes that shipped American cochineal insects between the 16th and the 18th centuries.

Study of Cochineal Dyes

The identification of cochineal species in historical textiles is an important tool for characterizing their provenance and date. Distinguishing cochineal species is generally achieved by using High Performance Liquid Chromatography coupled with Diode Array Detector (HPLC-DAD), which separates the cochineal dye compounds, permitting the distinction of the species present in the textiles (Figure 4). Developed by Wouters and Verhecken in the end of the 1980s [16-19], this technique is followed by quantified systematic analysis based on two compounds (dcII and flavokermesic (fk) + kermesic acids (ka)) that allows the distinction of the three most popular species of cochineal (*D. coccus*, *P. polonica* and *P. hamelii*) (Figure 5) [17-18]. This method of analysis has been used to the present day. However, recent taxonomic revision of the *Porphyrophora* and *Dactylopius* genus has revealed the existence of 57 different cochineal species. While 47 species, spread throughout Europe and Asia, are included in the *Porphyrophora* genus, *Dactylopius* includes 10 species, native to the Americas [15, 20-21]. Many of these species were available for preparing dyes, but these have not been well studied until now, mainly because literature on dye identification by HPLC-DAD has focused exclusively on characterization of the three most popular species in historical textiles, as they are most widely referred to in historical documents [2, 8 17-18, 23-25]. In addition, recent publications have revealed difficulty in distinguishing these three species, and, as a result, the presence of the American species may have been over-emphasized in analyses of textiles dating after the beginning of the 16th century [5, 7, 11, 24-25].

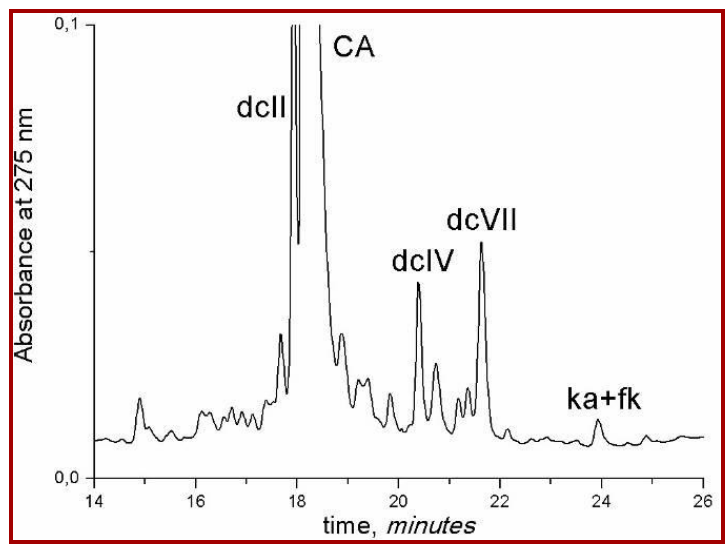


Figure 4 - Representative chromatogram from a *Dactylopius coccus* species [26].

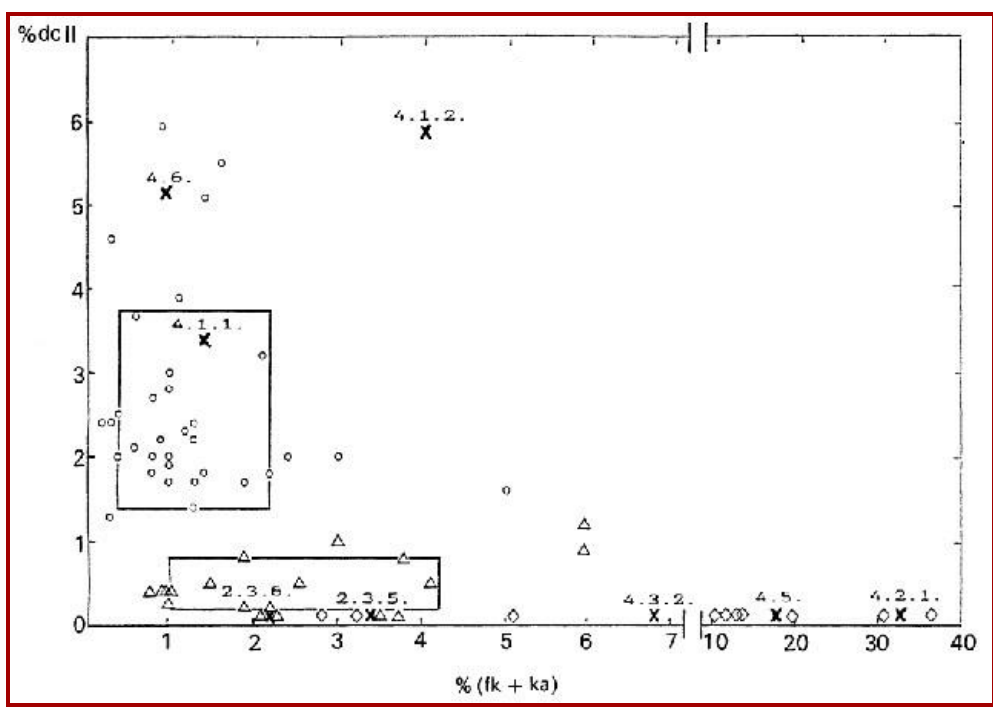


Figure 5 - Recognition of *D. coccus* (circle symbols), *P. hamelii* (triangle symbols), *P. polonica* (lozenge symbols) and historical textile samples (cross symbols) obtained by quantified systematic analysis, according with the Wouters and Verhecken method [18].

Scientific advances in the area of dye analysis have encouraged the development of new scientific methods for characterizing and distinguishing cochineal species [22, 27-32]. Recently, the work developed by Serrano *et al.* [10, 26], has shown, for the first time, that it is possible to identify different cochineal species in historical textiles, through HPLC-DAD analysis followed by Principal Component Analysis (PCA) (Figure 6). This statistical approach allows for a greater number of cochineal species to be correctly recognized and

identified in historical textiles, with successful results. Hence, this method provides the opportunity to conduct a detailed study into whether American cochineal was rapidly assimilated into European and Asian dyeing practices as suggested by previous publications: in Europe immediately after 1521, in Iran by the beginning of the 16th century, and in China after 1700 [2-3, 7, 11-12].

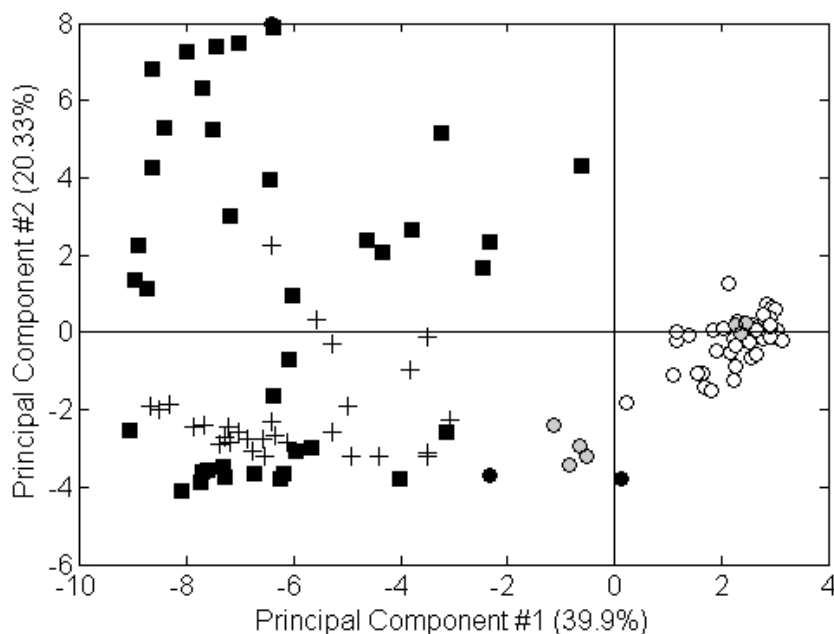


Figure 6 - PCA scores for the identification of cochineal species in historical textiles: *Porphyrophora* genus (solid squares), *D. coccus* species (open circles) and historical textile samples identified as *Porphyrophora* sp. (straight crosses) and *D. coccus* (solid grey circles) [10].

The main objective of Ana Serrano’s PhD thesis is to gain a comprehensive understanding of the revolution caused by American cochineal on both commercial routes and dyeing practices, in the main European and Asian textile-producing centres, soon after the beginning of the Iberian Expansion. This study involves a revision of the historical sources and published literature concerning the American cochineal trade, as well as other dyestuffs; and an optimization of the analytical method previously developed in [10], to correctly distinguish the cochineal species used to dye historical textiles, and establish their provenance and date. This distinction, in direct comparison with the historical records, is absolutely essential for a proper interpretation of the presence of American cochineal in historical textiles, to assess its adoption in Europe and Asia.

Questions Addressed by Access

In this sub-project, priority is given to the study of primary and secondary historical sources concerning the American dyestuff, as a commercial product, in the transatlantic

trade and its circulation and integration in European and Asian dyeing practices. The construction of a solid historical context is only possible by giving special attention to the evolving historiography, in relation to the introduction of the American insect, and by determining the extent to which arguments made so far by contemporary authors, namely Donkin [2-3] or Lee [12], are reliable.

Research on the literary sources is being undertaken in Portuguese archives and libraries, and their interpretation is being supported by the supervision of Dr. Jessica Hallett (CHAM, FCSH-UNL & UAç). Though, due to the limitations of these archives and libraries, it is extremely important to have personal contact with other European libraries, archives and databases to obtain a wider variety of resources and specialized literature, missing in Portuguese institutions. Scientific publications on historical textiles characterization also constitute valuable information, especially when the historical information is missing. Therefore, the literature review includes information regarding the scientific work undertaken during the last century on the characterization and identification of cochineal in historical works of art. Furthermore, involving chemists, historians and entomologists represents an interdisciplinary approach fundamental for developing an appropriate methodology for characterizing and interpreting this data with the historical context.

Hence, the chief questions addressed to the ARCHLAB Transnational Access to European archives were mainly related with the number of analyses so far undertaken for the identification of cochineal and other insect dyes, such as kermes, in historical textiles and historical paintings; and also, the extent of publications and historical sources accomplished on the historical, chemical and entomological characterization of these insect dyes, to this day.

Specific Aims of Access

The archives of the institutions belonging to the CHARISMA project, namely the RCE, the NGL and the BM, represented an obvious and important starting place for beginning such an evaluation of the study of red dyes. The archival dye data, such as reports, databases, analytical data and historical samples, gathered by investigators working in these institutions; their experience in the area of cochineal identification in historical textiles; and the access of secondary literature in the institutions' associated libraries, brought important contributions for the comprehension of the historical background on trade and dyeing traditions, as well as interesting influences for the chemical analytical approaches and interdisciplinary collaborations on cochineal species characterization.

Therefore, the access to the archival databases as well as the testimonies of the institutions' scientists about the current analytical approaches enhanced the possibility of making important advances in the analytical procedure and developing an approach to the

scientific characterization and identification of cochineal species in textiles and paintings in this project. While RCE and BM possess archives concerning previous experiences analyzing cochineal in historical textiles, NGL houses information on the identification of this dyestuff in paintings. The contact with the analytical data from these institutions contributed to gain a more complete view of cochineal results reported so far, and, through the date and provenance of the analyzed objects, to compare their analytical results with the obtained results for related works of art, which will be analyzed during later phases of this project.

Results and Achievements from Access

The research work performed at the three CHARISMA institutions was essential for the development of further phases of this project. Indeed, the research undertaken in the archives of these institutions revealed a large quantity of reports relating the presence of cochineal dye in historical works of art. However, as shown by Tables 1 to 7, the majority of the records concern objects of European provenance, dating from the late medieval period to the 17th century. Analyses of Asian objects are very small in number in comparison with the large number for European objects, and hence, further research will be undertaken during my PhD thesis. Nevertheless, the overall perspective offered by the reports was very helpful for a first evaluation of the types of historical textiles, and possibly paintings, which can be selected for analysis in later phases of this project. Also, it is important to note that reports about other insect red dyes, namely kermes, were considered, as they offer a valuable comparison with American cochineal and its acceptance in European centres of textile production.

The dyestuff identifications presented in Tables 1 to 7 also reflect a clear development in analytical instrumentation on the past few decades. Before the end of the 1980s, when Wouters and Verhecken created their analytical method to identify the most popular cochineal species in historical textiles through HPLC-DAD, analyses for characterizing dyestuffs in historical objects were based on UV spectroscopy or Thin Layer Chromatography (TLC) [16, 35]. Although today these methods are considered inaccurate and imprecise, they could successfully recognize the presence of carminic acid, the main component of cochineal species, in historical textiles, and this is observable from the results shown in Tables 1 to 3 and 6. The method of Wouters and Verhecken permitted much more advantageous analysis: not only a higher number of components could be detected, allowing the distinction of three cochineal species in historical textiles, but also smaller samples were required per analysis. Indeed, with TLC, circa 5 mg of textile sample were required [35], while with HPLC-DAD analysis only circa 0,2 - 0,3 mg are needed [10].

Currently, and as previously recorded, HPLC analysis, following the analytical method from Wouters and Verhecken, cannot provide a precise discrimination of cochineal species,

and, for this reason, this project pretends to optimize the analysis conditions and obtain more accurate results about the presence of American cochineal in historical textiles. As RCE possesses a large collection of well-documented samples that remain from previous analyses carried out over the years, these will be fundamental for this project, especially for the study of the extension of American cochineal in European dyeing practices, due to the significant number of textile samples available for this region. Moreover, the information about the original historical textiles, and respective hosting institutions, might also be a good contribution for choosing other related textiles from European, and hence, Asian regions, comprising the period of time in study.

It is noteworthy to emphasize that only part of the archive registries at the RCE, concerning dyes identification in historical objects, have been studied. As the time was not enough to finish the research, the remaining archive records, comprising the years between 1986 and 1994, will be studied later in this project. Nevertheless, this preliminary study on the RCE archives revealed to be a great contribution, and provided an opportunity to have personal contact with Dr. Maarten van Bommel, which was essential for outlining and evaluating the subsequent phases of this project.

The research at the BM archives was also useful, especially owing to the efficient electronic organization of this institution's archives. However, the number of records concerning cochineal dye identification was very limited, given the very small number of objects, belonging to the BM collections, which have been submitted to chromatographic analysis so far. Moreover, many of the analyzed historical textiles, in where cochineal was reported, are dated from as late as 19th and 20th centuries, making them inappropriate for consider in this project. The remaining textiles, which were asserted to have cochineal or kermes, and which are listed in Table 6, mostly date from before the 16th century. Although this early date cannot make these textiles directly helpful for answering the main questions of this project, they can, however, lead to conclusions about the use of local cochineal species before the major advent of the Iberian Expansion and the development of global dye trade routes.

Recently, BM has purchased HPLC-DAD equipment and this is expected to produce invaluable comparative results for this PhD thesis, through the work of Dr. Thibaut Devière, who is currently studying the collection of Peruvian archaeological textiles at the BM collections. By the personal contact with Dr. Devière, an important collaboration was accomplished, as American cochineal species are frequently present in South American textiles.

Concerning dyes identification in oil paintings, the research undertaken in the NGL was also extremely valuable, especially owing to the kind assistance of Dr. Jo-Kirby Atkinson who helped with finding reports on cochineal dye characterization in paintings, from the institution's collection, and the Tate Gallery of London (Table 7). This insect dye, has been

reported, through HPLC-DAD analysis, as a pigment lake in historical paintings ascribed to internationally recognized painters, such as Veronese (16th century), Rembrandt or Velazquez (17th century). However, and similar to historical textiles, this analytical method cannot accurately discriminate the correct cochineal species present in red lakes, observed in the results depicted in Table 7 [36]. Although the scope of this project does not currently embrace, the optimization of the characterization of cochineal species in lake pigments, the research carried out in historical paintings is fundamental for comparison with the results for historical textiles. In fact, red lake dyestuffs are strictly related with textiles dyeing industry, especially for the 14th to the 17th centuries [36-37]. For economic purposes, red lakes especially from *Porphyrophora* cochineal and kermes insects were obtained from red-dyed textiles shearing, immersed in alkali solutions, to extract the dye. Nowadays, studies in painting conservation can accurately distinguish lakes made with direct insect sources and those made from waste textile shearings. This technology, described in detail in historical recipes, might constitute an important link between historical textiles and historical paintings, as both follow comparable preparation procedures. Hence, the possibility of identifying the occurrence of cochineal species in historical textiles and paintings, from similar regions and dates, will probably bring important contributions for the historical interpretations in this project.

Besides the work accomplished at the archives of the three CHARISMA institutions, research on specialized literature was conducted at the associated libraries from RCE and BM (Centre for Anthropology). Here, essential resources for the historical construction of American cochineal as a source of dye in the Spanish trade routes, during the Iberian Expansion, were encountered. The achieved information, which could not, otherwise, be acquired in Portuguese libraries, was very important for consolidating the knowledge in the historical background, and for understanding the current historical arguments of published literature regarding cochineal as a commercial product, in the global market of dyes during the 16th and the 18th centuries.

The overall conclusions of the diverse research undertaken, in the CHARISMA institutions visited, highlights the importance of developing an interdisciplinary approach for future work on dyestuffs characterization. The results achieved could offer a possibility of connecting working progresses and enlarge the studies perspective among the European scientific community, working on dyes identification in historical objects.

Table 1: Project “On the occurrence of red Dyestuffs in Textile Materials from the period 1450-1600” - Analyses made with Thin Layer Chromatography (TLC), by Judith Hofenk de Graaff and Wilma Roelofs (1970) at the RCE. Data obtained from the institution archives and from [35].

Donor / Museum Collection	Historical Textiles Description	Provenance	Date	Samples Description	Dyestuff Identification
Aartsbisschoppelijk Museum, Utrecht, Netherlands Abegg-Foundation, Switzerland	Velvet - “Koorkap David van Bourgondië”	Italy	c. 1450	Red violet silk	Kermes (ka)
	Damask, I.N. 910 - “Rode zijden stof”	Italy	1525-1550	Red lilac silk	Cochineal (CA)?
	Velvet, I.N. 880	Italy	Late 15th cent.	Red dark violet silk	Kermes (ka)
	Velvet (chasuble)	Italy or Spain	Late 15th cent.	Red silk	Polish cochineal (CA + ka)
	Weave	Spain	c. 1500	Red silk	Kermes (ka)
	Weave	Spain	15th-16th cent.	Red silk	Kermes (ka) + trace of madder (alizarin+purpurin)
	Wool weave	Peru, Inka	Mid-16th cent.	Red rose wool	Cochineal (CA)
	Velvet	Italy	Late 16th cent.	Red silk	Cochineal (CA)
	Velvet Bern, Historisches museum	Italy	2nd half of the 16th cent.	Silk	Kermes (ka) + lac dye
	Deutsches Tapetenmuseum	Wall hanging, weave	Italy, Venice	1550-1570	Red silk
Galleria della Ufizi	Tapestry, gobelin	Brussels?	2nd half of the 16th cent.	Red lilac wool Red violet silk	Kermes (ka) Cochineal (CA)
Gewerbe Museum, Basel	Velvet, I.N. Dep. Hist. Mus. 1907/114	Italy?	c. 1600	Red violet silk	Kermes (ka)
	Velvet, I.N. Dep. Hist. Mus. 1907/230	-	16th/17th cent.	Wine red silk	Cochineal (CA) + kermes (ka)
	Velvet brocade, I.N. Dep. Hist. Mus. 1907/208	Italy	15th cent.	Wine red silk	Polish cochineal + kermes (CA+ka)
	Damask, I.N. Dep. Hist. Mus. 1907/106	Italy	2nd half of the 16th cent.	Red silk	Polish cochineal (CA)
	Damask, I.N. Dep. Hist. Mus. 1929/28	Italy	Late 16th cent.	Red silk	Cochineal (CA)
	Florentine string, I.N. Dep. Hist. Mus. 1933/59	Italy	Late 15th cent.	Red silk	Kermes (ka)
	Weave, I.N. Dep. Hist. Mus. 1933/96c	Italy	14th cent.?	Red silk	Kermes (ka)
	Velvet, I.N. Dep. Hist. Mus. 1966/33a-c	Italy	c. 1500	Red violet silk	Kermes (ka)
	Damask I.N. Dep. Hist. Mus. 1966/7	Italy	16th cent.?	Red violet silk	Polish cochineal (CA)
	Embroidery, I.N. Dep. Hist. Mus. 1967/st.47	Germany	2nd half 16th cent.	Red silk	Polish cochineal (CA)
	Damask, I.N. Dep. Hist. Mus. 1926/26	Italy	16th/17th cent.	Red silk	Polish cochineal (CA + ka) + kermes (ka)
	Velvet (pile), I.N. Dep. Hist. Mus. 1966/31	Central Europe	1460?	Red violet silk	Cochineal (CA)
	Damask, I.N. Dep. Hist. Mus. 1923/8	Italy	16th cent.	Red silk	Polish cochineal (CA + trace of ka)
	Embroidery, I.N. Dep. Hist. Mus. 1967/st.33	Italy	16th cent.	Red violet silk	Polish cochineal (CA + trace of ka)
	Linen embroidery, I.N. Dep. Hist. Mus. 1967/st.40	Italy	Late 16th cent.	Red silk	Cochineal (CA)

Donor / Museum Collection	Historical Textiles Description	Provenance	Date	Samples Description	Dyestuff Identification
Gewerbe Museum, Basel	Cushion-cover, embroidery, I.N. Dep. Hist. Mus. 1967/st.42	Italy?	16th/17th cent.	Red silk	Polish cochineal (CA + ka) or Cochineal (CA) + kermes (ka)
	Cushion-cover, embroidery I.N. Dep. Hist. Mus. 1967/st.41	Italy	late 16th cent.	Red silk	Cochineal (CA)
	Chasuble, linen embroidery, I.N. Dep. Hist. Mus. 1967/st.54	Central Europe	14th cent.	Red dark silk	Kermes (ka)
	Chasuble, linen embroidery, I.N. Dep. Hist. Mus. 1967/51	Italy or France	16th cent.	Red silk	Cochineal (CA)
	Embroidered strips of vestment, I.N. Dep. Hist. Mus. 1967/st.57a,b	Italy	c. 1560	Red silk	Cochineal (CA)
	Linen embroidery, I.N. Dep. Hist. Mus. 1897/216b	Italy	1st half of the 16th cent.	Red silk	Kermes (ka)
	Linen embroidery, I.N. Dep. Hist. Mus. 1967/st.37	Italy	late 16th cent.	Red violet silk	Cochineal (CA)
	Linen embroidery, I.N. Dep. Hist. Mus. 1967/st.25	Switzerland	16th/17th cent.	Red silk	Cochineal (CA)
	Brocatelle, I.N. Dep. Hist. Mus. 1907/105	Switzerland	c. 1600	Red violet silk	Cochineal (CA)
	Brocade, I.N. Dep. Hist. Mus. 1907/97 - "Altar-antependium, Nordschweiz, Basel, 2. Hälfte 15. Jh."	Italy	2nd half of the 15th cent.	Red silk	Polish cochineal + kermes (CA+ka)
Historisch Museum Bern	Velvet	Italy	2nd half of the 15th cent.	Red silk	Cochineal (CA)
Kungl. Livrustkammaren, Stockholm, Sweden	Velvet, I.N. 2930 - "harness saddle of Erik XVI"	Belgium, Antwerp	1560-62	Red silk	Polish cochineal (CA + ka)
	I.N. 755 - "Polish trumpet-flag, probably for Sigismundis III"	Poland	c. 1605	Red silk	Polish cochineal (CA + ka)
	Embroidery, I.N. 06/6687 - "canopy of the wife of Erik XVI - she was crowned in 1568"	Sweden, Stockholm	c. 1568	Red bordeau/crimson silk Red rose silk	Polish cochineal (CA + ka) Polish cochineal (CA + ka) + brazilwood (brasilein)
	I.N. 3936 - "velvet from inside of shield (rondache) Italian manufacture (Milano), late 16th cent. Warbooty from Prague 1648, part of the collection of Queen Kristina"	Italy, Milan	Late 16th cent.	Red silk	Polish cochineal (CA + ka)
	I.N. 2611a - "velvet from shield, dated 1548, probably belonging to Sigismund August of Poland. Etched by Jorg Sorg in Augsburg. Also part of the fringe"	Poland or Augsburg?	1548?	Red silk	Polish cochineal (CA + ka) + trace of kermes
Kunstindustri museet I Oslo Metropolitan Museum of Art, New York	"Tapestry, Brussel. Horsemen and knights in armour"	Belgium	Mid-16th cent.	Red wool	Cochineal (CA)
	Tapestry, gobelin - "Loth and his daughters fleeing from Sodom"	Norway	Late 16th cent.	Red wool	Kermes (ka)
	Satin velvet, I.N. 46.156.140 - "pile on pile"	Italy	Late 15th cent.	Red silk	Polish cochineal (CA + ka) or cochineal (CA) + kermes (ka)
	I.N. 52.20.11 - "Medallions a fal corner, servant in cut velvet on twill ground", Shah Tahmasp period	Iran	16th cent.	Red silk	Polish cochineal (CA + ka) or cochineal (CA) + kermes (ka)
I.N. 52.20.21 - "Satin, patterned in silver and gold"	Minor Asia, Bursa	16th cent.	Red silk	Polish cochineal (CA + ka) or cochineal (CA) + kermes (ka)	
Musee Historique des Tissus, France	Velvet, I.N. 33.357	Italy	2nd half of the 15th cent	Red silk	Polish cochineal (CA + ka)

Donor / Museum Collection	Historical Textiles Description	Provenance	Date	Samples Description	Dyestuff Identification
Musee Historique des Tissus, France	Velvet, I.N. 30.935	Italy	2nd half of the 15th cent.	Red silk	Polish cochineal (CA + ka)
Museos de Arte – Museo Textil, Barcelona, Spain	Velvet, I.N. 22864	Italy	15th/16th cent.	Red silk	Polish cochineal (CA + k a)
	I.N. 32.951	-	17th cent.	Red silk	Kermes (ka)
	I.N. 23.769	-	16th cent.	Red violet silk	Cochineal (CA)
	I.N. 32.946	-	14th cent.	Red violet silk	Kermes (ka)
	I.N. 22.690	Spain	15th cent.	Red silk	Cochineal (CA)? + brazilwood (a trace of brazilein)
	I.N. 23.878	-	15th cent.	Red silk	Kermes (ka)
	I.N. 22.213	-	16th cent.	Red silk	Kermes (ka)
Museu Calouste Gulbenkian	I.N. 23.758	-	16th/17th cent.	Red violet silk	Cochineal (CA)
	Velvet - “Velours Turc”	Turkey	16th cent.	Red violet silk	Cochineal (CA)
Museu de Aveiro	Velvet - “Parement de velours”	-	16th cent.	Red silk	Cochineal (CA)
Museu Nacional de Arte Antiga, Lisbon, Portugal	Bed-spread, I.N. 1745 - “Couvre-lit ‘Chine’ XVII siècle”	China	Mid-17th cent.	Red silk	Cochineal (CA)
	Bed-spread, I.N. 2136 - “Couvre-lit ‘India’ XVII siècle”	India	Mid-17th cent.	Red silk	Cochineal (CA)
Muzeum Narodowe w Warszawie, Poland	Velvet, I.N. 2033 - “Velours italien. Parement du Monastere dos Jeronimos”	Italy	15th-16th cent.	Red violet silk	Polish cochineal (CA + ka)
	Velvet (chasuble), I.N. 1616 - “brocad de velours”	Spain	15th cent.	Red violet silk	Polish cochineal (CA + ka)
	Satin	Italy	1650	Red silk	Polish cochineal (CA + ka) or cochineal (CA) + kermes (ka)
	Satin - “The coat of arms of Sforza and the white Eagle of our king Sigismundus the First”	Italy	1st half of the 16th cent.	Red silk	Polish cochineal (CA + ka) or cochineal (CA) + kermes (ka)
	Velvet - “Fragment of a chasuble? With the pattern of granate”	Italy	15th/16th cent.	Red violet silk	Cochineal (CA)?
	Brocade - “pattern of granate”	Turkey	16th cent	Red violet silk	Cochineal (CA)
Osterreichisches Museum für Angewandte Kunst, Wien, Austria	Velvet	Italy	16th cent.	Red violet silk	Cochineal (CA)
	Brocade, I.N. T4128	Spain	Mid-16th cent.	Red violet silk	Cochineal (CA)
	Brocade velvet, I.N. T5597	Italy	Beginnings of the 16th cent.	Red pink silk	Cochineal (CA)
	Brocade + velvet, I.N. T922	Italy	Mid-15th cent.	Red violet silk	Polish cochineal (CA + ka)
	Weave, I.N. T869	Spain, Granada	2nd half of the 15th cent.	Red silk	Kermes (ka) + madder (purpurin + alizarin)
	Velvet brocade, I.N. T9236	Italy	2nd half of the 15th cent.	Red silk	Cochineal (CA)
	Velvet, I.N. T2320	Italy or Spain	2nd half of the 16th cent.	Red silk	Cochineal (CA)
Palácio de Vila Viçosa	Velvet - “Velours italien et soie de la doublure”	Italy	15th cent.	Red violet silk	Cochineal (CA) Polish cochineal (CA + ka)

Donor / Museum Collection	Historical Textiles Description	Provenance	Date	Samples Description	Dyestuff Identification
Riksantik-varieämbetet, Stockholm, Sweden	Velvet, chasuble	Italy	1st half of the 17th cent.	Red violet silk	Cochineal (CA)
Schweizerisches Landesmuseum, Zürich, Switzerland	Velvet, chasuble Embroidery, I.N. LM6096	Italy Switzerland	Late 15th cent. 1552	Red lilac silk Red rose wool	Kermes (ka) Polish cochineal (CA + ka) or cochineal (CA) + kermes (ka)
Sé de Portalegre	Weave, I.N. LM29359	Basel or Oberrhein	1566	Red dark wool	Cochineal (CA) + madder (purpurin + alizarin)
Sé de Viseu	Velvet - "Chape du parement Anglais - velours"	-	15th cent.	Red violet silk	Kermes (ka) Polish cochineal (CA + ka)
Soprintendenza alle Gallerie. Museo Civico di Modena, Firenze, Italy	Weave - "Doublure de la chape" Tissue - "tessuto in seta ermisino"	Toscane, Italy	15th cent. 17th cent.	Red violet silk Red violet silk	Polish cochineal (CA + ka) Cochineal (CA) + brazilwood (brazilein)
	Brocade - "filato del broccato della meta del sec. XVI proveniente dai parimenti sacri della Cappella Degli Spagnoli, Santa Maria Novella Firenze: dono di Eleanora di Toledo"	Italy	16th cent.	Red violet silk	Cochineal (CA) + brazilwood (brazilein)
	Brocade - "Broccatello. Opere Saracene. Tessuto forse Lucchese (in una busta) filato del sec. XIV-XV"	Italy, Modena	14th-15th cent.	Red violet silk	Cochineal (CA) + brazilwood (brazilein)
	Brocade - "tessuto spolinado"	Italy, Toscana	18th cent.	Red rose silk	Cochineal (CA) + brazilwood (brazilein)
	Damask - "Damasco di seta"	Italy, Toscana	Mid-17th cent.	Red violet silk	Cochineal (CA) + brazilwood (brazilein)
	"tessuto in lampasso di seta"	Italy, Toscana	17th cent.	Red violet silk	Cochineal (CA)
	Damask - "tessuto in lampasso di seta damascata"	Italy, Toscana	Mid-17th cent.	Red violet silk	Cochineal (CA)
	Brocade - "Broccatello in seta e filaticcio"	Italy, Toscana	17th cent.	Red violet silk	Cochineal (CA)
	Damask - "Damasco in seta e filaticcio"	Italy, Florence	17th cent.	Red violet silk	Cochineal (CA)
	"Rasone in seta filaticcio"	Italy, Lucchese	17th cent.	Red violet silk	Cochineal (CA)
	"Gallone in velluto tagliato. Dal paliotto della chiesa fiorentina di S. Remigio"	Italy, Toscana	17th cent.	Red silk	Cochineal (CA)
	Velvet - "Velluto in seta Dal paliotto d'oro del Museo di S. Gimignano"	Italy, Toscana	2nd half of the 16th cent.	Red silk	Kermes (ka)
	Velvet - "Velluto in seta"	Italy, Florence	16th cent.	Red silk	Cochineal (CA) + trace of kermes (ka)
	Velvet - "Velluto in seta"	Italy, Toscana	c. 1550	Red silk	Polish cochineal (CA + ka)
	Velvet - "Velluto in seta"	Italy, Toscana	16th cent.	Red silk	Kermes (ka)
	Satin - "Tessuto in seta fiamma"	Italy, Lucchese	16th cent.	Red silk	Polish cochineal (CA + ka)
	Satin brocade - "Broccatello in cascame di seta"	Italy, Lucchese	Mid-16th cent	Red silk	Polish cochineal (trace of kermes) (CA + ka)
	Brocade - "Broccatello in cascame di seta"	Italy, Lucchese	16th cent.	Red silk	Polish cochineal (trace of kermes) (CA + ka)

Donor / Museum Collection	Historical Textiles Description	Provenance	Date	Samples Description	Dyestuff Identification
Soprintendenza alle Gallerie. Museo Civico di Modena, Firenze, Italy	Brocade - "Broccatello in cascame di seta"	Italy, Toscana	16th cent.	Red silk	Polish cochineal (spoor kermes) (CA + ka)
Staatliche Museen Preussischer Kulturbesitz	Pluvial, velvet, I.N. 62.155	Italy	Mid-15th cent.	Red violet silk	Polish cochineal (CA + ka)
Kunstgewerbe Museum, Berlin, Germany	Embroidery indo-portuguese, I.N. 65.33	Portugal	c. 1600	Red pink silk	Polish cochineal (CA + ka)
	Embroidery/satin, I.N. 6510	France	1550	Red violet silk	Cochineal (CA) + madder (purpurin + alizarin)
	Velvet, I.N. 1986.10	Italy or Spain	1480	Red violet silk	Cochineal (CA) + brazilwood (brazilein)
Textile Museum Krefeld, Germany	Velvet brocade, I.N. 00185	Italy	15th cent.	Red violet silk	Polish cochineal (CA + ka)
	Weave, I.N. 01270	Spain, Granada	c. 1500	Red silk	Kermes (ka)
(Gewebesammlung, Krefeld, An der	Velvet, I.N. 00059	Italy	15th cent.	Red silk	Kermes (ka)
Ingenieurschule für Textilwesen)	Damask, I.N. 01982A	Italy	16th cent.	Red silk	Stone red silk
	Brocade, I.N. 01156	Italy, Florence	2nd half of the 15th cent.	Red silk	Cochineal (CA)
	Brocade, I.N. 01151	Italy	Mid 15th cent.	Red silk	Kermes (ka)
	Brocade, I.N. 01310	Spain	c. 1600	Red violet silk	Cochineal (CA)

Table 2: Analyses made with Thin Layer Chromatography (TLC), by Wilma Roelofs (1972), at the RCE. Data obtained from the institution archives.

Donor / Museum Collection	Historical Textiles Description	Provenance	Date	Samples Description	Dyestuff Identification
Det Danske Kunstindustrimuseum, Copenhagen	Tapestry	North Netherlands	2nd half of the 17th cent.	Red wool	Cochineal (CA)
Gemeentemuseum, Den Haag	Tapestry	North Netherlands	Mid-17th cent.	Red wool	Cochineal (CA)
Germanisches Nationalmuseum, Neurenberg	Tapestry	North Netherlands	1st half of the 17th cent.	Red wool	Cochineal (CA)
Graaf Leon Moltke Huitfeldt, Glorup	Tapestry	North Netherlands	Mid-17th cent.	Orange wool	Kermes (ka)
Het Prinsenhof, Delft	Tapestry	North Netherlands	Mid-17th cent.	Red wool	Cochineal (CA) + madder (alizarin + purpurin)
Holmens Kirke, Copenhagen	Tapestry	North Netherlands	Mid-17th cent.	Red wool	Cochineal (CA)
H. H. M. M. de Koning en Koningin van Denemarken	Tapestry	North Netherlands	Mid-17th cent.	Red wool	Cochineal (CA)
H. M. Koningin Juliana, Paleis Het Loo	Tapestry	North Netherlands	Mid-17th cent.	Red wool	Cochineal (CA) + indigo
J. M. N. Thompson, Bridgnorth (Shropshire)	Tapestry	North Netherlands	Mid-17th cent.	Red wool	Cochineal (CA)
Koninklijke Musea voor Kunst en Geschiedenis, Brussel	Tapestry	North Netherlands	2nd half of the 17th cent.	Red wool	Madder (alizarin+purpurin) + brazilwood (brazilein) + traces of cochineal (CA)
Mayorcas Ltd., London	Tapestry	North Netherlands	Mid-17th cent.	Red violet wool	Cochineal (CA)
	Tapestry	North Netherlands	1st half of the 17th cent.	Red violet wool	Cochineal (CA)
Regenten van het Deutzenhofje, Amsterdam	Tapestry	North Netherlands	Mid-17th cent.	Red wool	Cochineal (CA)
Rijksmuseum Amsterdam	Tapestry	North Netherlands	Mid-17th cent.?	Red wool	Cochineal (CA)
	Tapestry	North Netherlands	Mid-17th cent.	Red wool	Cochineal (CA)
				Red wool	Cochineal (CA) + madder (alizarin + purpurin)
	Tapestry	North Netherlands	Mid-17th cent.	Red violet wool	Cochineal (CA)
				Red violet wool	Cochineal (CA) + madder (alizarin + purpurin) + brazilwood (brazilein)
Rohsska Konstslojdmuseet, Gothenburg	Tapestry	North Netherlands	Mid-17th cent.	Red silk	Cochineal (CA)
Stedelijk Museum Het Catharina Gasthuis, Gouda	Tapestry	North Netherlands	Late 17th cent.	Red wool	Cochineal (CA)
Vestlandske Kunstindustrimuseum, Bergen	Tapestry	North Netherlands	2nd half of the 17th cent.	Red wool	Cochineal (CA)
Victoria and Albert Museum, London	Tapestry	North Netherlands	Mid-17th cent.	Red violet wool	Cochineal (CA)
Z. M. de koning van Zweden	Tapestry	North Netherlands	1st half of the 17th cent.	Red violet wool	Cochineal (CA)

Table 3: Other projects made with TLC analyses, by Wilma Roelofs (1986). Data obtained from the RCE archives.

Donor / Museum Collection	Historical Textiles Description	Provenance	Date	Samples Description	Dyestuff Identification
Rijksmuseum Amsterdam	Arabian textile "April serie Maanden en Planeten"	Central Asia -	14th cent. Mid-16th cent.	Red rose Red wool Violet wool	Polish cochineal (CA + ka) Cochineal (CA) Cochineal (CA) + madder (purpurin) + indigo
Röhsska Konstsöjdmuseet	Red textile Tapestry, I.N. RKM 433-30 – "Late Roman tapestry, a medallion of dark purple wool with patterns in natural linen and gold thread"	Lyon -	Late 18th cent. 2nd half of the 4th cent.	- Purple wool	Cochineal (CA) Polish cochineal (CA + ka) + indigo

Table 4: Analyses made with High Performance Liquid Chromatography (HPLC), by Judith Hofenk de Graaff and Wilma Roelofs (1994), on historical textiles previously analyzed with TLC (Table 1), at the RCE. Data obtained from the institution archives.

Note: The dye extraction was made with 400µL H₂O/MeOH:37%HCl (1:1:2 v/v/v), and the elution program was (A) water, (B) MeOH (C) aqueous 5% phosphoric acid: 2 min. 6A/24B/10C; 27 min. 0A/90B/10C. The areas of the most representative compounds were calculated according with the Wouters method [17].

Donor/ Museum Collection	Historical Textiles Description	Provenance	Date	Samples Description	Dyestuff Identification
Gewerbe Museum Basel, Switzerland	Brocatelle, I.N. Dep. Hist. Mus. 1907/105	Switzerland	c. 1600	Red violet silk	Cochineal (CA + dcIV + dcVII + fk + ka) + ellagic acid (ea)
	Chasuble, embroidery, I.N. Dep. Hist. Mus. 1967/st.54	Italy	14th cent.	Red dark silk	Kermes (fk + ka) + ellagic acid (ea)
	Damask, I.N. Dep. Hist. Mus. 1923/8	Italy	16th cent.	Red silk	Cochineal (dcII (co-eluted?) + CA + dcIV + dcVII + fk + ka) + ellagic acid (ea)
	I.N. Dep. Hist. Mus. 1926/26	Italy	16th/17th cent.	Red silk	Cochineal (dcII (?) + CA + dcIV + dcVII + fk + ka (?)) + ellagic acid (ea)
	Damask, I.N. Dep. Hist. Mus. 1929/28	Italy	Late 16th cent.	Red silk	Cochineal (dcII (?) + CA + dcIV + dcVII + fk + ka (?)) + ellagic acid (ea)
Museos de Arte – Museo Textil, Barcelona, Spain	I.N. 22213	-	16th cent.	Red silk	Kermes (fk + ka) + ellagic acid (ea)
	I.N. 32946	-	14th cent.	Red violet silk	Kermes (fk + ka) + ellagic acid (ea)
Abegg-Foundation, Switzerland	Velvet	Italy	late 16th cent.	Red silk	Cochineal (dcII (?) + CA + dcIV + dcVII + fk + ka (?)) + ellagic acid (ea) + indigo (indigotin)
	-	Italy	2nd half of the 15th cent.	-	Kermes (fk + ka) + ellagic acid (ea) + indigo (indigotin)

Table 5: Several analyses made with High Performance Liquid Chromatography and Photo-Diode Array (HPLC-PDA) at the RCE. Data obtained from the institution archives. Note: Analyses were made following the preparation procedure described in Table 4.

Author (Year) of the Analyses	Project/ Report	Museum Collection	Historical Textiles Description	Provenance	Date	Samples Description	Dyestuff Identification
Judith Hofenk de Graaff (1997)	"Between Persia and China"	Abbeg Stiftung	Textile fragment from Asia, I.N. 4921 - "Schuss 5e lat"	"Between Persia and China"	7th to 10th cent.	Red silk	Cochineal (CA) + brazilwood + lac (lacaic acids A and B) + madder (alizarin + purpurin) + indigo (indigotin) + chayroot (erythrolaccin)
Judith Hofenk de Graaff (1997)	Frederik III's "Polish" Costume (ca. 1650)	Royal Danish Collection, Rosenbor Castle Frederik III's Polish Costumes, Kopenhagen	Red damask trousers Velvet robe Brocade robe	Europe or Asia?	At least from 1651	Red damask from seam allowance Green/red silk from selvedge Red sewing thread Red and rose velvet Rose silk taffeta Red from seam allowance	Cochineal (CA, dclV, dcVII, fk, ka) + ellagic acid (ea) Armenian cochineal (CA, dclV, dcVII, fk, ka) + ellagic acid (ea) Cochineal (CA) + ellagic acid (ea) Cochineal (CA) + brazilwood (brazilein) + ellagic acid (ea) Cochineal (CA, dcVII) + ellagic acid (ea) Cochineal (CA, dclV, dcVII, fk, ka) + ellagic acid (ea) Cochineal (CA) + ellagic acid (ea)
Wilma Roelofs (1998)	Textiles from the grave of Pandolfo III Malatesta (1370-1427), Prince of Fano, and Velo di Classe	Arakhne, di Claudia Kusch & C., Ancona, Italia	jacket, red velvet Velo di classe, red	-	8th cent. ?	- -	Armenian cochineal (CA, dclV) + lac (lacaic acids A and B) + ellagic acid (ea) Kermes (fk + ka) + ellagic acid (ea)
Maarten van Bommel (2000)	Archaeological textiles from the Church of St. Chiara, Urbino	Textiles from the Della Robere family	Red shroud, tapestry, from the Cardinale Giulio Feltrio della Rovere, 1533-1578	-	-	-	kermes (ka)
Maarten van Bommel (2000)	Dyestuff Analysis of Medieval Textiles	Instituto Centralo del Restauro	Bandiera di S. Giorgio The bonnet of Constanza Silk Lampas from the tomb of Henry IV	- - -	13th cent. - -	- - -	Presence of kermes dye along with other dyes Presence of kermes dye along with other dyes; trace of CA Kermes (fk + ka) + ellagic acid (ea)

Author (Year) of the Analyses	Project/ Report	Museum Collection	Historical Textiles Description	Provenance	Date	Samples Description	Dyestuff Identification
Wilma Roelofs (2000)	-	Museo Opera del Duomo, Assisi	Red silk brocade, Paliotto di Assisi, su disegno di Antonio Pollaiuolo	Italy	2nd half of the 15th cent.	-	Kermes (ka) Polish cochineal (CA + ka) Cochineal (CA)
Maarten van Bommel (2001) Maarten van Bommel (2001)	- Dyestuff analysis of Central Asian Textiles	Cathedral in Brandenburg, Germany Abegg-Stiftung	Atlas der Kasel (C4), Ende 15 Jh I.N. 5158 I.N. 5156 I.N. 5157	Central Asia -	End of the 15th cent. 30 B.C. to 300 A.D.	Bright red warp, probably silk Pink sample Reddish pink sample Reddish pink sample	Polish cochineal and trace of indigo Porphyrophora coccid insect dyestuff - CA (16%) + ka (70%) + ka-alike (13%) + fk-alike trace Kermes (ka) Polish cochineal or related Porph. species - CA (52%) + ka (48%) Kermes
Maarten van Bommel (2002)	The Coronation robes, Regione Siciliana	Imperial workshop at Sicily 'Nobiles Officinae', Area Soprintendenza per i Beni Culturali	Alb (Alba), gown, with later additions Coronation mantle (Krönungsmantel) Blue Dalmatic (Tunicella) Eagle Dalmatic (Adlerdalmatika) Gloves (Handschuhe) Hose (Strümphe) Shoes (sandalia) (Schuhe) Tablet wave	Palermo, Royal Workshop Palermo, Royal workshop Sicily, Royal workshop China Palermo, Royal workshop Palermo, Royal workshop Germany Palermo	1181 1133-1134 1st half of 12th cent. 14th century Before 1200 2nd half of 12th cent. 1st quarter of 17th cent. 12th-13th cent.	- - - - - - - - - - - -	Kermes Kermes Kermes and Polish or Armenian cochineal Kermes Kermes and Polish or Armenian cochineal Kermes Kermes and Polish or Armenian cochineal Kermes and Polish or Armenian cochineal Kermes and Polish or Armenian cochineal Kermes and Polish cochineal?
Maarten van Bommel (2002)	Hallstatt archaeological textile fragments	-	-	Austria	800-400 B.C.	-	Kermes and Polish cochineal?
Maarten van Bommel (2003)	Queen Kristina's tomb	Royal Armoury	Crown, Lrk, I.N. 32961 Splendour costume, nr 32979	Stockholm -	- 1689	Warp weft	Kermes (ka) or cochineal (trace of CA) on alum and indigo (indigotin) Cochineal (CA)

Table 6: Dye analyses made at the BM, on historical objects belonging to the museum collection. Data obtained from the institution archives and [38].

Author (Year) of the Analyses	Project/ Report	Historical Objects Description	Provenance	Date	Samples Description	Dyestuff Identification
Yvonne Shashoua (1989) - analysis by UV spectroscopy	Identification of Dyes from a South American Burial Rug	I.N. 1954 WAM 5566 - "The rug was woven from wool and cotton, and incorporated traditional Peruvian designs"	Peru	-	3 red, pink and carmine samples	Cochineal
Yvonne Shashoua (1989) - analysis by UV spectroscopy	Identification of Dyes from Peruvian Textile	Woolen Peruvian textile, I.N. Q86AM258	Peru	600-900 A.D.	4 red, pink, mid-brown and chocolate samples	Cochineal
Yvonne Shashoua (1989) - analysis by UV spectroscopy	Identification of Dyes from South American Poncho	Woolen poncho, I.N. Q86257	South America	500-900 A.D.	2 pink and rust samples	Cochineal (CA)
L. R. Green (1990) - analysis by UV spectroscopy	Analysis of dyes from silk textile fragments found with the Basel Reliquary Head	"Fragments of silk textiles wrapped around relics"	Basel Cathedral, Switzerland	c. 1477	Red sample	Cochineal (CA)
Vincent Daniels (1991) - analysis by TLC	Analysis of dyes on eight textile samples	Red textile from Basel Reliquary Head	Basel Cathedral, Switzerland	c. 1477	Red sample	Kermes
		Red textile from Malatesta Belt	Halkida, Greece	1400-1500	Red sample	Kermes
		Bright red textile	-	-	-	Kermes
		Dark purple textile ("Masada sample")	-	-	-	Kermes + indigo
Vincent Daniels (1992) - analysis by TLC	Dye Analysis on Four Textiles	Pink textile	Central Asian or Italian origin	13th cent.	-	Kermes (ka)
Vincent Daniels (1993) - analysis by TLC	Analysis of Red Pigment from Aztec Spear Thrower	Department of Ethnography - I.N. AM5226	Mexico	-	Three red lake samples	Cochineal <i>D. coccus</i> (CA)
Vincent Daniels - analysis by TLC	-	Textile/fragment of a tapestry - I.N. 1990,0612.48	Egypt	4th cent.	Weft of wool	Probably Armenian cochineal (CA)

Table 7: Dye analyses made at the NGL, on historical paintings belonging to the museum collection. Data obtained from the institution archives and from [36-37].

Project/ Report	Analysis Conditions with HPLC-DAD	Author (Provenance)	Paintings' Title	Date	Dyestuff Identification
Brazilian School, 1992	Dye extraction was made with 4% BF ₃ / MeOH. HPLC elution program: (A) 98%H ₂ O + 2% H ₃ PO ₄ (B) MeOH. Identification based on ions retention time.	Friar Ricardo do Pilar (Brazil)	<i>Christ in Martyrdom</i> , I. N. BRZRW1	c. 1690	Cochineal (CA)
HPLC analysis of dyestuffs (1992)	Dye extraction was made with 4% BF ₃ / MeOH. HPLC elution program: (A) 93% H ₂ O + 5% ACN + 2% formic acid (B) MeOH. Identification based on ions retention time.	Maurice-Quentin de La Tour (France)	<i>Henry Dawkins</i> , I. N. NG5118	c. 1750	Cochineal (CA)
HPLC analysis of dyestuffs (1993)	HPLC elution program: (A) 94.5% H ₂ O + 5% ACN + 0.5% TFA (B) 95% MeOH + 5% ACN	T. Lawrence (England)	<i>Queen Charlotte</i> , I. N. NG4257	c. 1789	Probably cochineal (New World)
HPLC analysis of dyestuffs (1993)	HPLC elution program: (A) 93% H ₂ O + 5% ACN + 2% H ₃ PO ₄ (B) 95% MeOH + 5% ACN	-	<i>Greek icon, ascribed to the circle of Dionysius of Fourna</i> , I.N. AELLA I	1770	Probably cochineal
	HPLC elution program: (A) 94.9% H ₂ O, 0.1% TFA + 5% ACN (B) 95% MeOH + 5% ACN.	Sir Thomas Gainsborough (England)	<i>Mrs. Siddons</i> , I. N. NG683	1785	Cochineal (New World)
		Sir Joshua Reynolds (England)	<i>Anne, Countess of Albemarle</i> , I. N. NG1259	c. 1759	Cochineal (New World)
		Gerard David (Netherlands)	<i>The Virgin and Child with Saints and Donor</i> , I. N. NG1432	c. 1500-1511	Kermes and an old World cochineal insect
		Lorenzo Lotto (Italy)	<i>Family Group</i> , I.N. NG1047	c. 1547	Kermes and cochineal
		Veronese (Italy)	<i>The Consecration of St. Nicholas</i> , I.N. NG26	c. 1562	Old World cochineal insect dyestuff, such as Polish cochineal (trace of kermes) – it could be also New World cochineal + kermes
		Veronese (Italy)	<i>The Adoration of the Kings</i> , I.N. NG268	1573	Old World cochineal insect, with additional kermes dyestuff present (CA + ka)
		Ambrosius Benson (Netherlands)	<i>The Magdalen Reading</i> , I.N. NG655	1518-1550	Kermes and a trace of cochineal (probably Old World cochineal)
		Rembrandt, follower of (Netherlands)	<i>A Young Man and Girl playing cards</i> , I.N. NG1247	1645-50	Probably cochineal
HPLC analysis of dyestuffs (1994)	HPLC elution program: (A) 94.9% H ₂ O, 0.1% TFA + 5% ACN (B) 95% MeOH + 5% ACN.	Paul Delaroche (France)	<i>The Execution of Lady Jane Grey</i> , I.N. NG1909	1833	Cochineal
		William Larkin (England)	<i>Portrait of Susan Villiers, Countess of Denbigh</i> , I.N. LAHIC 220	1610-20	Probably cochineal
		J. M. W. Turner (England)	<i>Ulysses deriding Polyphemus</i> , I.N. NG508	Exhibited at the Royal Academy 1829	Cochineal (New World)
		Palma Giovane (Italy)	<i>Mars and Venus</i> , I.N. NG1866	1580s	Cochineal, probably New World

Project/ Report	Analysis Conditions with HPLC-DAD	Author (Provenance)	Paintings' Title	Date	Dyestuff Identification
HPLC analysis of dyestuffs (1994)		Murillo (Spain)	<i>The Adoration of the Shepherds</i> , I.N. NG232	1640s?	Cochineal (CA)
HPLC analysis of dyestuffs (1995)	HPLC elution program: (A) 94.9% H ₂ O, 0.1% TFA + 5% ACN (B) 95% MeOH + 5% ACN.	Hendrick ter Brugghen (Netherlands)	<i>Jacob reproaching Laban for giving him Leah in place of Rachel</i> , I.N. NG4614	1627	Essentially cochineal, probably New World
		Anthony van Dyck (Netherlands)	<i>Charity</i> , I.N. NG6494	c. 1627-8	Cochineal
		Peter Paul Rubens (Netherlands)	<i>Minerva protects Pax from Mars ('Peace and War')</i> , I.N. NG46	1629-30	Cochineal + madder
		Jan Jansz Treck (Netherlands)	<i>Vanitas Still Life</i> , I.N. NG6533	1648	Cochineal (New World?)
		Pierre Mignard (France)	<i>The Marquise de Seignelay and Two of her Children</i> , I.N. NG2967	1691	Cochineal, probably New World
		Veronese (Italy)	<i>Allegory of Love I ('Unfaithfulness')</i> , I.N. NG1318	Probably 1570s	Cochineal
		Veronese (Italy)	<i>Allegory of Love IV ('Happy Union')</i> , I.N. NG1326	Probably 1570s	Probably New World cochineal (also ka is present)
		After Guido Reni (Italy)	<i>Perseus and Andromeda</i> , I.N. NG87	c. 1635	Cochineal
		Giovanni Antonio Pellegrini (Italy)	<i>Rebecca at the Well</i> , I.N. NG6332	1708-13	Cochineal, probably New World
		Canaletto (Italy)	<i>Regatta on the Grand Canal</i> , I.N. NG4454	c. 1735-41	Cochineal, probably New World
The Identification of Red Lake Pigment Dyestuffs and a Discussion of their Use (1996) [36]		Lorenzo Monaco (Italy)	<i>Adoring Saints</i> , I.N. NG216	Probably 1407-9	Probably kermes
		Fra Angelico, follower of (Italy)	<i>The Annunciation</i> , I.N. NG1406	c. 1434	Kermes + possibly lac
		Giovanni di Paolo (Italy)	<i>Saints Fabian and Sebastian</i> , I.N. NG3402	c. 1475-82	Kermes + possibly lac
		Domenico Ghirlandaio (Italy)	<i>The Virgin and Child</i> , I.N. NG3937	Probably 1480-90	Probably lac + kermes
		David Ghirlandaio (Italy)	<i>The Virgin and Child with Saint John</i> , I.N. NG502	Probably 1480-90	Probably lac + kermes
		Filippino Lippi, follower of (Italy)	<i>The Worship of the Egyptian Bull God</i> , I.N. NG4905	c. 1500	Probably kermes
		Bacchiacca (Italy)	<i>Joseph pardons his Brothers</i> , I.N. NG1219	Probably 1515	Kermes
		Altobello Melone (Italy)	<i>The Walk to Emmaus</i> , I.N. NG753	c. 1516-20	Kermes
		Vincenzo Catena (Italy)	<i>Portrait of the Doge, Andrea Gritti</i> , I.N. NG1047	Probably 1547	Kermes + a trace of cochineal
		Neapolitan School (Italy)	<i>The Adoration of the Shepherds</i> , I.N. NG232	Probably 1630s	Cochineal (New World)
		Diego Velázquez (Spain)	<i>Portrait of Archbishop Fernando de Valdés</i> , I.N. NG9380	1640-5	Cochineal (probably New World)

Project/ Report	Analysis Conditions with HPLC-DAD	Author (Provenance)	Paintings' Title	Date	Dyestuff Identification
The Identification of Red Lake Pigment Dyestuffs and a Discussion of their Use (1996) [36]	HPLC elution program: (A) 94.9% H ₂ O, 0.1% TFA + 5% ACN (B) 95% MeOH + 5% ACN.	Netherlandish School	<i>The Virgin and Child with Saints and Angels in a Garden</i> , I.N. NG1085 – Central Panel <i>Mystic Marriage of Saint Catherine</i> <i>Saint Giles and the Hind</i> , I.N. NG1419	c. 1500	Probably kermes
		Master of Saint Giles (Netherlands)		c. 1500	Madder + kermes
		Stephan Lochner (Germany)	<i>Saint Mathew, Catherine of Alexandria and John the Evangelist</i> , I.N. NG705. Reverse: <i>Saint Jerome, a female martyr, Saint Gregory the Great and a Donor</i>	c. 1445	Probably kermes
		Hendrick ter Brugghen (Netherlands)	<i>Jacob reproaching Laban for giving him Leah in place of Rachel</i> , I.N. NG4164	1627	Cochineal (New World)
		Master of the Aachen Altarpiece (Germany)	<i>The Crucifixion</i> , I.N. NG1049	c. 1495-1505	Probably largely kermes
		Maurice-Quentin de la Tour	<i>Henry Dawkins</i> , I.N. NG5118	c. 1750	Cochineal (New World)
		Gustave Moreau	<i>Saint George and the Dragon</i> , I.N. NG6436	1889-90	Cochineal (New World)
HPLC analysis of dyestuffs (1999)	HPLC elution program: aqueous 0.1% TFA (B) MeCN + 0.1% TFA	Veronese (Italy)	<i>The Rape of Europa</i> , I.N. NG97	c. 1570	Probably cochineal - very irregular baseline
		P. Campaña (formerly Zuccaro follower) (Spain)	<i>The Conversion of the Magdalen</i> , I.N.1241	1580-1600?	Cochineal (CA)
HPLC analysis of dyestuffs (2000) HPLC analysis of dyestuffs (2001)	HPLC elution program: aqueous 0.1% TFA (B) MeCN + 0.1% TFA HPLC elution program: aqueous 0.1% TFA (B) MeCN + 0.1% TFA	Sir Nathaniel Bacon (England)	<i>Cookmaid with Still Life of Vegetables and Fruit</i> , I.N. Tate, T06995	c.1620-5	Cochineal (CA + dclI trace not well separated)
		E. Le Sueur (France)	<i>Alexander and his Doctor</i> , I.N. NG6576	c. 1655	Cochineal (CA) + a trace of ea
		Giovanni Bellini (formerly attributed Carpaccio) (Italy)	<i>Adoration of the Kings</i> , I.N. NG3098	Probably c. 1490	Probably Polish cochineal or mixture with kermes – very low acquisition
		Velazquez (Spain)	<i>Saint John the Evangelist on the Island of Patmos</i> , I.N. NG6264	c. 1618	Cochineal (CA)
		Velazquez (Spain)	<i>The Immaculate Conception</i> , I.N. NG6424	c. 1618	Cochineal (CA) and possibly the presence of madder due to later additions
		Velazquez (Spain)	<i>Portrait of Archbishop Fernando de Valdés</i> , I.N. NG6380	c. 1640-5	Cochineal (CA) – very low acquisition
		Giovanni Battista Cima da Conegliano (Italy)	<i>Virgin and Child</i> , I.N. 2506	c. 1499-1502	Probably Polish cochineal (CA + ka)
HPLC analysis of dyestuffs (2002)	HPLC elution program: aqueous 0.1% TFA (B) MeCN + 0.1% TFA	Delacroix (France)	<i>Louis-Auguste Schwiter</i> , I.N. NG3286	1826-30	Madder + cochineal (trace of CA) – very irregular baseline
		Joachim Beuckelaer (Netherlands)	<i>The Four Elements: Air. A Poultry Market, with the Prodigal Son in the Background</i> , I.N. NG6587	1570	cochineal (CA + dclI?), probably New World + ea

Project/ Report	Analysis Conditions with HPLC-DAD	Author (Provenance)	Paintings' Title	Date	Dyestuff Identification
Dyestuff Examination (2004)	Dye extraction was made with 4% BF ₃ / MeOH left overnight. HPLC elution program: (A) aqueous 0,1% TFA (B) MeCN + 5% MeOH + 0,1% TFA.	Joachim Beuckelaer (Netherlands)	<i>The Four Elements: Water, A Fish Market with the Miraculous Draught of Fishes in the Background</i> , I.N. NG6586	1569	Cochineal (CA + dcll trace + ea)
		Joachim Beuckelaer (Netherlands)	<i>The Four Elements: Fire. A Kitchen Scene with Christ in the House of Martha and Mary in the Background</i> , I.N. NG6588	1570	Cochineal (CA + trace ea)
		Reni (France)	<i>Christ embracing Saint John the Baptist</i> , I.N. 191	About 1640	Cochineal (CA) + trace of ea
		Reni (France)	<i>Susannah and the Elders</i> , I.N. 196	1620-5	Cochineal (CA)
		Domenichino (Italy)	<i>The Vision of Saint Jerome</i> , I.N. 85	Before 1603	Cochineal (CA)
		Annibale Carracci (Italy)	<i>The Dead Christ Mourned ('The Three Maries')</i> , I.N. 2923	c. 1604	Cochineal (CA)
		Pietro da Cortona (Italy)	<i>St. Cecilia</i> (formerly Roman School), I.N. 5284	1620-25	Cochineal (CA) + brazilwood + unknown yellow + quercitrin
		Sassetta (Italy)	<i>Saint Francis giving away his clothes and Saint Francis dreaming</i> , I.N. 4757	1437-44	Kermes (fk+ka) + trace of CA
		Sassoferrato (Italy)	<i>The Virgin in Prayer</i> , I.N. NG200	1640-50	Cochineal (CA) + trace of ea (?)
		Bernardo Cavallino (Italy)	<i>Christ Driving the Traders from the Temple</i> , I.N. 4778	c. 1645-50	cochineal (CA)
Rembrandt paintings (2004)		Rembrandt (Netherlands)	<i>Self portrait at the age of 63</i> , I.N. MG22	1669	Cochineal (CA) + madder (?) (alizarine + purpurine)
Rembrandt paintings (2005)		Rembrandt (Netherlands)	<i>Portrait of Jacob Trip</i> , I.N. MG1674	1661	Probably cochineal (CA)
	<i>Portrait of Hendrkjestojtels</i> , I.N. b432		probably 1654-6	Cochineal (CA) + madder (alizarin + purpurin)	
			<i>Portrait of Margaretha de Geer, wife of Jacob Trip</i> , I.N. 1675	about 1661	Trace of CA
		Follower of Rembrandt (Netherlands)	<i>Diana bathing surprised by a Satyr</i> , I.N. MG2538	-	Cochineal (CA)
The Technology of Red Lake Pigment Manufacture: Study of the Dyestuff Substrate (2005) [37]			<i>An Old Man in an Armchair</i> , I.N. 6274	17th cent.	Cochineal (CA) + dcll
			<i>Portrait of Frederick Rihel on Horseback</i> , I.N. 6300	probably 1663	Cochineal (CA) + seemingly brazilwood (faded?) – very low acquisition
		Gerard David (Netherlands)	<i>The Virgin and Child with Saints and Donor</i> , I. N. NG1432	Probably 1510	Kermes and madder
		Dirk Bouts workshop (Netherlands)	<i>Christ Crowned with Thorns</i> , I.N. NG 712	Probably c. 1470-5	Kermes (ka)+ ea

Project/ Report	Analysis Conditions with HPLC-DAD	Author (Provenance)	Paintings' Title	Date	Dyestuff Identification
The Technology of Red Lake Pigment Manufacture: Study of the Dyestuff Substrate (2005) [37]	Dye extraction was made with 4% BF ₃ / MeOH left overnight. HPLC elution program: (A) aqueous 0,1% TFA (B) MeCN + 5% MeOH + 0,1% TFA.	Marinus van Reymerswaele (Netherlands)	<i>Two Tax Gatherers</i> , I. N. NG944	c. 1540	Madder + kermes
		Eustache Le Seuer (France)	<i>Alexander and his Doctor</i> , I. N. NG6576	c. 1648-9	Mexican cochineal (CA) + ea
		Master of Saint Giles (France)	<i>The Mass of Saint Giles</i> , I. N. NG4681	c.1500	Kermes + madder
		Austrian School	<i>The Trinity with Christ Crucified</i> , I.N. NG3662	c. 1410	Madder (alizarin) + trace of Kermes (ka)
		Albrecht Dürer workshop (Germany)	<i>The Virgin and Child</i> , I. N. NG5592	c.1500-10	Madder and kermes
		Giovanni Bellini workshop (Italy)	<i>The Adoration of the Kings</i> , I.N.NG3098	c.1475-80	Old World cochineal (Polish?) (CA + ka)
		Francesco Bissolo (Italy)	<i>The Virgin and Child with Saints Michael and Veronica and Two Donors</i> , I.N. NG3083	Probably 1500-25	Kermes (ka)
		Sandro Botticelli workshop (Italy)	<i>The Virgin and Child with a Pomegranate</i> , I.N. NG2906	Probably c. 1480-1500	Kermes (ka)
		Anibale Carracci (Italy)	<i>The Three Maries</i> , I.N. NG2923	c. 1604	Cochineal (CA)
		Bernardo Cavallino (Italy)	<i>Christ Driving the Traders from the Temple</i> , I.N. NG4778	c. 1645-50	Cochineal, probably Mexican (CA)
		Garofalo (Italy)	<i>The Virgin and Child with Saints Dominic and Catherine of Siena</i> , I. N. NG3102	Probably 1500-5	Madder and kermes
		Ridolfo Ghirlandaio (Italy)	<i>The Procession to Calvary</i> , I. N. NG1143	Probably c. 1505	Kermes (ka)
		Giannicola di Paolo (Italy)	<i>The Annunciation</i> , I. N. NG1104	Late 15 th cent.	Kermes (ka)+ madder (trace of alizarin) + ea
		Marco Marziale (Italy)	<i>The Virgin and Child with Saints</i> , I. N. NG804	1507	Kermes + ea + trace of madder
		Master of the Story of Griselda (Italy)	<i>The Story of Patient Griselda, Part III</i> , I. N. NG914	Probably c. 1493-1500	Kermes
		Raphael (Italy)	<i>The Ansidei Madonna</i> , I. N. NG1171	1505	Kermes + trace of brazilwood
		Dutch School (Netherlands)	<i>The Yarmouth Collection, lent to Tate by Norwich Castle Museum</i> , I.N. X03693	Late 1670's	Cochineal (CA trace) – very low acquisition
		Drouais (France)	<i>Le Comte de Vaudreuil</i> , I.N. 4253	1758	Cochineal (CA)
		Examination of lake dyestuffs (2006)		Canaletto (Italy)	<i>Venice: the Feast Day of St. Roch</i> , I.N. 937
Tiepolo (Italy)	<i>An Allegory with Venus and Time</i> , I.N. NG6387			c. 1754-8	Cochineal (CA + trace of dcll + ka)

Project/ Report	Analysis Conditions with HPLC-DAD	Author (Provenance)	Paintings' Title	Date	Dyestuff Identification
Examination of lake dyestuffs (2006)	Dye extraction was made with 4% BF ₃ / MeOH left overnight. HPLC elution program: (A) aqueous 0,1% TFA (B) MeCN + 5% MeOH + 0,1% TFA.	Pompeo Batoni (Italy)	<i>Portrait of Richard Milles</i> , painted in Rome, I.N. 6459	Probably 1760's	Cochineal (CA) – irregular baseline
		Velazquez (Spain)	<i>Pope Innocent X</i> , Apsley House (English Heritage, formerly V&A), I.N. M713	–	Cochineal + brazilwood
Examination of lake dyestuffs (2007)		Romney (England)	<i>Mrs. Johnstone and her Son</i> (?), I.N. Tate N01667	c. 1775-80	Cochineal (CA) + trace of madder, probably added later
		Sir Joshua Reynolds (England)	<i>Sir James Hodges</i> , I.N. Tate N03545	1765	Cochineal (CA)
		Rubens (Netherlands)	<i>Saint Bavo is received by Saint Amand and Floribert</i> , I.N. NG57	Before 1612 or 1616-23	Cochineal (CA)
		Antoine François Callet (France)	<i>Louis XVI</i> (Waddesdon, via A. Sanden)	-	Cochineal (CA) + trace of dcll
Examination of lake dyestuffs (2008)		Larkin, William (attrib.) (England)	<i>George Villiers, 1st Duke of Buckingham</i> (via S. Cove), I.N. NPG3840	c. 1616	Cochineal + madder (?) – very low acquisition
		Gérôme (France)	<i>Portrait of Armand Gérôme</i> , I.N. NG3251	1848	Cochineal (CA)
		Murillo (Spain)	<i>Christ healing the Paralytic at the pool of Bethesda</i> , I.N. NG5931	-	Cochineal (CA) + ellagic acid

Potential Future Research

It is believed that the work carried out in this sub-project will offer proper historical conclusions concerning both the precise cochineal species used in historical textiles and their circulation in long-distance trade routes. Thus, in a further phase of this sub-project, characterization and identification of cochineal species with Ultra-Performance Liquid Chromatography coupled to Mass Spectrometer (UPLC-MS), in combination with cochineal-dyeing and ageing experiments on contemporary textile samples, will be assessed in RCE, under the co-supervision of Dr. Maarten van Bommel. These analyses will be followed by the construction of a reference library, through PCA, which will be undertaken by Dr. João Lopes (Porto University, Portugal). This statistical method will permit to distinguish the cochineal species and match with the correspondent contemporary dyed-textile samples, so that the insect species can be properly identified in historical textiles. The accurate results obtained will certainly contribute for the attribution of historical textiles date and provenance and to confirm the efficacy of a cochineal species reference library, for future research on cochineal identification, both in entomological and textile conservation research.

As a dyestuff product, the knowledge on the localization of the species, the extent of their trade, the application as dyes or painting materials, and especially their presence in historical textiles, can help to trace the impact of this insect in diverse cultures. Moreover, the possibility of determining the exact species of cochineal in the historical textiles, not only will constitute important evidence for testing the veracity of the historical sources, but will also help to answer several questions about certain cultures and periods, in which the historical sources are scarce or missing. On the other hand, this new approach on cochineal species characterization will constitute an important technological advance for the study of dyestuffs, and assist in overcoming the limits of current methodologies [10].

International dissemination of the historical picture and analytical advances resulting from this project will occur through oral communications at scientific meetings, and publication in international journals of an artistic, historical, chemical, or entomological nature. It is expected that this diffusion will encourage a better understanding and awareness of the necessity of a rigorous approach for identifying natural dyes, especially in historical samples. Moreover, this dissemination will enhance the correct identification of these dyes in historical textiles, so that good results can be obtained with HPLC-DAD analysis for valuable historical textile samples from international museums.

The information in the archives of the institutions belonging to CHARISMA was also found to be extremely useful and interesting for other related sub-projects which are currently ongoing in the TEXTILES, TRADE AND TASTE (TTT) project. These are focused on other sources of red, such as lac dye or redwood, which played a significant role in European and Asian trade. The first is the PhD thesis of Raquel Santos which aims to look at the use of lac

dye as the primary red dye source in 'Indo-Persian' carpets; the second is a Post-Doctoral project being conducted by Dr. Ana Claro on the trade of natural dyes and their influence on Chinese and Portuguese textiles. Both of these individuals will be conducting their analytical work later at the Freer Gallery of Art in Washington, DC. It is hoped that the interdisciplinary approach being developed in all three of these sub-projects will result in a healthy cross-fertilization of ideas, and wider dissemination of information and results between them, so that together they will make a considerable contribution to the TTT project, and hence, our knowledge of colour and dyeing practices and the changes that occurred across the world as a result of the European Overseas Expansion. For this reason, it is hoped that future ARCHLAB Transnational Access opportunities in CHARISMA institutions may be made available to these two researchers, for the continued development of the TTT project.

References

- [1] Born, W., "Scarlet", *Ciba Review*, **1** (7) (1938) 206-227.
- [2] Donkin, R. A., "The insect dyes of Western and West-Central Asia", *Anthropos, International Review of Ethnology and Linguistics*, **72** (1977) 848-868.
- [3] Donkin, R. A., "Spanish red: An ethnogeographical study of cochineal and the Opuntia cactus", *Transactions of the American Philosophical Society*, **67** (5) (1977) 1-84.
- [4] Marichal, C., "A forgotten chapter of international trade: Mexican cochineal and the European demand for American dyes, 1550 - 1850", in *Latin America Global Trade and International Commodity Chains in Historical Perspective*, Stanford University, 16-17 November 2001, 1-27.
- [5] Munro, J. N., "The Medieval Scarlet and the Economics of Sartorial Splendour", in *Cloth and Clothing in Medieval Europe: Essays in Memory of Professor E. M. Carus-Wilson*, dir. N. B. Harte and K. G. Ponting, London, The Pasold Research Fund (1983) 13-70.
- [6] Oakley, P., "The Point of Red", *HALI*, **144** (2006) 70-75.
- [7] Phipps, E., "Cochineal Red, The Art History of a Color", *The Metropolitan Museum*, New York (2010) 1-48.
- [8] Cardon, D., *Natural Dyes - Sources, Tradition, Technology and Science*, Archetype Publications, London (2007).
- [9] Buss, C., *Seta Oro Cremisi, Segreti e Tecnologia alla Corte dei Visconti e degli Sforza, at the Museo Poldi Pezzoli*, Silvana Editoriale, Milano (2009).
- [10] Serrano, A., Sousa, M. M., Hallett, J., Lopes, J. A., Oliveira, M. C., 2011, "Analysis of natural red dyes (cochineal) in textiles of historical importance using HPLC and multivariate data analysis", *Analytical and Bioanalytical Chemistry*, **401** (2010) 735-743.
- [11] Phipps, E., "Cochineal Red, Tracing History Through Colour", *HALI*, **164** (2010) 76-85.

- [12] Lee, R., "Cochineal in European Commerce, 1626-1625", *The Journal of Modern History*, **23** (3) (1951), 205-224.
- [13] Leggett, W. F., *Ancient and Medieval Dyes*, Chemical Publishing Co., Inc., New York (1944).
- [14] Graaff, J. H., Roelofs, W., "Occurrence of Textile Red Dyes 1450-1600 AD", *American Dyestuff Reporter*, **65** (1976) 32-34.
- [15] Chávez-Moreno, C. K., Tecante, A., Casas, A., "The *Opuntia* (Cactaceae) and *Dactylopius* (Hemiptera: Dactylopiidae) in Mexico: a historical perspective of use, interaction and distribution", *Biodiversity and Conservation*, **18** (2009) 3337-3355.
- [16] Wouters, J., "High performance liquid chromatography of anthraquinones: analysis of plant and insect extracts and dyed textiles", *Studies in Conservation*, **30** (1985) 119 - 128.
- [17] Wouters, J., Verhecken A., "The Coccid Insect Dyes: HPLC and computerized diode-array analysis of dyed yarns", *Studies in Conservation*, **34** (4) (1989) 189-200.
- [18] Wouters, J., Verhecken A., "The scale insect (*Homoptera: Coccoidea*). Species recognition by HPLC and diode-array analysis of the dyestuffs", *Annls Soc. ent Fr. (N.S.)*, **25** (4) (1989) 393 - 410.
- [19] Wouters, J., Verhecken A., "Potential taxonomic applications of HPLC analyses of coccoidea pigments (*Homoptera: Sternorrhyncha*)", *Belg. J. Zool.*, **121** (1991) 211 - 225.
- [20] Vahedi, H., Hodgson, C. J., "Some species of the hypogeal scale insect *Porphyrophora* Brandt (*Hemiptera: Sternorrhyncha: Coccoidea: Margarodidae*) from Europe, the Middle East and North Africa", *Systematics and Biodiversity*, **5** (1) (2007) 23 - 127.
- [21] Portillo, L., "Origen de *Dactylopius coccus* Costa (*Hemiptera: Dactylopiidae*) ¿Norte o Sudamérica?", *Dugesiana*, **12** (1) (2005) 1-8.
- [22] Chávez-Moreno, C. K., Tecante, A., Fragoso-Serrano, M., Pereda-Miranda, R., "Metabolic profiling of *Dactylopius* (*Hemiptera:Dactylopiidae*) species pigments by geographical origin and hosts using multivariate data analysis", *Biochemical Systematics and Ecology*, **38** (2010) 671-679.
- [23] Mushak, P., "The Use of Insect Dyes in Oriental Rugs and Textiles: Some Unresolved Issues", *Oriental Rug Review*, **8** (5) (1988).
- [24] Graaff J. H., *The Colourful Past – Origins, Chemistry and Identification of Natural Dyestuffs*, Abbeg-Stiftung, Switzerland (2004).
- [25] Atasoy, N., *IPEK: Imperial Ottoman Silks and Velvets*, Azimuth Editions Limited, London (2001).
- [26] Serrano, A., *Cochineal, a precious source of red: Cochineal Dyes Identification by High Performance Liquid Chromatography with Diode Array Detection and Principal Component Analysis*, Master Thesis, Lisboa, Faculdade de Ciências e Tecnologia - Universidade Nova de Lisboa (2010).

- [27] Peggie, D. A., Hulme, A. N., McNab, H., Quye, A., "Towards the identification of characteristic minor components from textiles dyed with weld (*Reseda luteola* L.) and those dyed with Mexican cochineal (*Dactylopius coccus* Costa)", *Microchimica Acta*, **162** (2008) 371 – 380.
- [28] Rosenberg, E., "Characterisation of historical organic dyestuffs by liquid chromatography–mass spectrometry" *Anal. Bioanal. Chem.*, **391** (2008) 33-57.
- [29] Mantzouris, D., Karapanagiotis, I., Valianou, L., Panayiotou, C. "HPLC–DAD–MS analysis of dyes identified in textiles from Mount Athos", *Anal. Bioanal. Chem.*, **399** (2011) 3065-3079.
- [30] Valianou, L., Karapanagiotis, I., Chryssoulakis, Y., "Comparison of extraction methods for the analysis of natural dyes in historical textiles by high-performance liquid chromatography", *Anal. Bioanal. Chem.*, **395** (2009) 2175-2189.
- [31] Lech, K., Jarosz, M., "Novel methodology for the extraction and identification of natural dyestuffs in historical textiles by HPLC–UV–Vis–ESI MS. Case study: chasubles from the Wawel Cathedral collection", *Anal. Bioanal. Chem.*, **399** (2011) 3241-3251.
- [32] Méndez, J., González, M., Gloria Lobo, M., Carnero, A., "Color Quality of Pigments in Cochineals (*Dactylopius coccus* Costa). Geographical Origin Characterization Using Multivariate Statistical Analysis", *J. Agric. Food Chem.*, **52** (2004) 1331-1337.
- [33] Lagowska, B., Golan, K., "Scale Insects /Hemiptera, Coccoidea/ as a Source of Natural Dye and Other Useful Substances", *Aphids and Other Hemipterous Insects*, **15** (2009) 151-168.
- [34] Deviése, T., Higgitt, C., Bosscher, N., Verger, L., "Analysis of organic colorants at the British Museum and preliminary results from study of the Andean textile collection" in *30th Dyes in History and Archaeology*, University of Derby Enterprise, 13-14 October 2011.
- [35] Graaff, J. H., Roelofs, W., "On the Occurrence of Red Dyestuffs in Textile Materials from the Period 1450-1600", in *International Council of Museums Committee for Conservation (ICOM)*, Madrid, 2-5 October 1972.
- [36] Kirby, J., White, R., "The Identification of Red Lake Pigment Dyestuffs and a Discussion of Their Use", *National Gallery Technical Bulletin*, **17** (1996) 56-80.
- [37] Kirby, J., Spring, M., Higgitt, C., "The Technology of Red Lake Pigment Manufacture: Study of the Dyestuff Substrate", *National Gallery Technical Bulletin*, **26** (2005) 71-87.
- [38] Textiles collection database from the British Museum website, assessed in 15 November 2011: http://www.britishmuseum.org/research/search_the_collection_database.aspx.



Signature of lead researcher:.....