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TRACING COCHINEAL THROUGH THE COLLECTION OF THE METROPOLITAN MUSEUM[1]

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Cochineal—*Dactylopius coccus*-- is a small insect that lives on cactus and yields one of the most brilliant red colors that can be used as a dye. (Fig. 1) Originating in the Americas—both Central and South —it was used in Pre-Columbian times in the making of textiles that were part of ritual and ceremonial contexts, and after about 100 B.C., was the primary red dye source of the region. Cochineal, along with gold and silver, was considered by the Spanish, after their arrival in the 16th century to the Americas, as one of the great treasures of the New World. In the colonial era, cochineal continued to be produced in the region, using cultivation techniques from earlier times.[4]

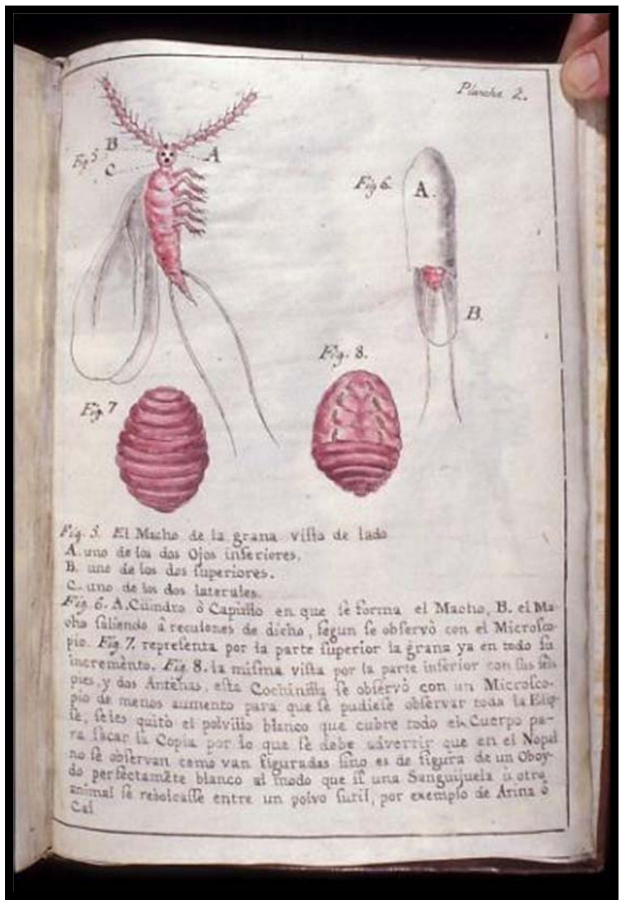

Figure 1 Male and Female Cochineal. José Antonio de Alzate y Ramírez *Memoria sobre la naturalesa cultivo y eneficion de la grana* *(Mexico City 1777) pl 2. Newberry Library, Chicago, Edward E. Ayer Manuscript Collection (Ayer ms 1031).*

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[3] Research Scientist, Department of Scientific Research, Metropolitan Museum of Art.

[4] See H. Meneses, this volume.

Heralding the age of global trade in the sixteenth through the eighteenth centuries, cochineal was shipped throughout the world. First from the Americas to Spain, from there it travelled by land and sea throughout Northern and Western Europe, through to North Africa, the Levant and onto to the Middle East. Another route left from Acapulco, Mexico and Lima, Peru along the Pacific route with the Manila galleons—the fleets of Spanish ships—that travelled to the Philippines—and from there to Canton with the exchange of American silver and cochineal, for Asian silks and porcelains. This story has been told many times by dye specialists, and historians and thanks to a number of great scholars over the centuries, the history of this extensive trade has been well documented.[5]

So as a conservator and art historian at the Metropolitan Museum, and interested in issues of preservation, authentication, provenance and cultural context, knowing this rich and vital history yielded an important perspective when looking at actual works of art. Working with the textile collections of the Museum, including their 35,000 textiles that span the globe, the project aimed to contextualize this history by tracing the presence of American cochineal-- through examining the physical objects—and to document how history and art intersect.

Red dyes were always precious and as a result, trade in these dyes was a very early occurrence. Brilliant red dyes from Eastern Europe travelled along the northern trade route from Cracow to Mainz and Cologne. Lac, from India, moved into the Middle East, and through China and Central Asia. Kermes from the Mediterranean spread throughout Western Europe, and by the sixteenth century, American cochineal came into the mix. Looking at the textiles from cultures where the dye trade had an impact on artistic production. For example, analysis of the red dye used in an ikat fabric lining an embroidered nineteenth century coat from Turkmenistan belonging to the Metropolitan Museum, found that American cochineal had been used as the dye.[6] This was of great interest to this study. These complex interrelationships between local textile production and the long-distance dye trade underscored the need for accurate identification of the dyestuff for our study, in order to tell the story accurately.

To do this, the cochineal project developed in collaboration with Museum scientists—particularly Nobuko Shibayama, Research Scientist who conducted analyses of over 100 samples, and Marco Leona, the head of the Department of Scientific Research, to whom I could turn for examining the problematic and difficult issues. These issues included, for example, whether it was possible to analyze a textile with a Raman laser through its Plexiglas cover, which is was—and enabled us to confirm my assessment that the bright orange colorant used in the Warring States (475–221 B.C) textile from China was the mercury pigment, cinnabar.[7] Another challenge was whether it was possible to identify the red colorant on a fragment of a polychrome leather quiver cover found in Egypt from 1800 B.C., whose condition was highly deteriorated, and where sampling was near-impossible.[8] (Thanks to Marcos micro-sampling technique the analysis revealed one of the earliest reported findings of madder dye.)[9]

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[5] See especially Donkin, 1977a and 1977b ; Lee ,1948 and 1951.
[6] MMA 1998.244. See fig 76, Phipps, 2010a.
[7] MMA 2002.558. See fig 2, Phipps, 2010a.
[8] MMA 28.3.5 See fig 5, Phipps, 2010a.
[9] These collaborations are very important because looking at a textile with the naked eye, it is not possible to know what constitutes the dyestuff, in spite of years of working with collections. Rather, the scientific identification of the dye components contributes a key factor to any historical or contextual study. Although with scientific analysis, a dialogue between scientist and conservator/art historian is critical in order to formulate the context for the study and to hone the questions on which to focus. This dialogue also requires a critical assessment of the significance of the results.

For this project, the primary method of analysis was HPLC (High Performance Liquid Chromatography) with some samples examined with SERS (Surface Enhanced Raman Spectroscopy).[10] HPLC, considered to be the method of choice for identification of dye compounds, requires that samples be taken from the textiles. These were extracted and analyzed.[11] HPLC shows the presence of compounds that make up the dye. Madder, for example, is composed of several dye components and HPLC can detect them, including of alizarin and purpurin. These results, in other words, do not identify the source of the dye—that is the species of the plant or its origin- but rather, the building blocks of the colorant. Results, therefore, require assessment and discourse, to interpret their meaning, understand their accuracy and understand their significance.

This current cochineal research project was formulated over the past 35 years, guided by the experience of working with the Met's collection, and intensified and focused over the past 5 years—for its culmination in the publication *Cochineal: the art history of a color* (Metropolitan Museum of Art *Bulletin*, Winter 2010). The basic storyline of the project can be found in the publication; this paper will present some interesting examples—case studies. In doing so, my aim is to underscore how material and technical studies can contribute to our greater knowledge of history and art and the process of cultural change through collaborative dialogues, and to discuss some of the issues and questions that arise during these dialogues.

1. Paracas reds

As we know that cochineal originates in the Americas, one of the first questions that comes to mind is: what is the earliest example we can find?

Some of the earliest textiles with red colorants that have been preserved in the Americas are associated with the Chavin culture that flourished between 900 and 200 B.C.—who used earth pigments to create their striking religious iconography. Since the majority of these early extant textiles were cotton, it is less likely that the reds would have been produced with cochineal, as cochineal is primarily a dyestuff that is used on animal fibers, and so we need to look there. The native Andean animal fiber comes from the camelid, whose origins are the highlands. Their fine silky hairs were highly valued from early periods, but since few extant remains from highland cultures have been preserved, due to environmental issues, it is only when they appear in the coastal burials, can we find the use of red dyestuffs fully developed.[12] By around 300 B.C. we find extensive evidence of these wool fibers used in some of the most complex artistic textile creations, dyed in brilliant red colors.

The famous Paracas mantles, found wrapped layer upon layer in burials in the South Coast, were among the great achievements of Peruvian prehistory, and were abundantly red.[13] These reds, however, for the most part come from the root of a plant related to Madder, called relbunium. While we tend to associate madder reds as a more orange hue, Andean dyers were able to achieve a brilliant, almost florescent crimson red with the plant dye (so much so, that one would be hard pressed to try to differentiate between a relbunium and a cochineal red, solely by its hue.) **(Fig 2)** Max Saltzman, a chemist working in the 1960s on Peruvian dyes, found both cochineal and relbunium embroidered yarns, sometimes on the same textile,

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[10] Some of the samples which are especially minute were analyzed by Surface Enhanced Raman Spectroscopy (SERS) because of the highly sensitive detection capabilities of this method, which, however, has other limitations. See Marco Leona, Scientific Research in the Metropolitan Museum of Art. *MMA Bulletin* Summer 2009.

[11] The amount sample taken varied, depending on the fiber, the condition of the yarn and the condition of the textile, and the availability of sample—such as yarns that were still attached to the textile, but nearly detached, for example along cut or pulled edges.

[12] This is evidenced by their early domestication, by the 6th or 5th millennium B.C.

[13] See, for example, J. C. Tello, *Paracas.- primera parte. Vol. 1*. Publicación antropológica del Archivo "Julio C. Tello" de la Universidad Nacional Mayor de San Marcos, Lima 1949 and Danièle Lavallée, editor, *Paracas, unpublished treasures of ancient Peru*. Paris: musée du quai Branly/Flammarion**,** 2008

indistinguishable in hue, by the naked eye.[14] Among the Metropolitan Museum's Paracas textiles, approximately forty or fifty examples were visually examined, and five were selected for testing: all were relbunium. [15]

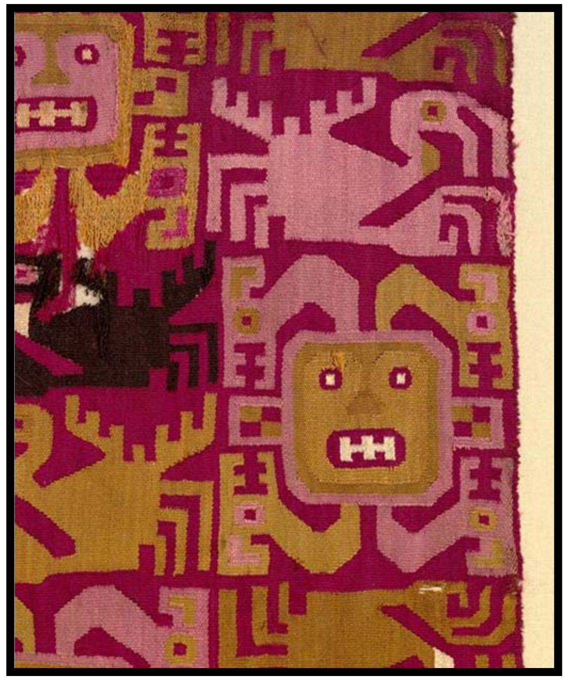

Figure 2, left. *Embroidered Border Fragment, Paracas, Peru, 4th–3rd century B.C.E. Camelid hair embroidery on cotton. The Metropolitan Museum of Art, Gift of George D. Pratt, 1933 (33.149.87). Fluorescent red relbunium (Shibayama 2008).*
Figure 3, right. *Textile fragment, Peru, Recuay culture, 4th–6th century. Tapestry weave, camelid hair. The Metropolitan Museum of Art, Gift of George D. Pratt, 1930 (30.16.7). Cochineal (Shibayama, 2008.)*

For our project, the earliest cochineal example in the Met's collection was a textile from the Recuay culture that flourished between 4th and 6th A.D., whose origin lay in the Southern Andean region, mid-way between the highlands and the coast. **(Fig 3)** It is in this mid-altitude region that even today, the cultivation of cochineal persists. And it may have been exactly that region where cochineal insects originally flourished, along with its host, the Opuntia cactus.

Shortly after this period, cochineal red can be found in the textiles throughout the north and south coast, and with few exceptions, nearly all of the examples we studied after around 400 A.D. had been dyed with cochineal. The Inca used cochineal to achieve their 'blood' red color, sometimes mixed with a yellow dye, used in a number of official royal Inca garments. Red for the Inca was notably a symbol of kingship, the *mascaypaycha* **--** the red fringe worn at the forehead of the king's.[16]

[14] For analysis of red dyes in Paracas textiles, see M. Saltzman "Analysis of Dyes in Museum Textiles: or You Can't Tell a Dye by Its Color." In *Textile Conservation Symposium in Honor of Pat Reeves*, edited by Catherrine McLean and Patricia Connell, pp. 27-39. Los Angeles, 1986. See also Masako Saito "Identification of Six Natural Red Dyes by High Performance Liquid Chromatography" in *Dyes in History and Archaeology* 19, edited by Jo Kirby, pp. 70-87, London, 2003.

[15] Paracas textiles tested with analytical results for the red being relbunium included 33.149.93, 33.43, 1986.488.1, 1986.488.2.

[16] See Phipps, 2003.

2. Spain

Prior to the influx of American dyestuff into Europe, brought literally by the ton in the Spanish fleets, Spain had its own source of red insect dye—kermes (*kermes vermilio*)-- that thrived along the shores of the Mediterranean, and was used throughout the region, since prehistoric times.[17] For our study, as expected, we found a consistent use of kermes as the primary red dye in Spanish textiles in pre-sixteenth century materials.[18] (Fig 4)

Figure 4, left. *Fragment, Spain, Islamic, Taifa kingdoms perriod, first half of 12th century. Silk, metal wrapped thread; lampas weave. The Metropolitan Museum of Art, Funds from Various Donors, 1958 (58.85.1). Kermes (Shibayama, 2008).*

Figure 5, right. *Chasuble, Spanish, late 16th or early 17th century. Laher, wool, silver and gold leaf. The Metropolitan Museum of Art, Frederick C. Hewitt Fund, 1914 (14.134.19). Cochineal (Shibayama, 2010).*

We were interested to find among the Spanish textiles in the MMA collection, a textile that might indicate when the local kermes industry gave way to imported cochineal. Perhaps one of the earliest that we found may be a Spanish cope, (MMA 51.139.7) with cochineal used in the ground cloth.[19] Another interesting example was a spectacular late 16th or early 17th century gilt leather chasuble—with large-scale designs produced with cochineal-dyed wool flocking. (Fig 5)

It is likely that the wool flocking had been made from reused and shredded woolen cloth scrap—evidence of a thriving cochineal-dyed wool industry. But since we were looking for that pivotal moment when the impact of the tons of cochineal from the Americas hit the shores of the Iberian Peninsula, the analysis of a

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[17] See Cardon, “Chapter 12: Vermillion, scarlet and crimson: scale insect sources of anthraquinone dyes” pp 607-666, in *Natural Dyes*, 2007.

[18] MMA Spanish textiles analyzed included: 12th Century silk lampas textiles (MMA 58.85.1 and 2) and a 15th Century Nasrid textile with lions (MMA 1981.372). For photo of the second piece, see fig 48, Phipps, 2010a.

[19] See fig 50, Phipps, 2010a.

fifteenth century textile encapsulates a key issue for the problem. (Fig 6) This textile, part of a group attributed to the last of the Hispano-moresque dynasties in Spain, the Nasrid who reigned from mid-13th c to the end of the 15th c. (r. 1232-1492), just at the time that Columbus set sail for the Americas, in 1492. The textile, a curtain fragment, dated to sometime during the fifteenth century—and therefore likely to have been made prior to the conquest-- was found to have carminic acid, the chemical compound that is characteristic of American cochineal. [20] It also is the primary coloring component of the insect commonly referred to as Armenian cochineal, a different insect.

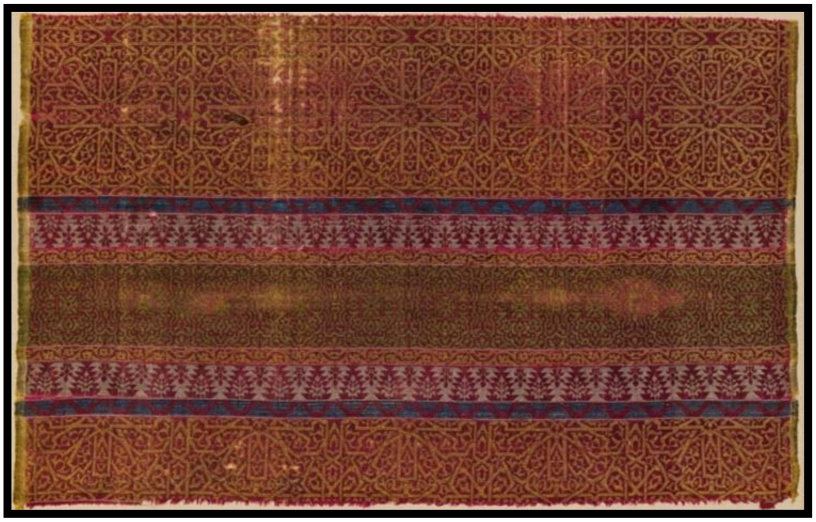

Figure 6. *Fragment of Curtain Panel. Spain, 15th c. Lampas. Silk. The Metropolitan Museum of Art, Rogers Fund, 1912 (12.55.6a). Red is cochineal (Armenian or American) (Shibayama, 2009).*

Thanks to the research Dominique Cardon has conducted over the past twenty years on understanding and characterizing the various species of red dye producing insects, we have a clearer picture of the types and variety, their extent and habitats throughout the world. And her clarification particularly of the historical terminology with the identification of species has been a great contribution. The confusion, for example, of the historical documents that refer to *Kirmiz*, which now we know was not the Mediterranean kermes, but rather an insect of a different genus, the Prophyrophora whose origins are further East, in Eastern Europe, Armenia, Central Asia and Russia.[21] Chemists have differentiated between the red insects based on different chemical compounds responsible for the red color. These compounds are characteristic of the respective insect red dyes, and they are used in their identification. Lac (*kerria lacca*), found in India and Southeast Asia has laccaic acid; kermes from the Mediterranean, has kermesic acid; and cochineal, has carminic acid. The difficulty lies in differentiation between the American species of cochineal and the Armenian type insect—as each have carminic acid as their primary colorant.[22]

Jan Wouters, former head of the laboratory of the Royal Institute for the Study and Conservation of Belgium's Artistic Heritage and a leading scientist in the field, had developed a method to differentiate between the American and Armenian species of cochineal based on the presence of a secondary compound – which he referred to as dcII—found in greater quantities in the American than found in the Armenian. His publication in the 1980s has been a standard in the field.[23] With this work in mind, we examined our samples for the distinguishing dcII but encountered some difficulties.

[20] For other references to Spanish textiles analyzed with results of Armenian cochineal, see Cristina Partearroyo "Tejidos hispanomusulmanes" *Bienes Culturales, no 5 (2005)* pp. 37-74.
[21] See Donkin, 1977a, also Cardon, 2007, pp 635-655.
[22] The so-called Polish cochineal, *Porphyrophora polonica*, has both carminic and kermesic acids.
[23] Wouters and Verhecken, 1989.

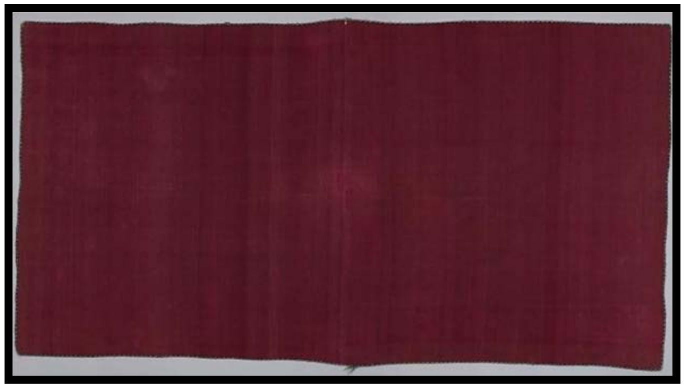

Figure 7. *Ceremonial Mantle, Bolivia, Aymara, 18th-19th century. Warp-faced plain weave, alpaca. The Metropolitan Museum of Art, Bequest, John B. Elliott, 1977 (1999.247.251). Cochineal (Shibayama, 2009).*

We found, for example, that samples of known South American origin, and undoubtedly produced with American cochineal, in some cases did, but in other cases did not always contain the dcII. (Fig 7) We considered whether this may have been the result of archaeological conditions that may have affected the compound, or a result of the dyer's use of wild versus cultivated species of the insect or about our own laboratory methods or conditions, which were slightly different in the extraction process. As a result, for our study, certain critical identifications—whether a textile had been dyed with the cochineal from the Americas, or one imported from the East – has not yet been made. After a number of repeated analysis and discussions, further study on the crucial component dcII is planned and also a different approach to the problem was considered.

Figure 8. *Habitat of American and Armenian cochineal.* ***Left:*** *Cochineal on cactus pad, Bolivia .(Photo: E. Phipps).* ***Right:*** *Armenian cochineal on roots of grass at the base of Mt. Ararat, 2008. (Photo: J. Lyman).*

We looked, for example, at the physiological differences between the two insects: physically—they were very different in size and appearance, noting that they also come from different habitats feeding on very different plant sources**.** (Fig.8) The American insect lives out in the sunlight on the pads of a particular type of cactus, whereas the Armenian type lives underground, on the root of local grasses. The Armenian insect, even in its dried state, remains fat, as it has a high concentration of lipids—more so than the American,[24] which completely dries. Research in this area may contribute to the differentiation between

[24] See Cardon 2007, p. 649 for the dye composition of Armenian cochineal.

the two insect sources based on the comparative presence of fatty acids in the extracts of dyed yarns.[25] (Fig. 9).

Figure 9. *Dried states of American and Armenian cochineal.* ***Left:*** *Dried cochineal from Peru*
Right: *dried Armenian cochineal. (Photos: E. Phipps)*

3. Italian velvets

When the subject of the study turned to the examination of Italian velvets, the problematic issue of the inability to clearly differentiate between the Armenian vs. American sources surfaced once again. Armenian cochineal was traded since Medieval times into Italy, and so findings of carminic acid as the red colorant in a number of velvet examples yielded the uncertain result. So as the scientific approach in this project had not yet provided the definitive answers, the project took another direction, seeing whether archival sources could help clarify the situation.

Italy by the 14th century, was known for its luxury textile trade and production, notably for its lush red velvets. The high cost of the textiles was based in part on the dyestuffs used and powerful dyers guilds and local silk organizations, the *setaoli* regulated all aspects of their production. These regulators were skeptical of the new red dye source from the Americas, and early on in the sixteenth century, shortly after the shipments began to arrive into Europe, and particularly in to Northern Italy, its use had been banned. After the dyers guilds conducted experiments and trials with Mexican 'cugnilia', by mid-century, cochineal was beginning to be accepted.[26] To insure that the specific dye had been used in the production of the velvets a system of coded selvages was implemented. (Fig 10)

Figure 10. *Velvet fragment, Italy, 16th century. Cut silk velvet with silver thread in green selvage. The Metropolitan Museum of Art, Gift of Nanettte B. Kelekian, in honor of Olga Raggio, 2002 (2002.494.469).*
Cochineal (Shibayama, 2009).

[25] MMA organic chemists Julie Arslanoglu and Adriana Rizzo are conducting preliminary studies on this problem using Gas Chromatography with Mass Spectrometry. In addition, Nobuko Shibayama is pursuing research into the subject of wild vs cultivated cochineal, along with examining laboratory methods for differentiating the dye components and dcII.

[26] Molà, 2000, pp 121-22.

According to Lucas Molà, historian of the Italian textile industry, by mid-16th century a solid green silk selvage on a red velvet was to indicate kermes had been used, while a green selvage with a silver thread down the center marked that the 'foreign' (meaning American) cochineal had been used.[27] This historical information was kept in mind during the examination of a collection of Italian 16th-17th century velvets that had recently been given to the Met.[28] Of the 800 or so samples, fortunately a number were encountered that had green selvages. Upon close examination, two appeared to have the single silver thread down the center, (see fig. 10, right) and we used these for the study, along with a third fragment that had a solid green selvage with no silver thread.[29] The solid green selvage, following guild regulations, was expected to certify kermes. The analysis of the two samples with silver thread showed that both were dyed with Carminic acid. (An interesting note was that one also had another colorant, identified as Orcein, from orchil or lichen dye.) The result of the velvet sample with no silver thread, however, did not show kermes, but rather carminic acid, like the others (along with high amounts of ellagic acid, a tannin traditionally used for mordanting and also to add weight to the silk.) This would indicate cochineal (either American or Armenian) and not the specified kermes dye.[30] If this was American cochineal, what would be the explanation? One observation is that as we know from other studies, that Italian dyers were constantly going outside of the regulations, which may be one of the reasons why the guild regulations were constantly being renewed, re-stated and reimposed. So, the historical approach was inconclusive, and perhaps together with the scientific analysis may together provide a clearer picture.

Figure 11. *Pieced fragment, Islamic (Safavid period), 17th century. Silk, metal thread.*
The Metropolitan Museum of Art, The Friedsam Collecion, Bequest of Michael Friedsam, 1931 (32.100.461).
Cochineal (bird's wings) and safflower (faces and flowers) (N. Shibayama, 2008).

[27] Earlier, in the mid-fifteenth century, a green selvage with a single gold thread down its center certified that a fabric had been dyed with kermes. L. Molà, 2000, p.129. On the use of selvage marks for velvets, see also John Munro "The Medieval Scarlet and the Economics of Sartorial Splendour" in *Cloth and Clothing in Medieval Europe*, ed. by N. Harte and K. Ponting, pp.13-70. Pasold Studies in Textile History no. 2. London, 1983.

[28] Collection of various Italian velvets, A. Kelekian, gift in honor of Olga Ragigo, MMA 2002.

[29] MMA accession numbers: 2002.494.469 and 2002.494.419 had green selvage with silver threads, 2002.494. 629 had green selvage, no silver.

[30] One, (496) had a small amount of dcII, but it was not detected in the other, (491). (Although a peak was detected at the same retention time when dcII is normally detected, but the UV-visible spectrum did not match that of dcII, indicating a difference between them, and the probability that it likely was American cochineal (but not conclusive, according to Wouter's standards.)

CONCLUSIONS

Of the hundred or so samples that were tested for this project, objects were selected from the collection that could potentially be key transitional pieces—that show the change of one cultural habit—that of using local and regional dyes—to another habit—the incorporation of foreign dyes. (Fig. 11) One of many examples of this phenomenon in the study was a Persian seventeenth century textile that used two red dyes. Analysis revealed that one of the reds used in the orange faces of the birds, came from safflower dye, typical of the region and the deep crimson color used in the wings of the birds, was from American cochineal, thus documenting a particular moment in time, with a concrete example of the results of the international routes as the dyestuff travelled from of the Americas to Europe and on to the Middle East.

As we know, dyes—the plants and animals whose precious colorants were exploited by cultures around the world, have their particular origins and habitats. In the field of historic textiles, along with a focus on design and weaving methods, the study of dyes and colorants, can be particularly key to identification of culture, provenance and dating. Understanding dyes, their origins and characteristics can also contribute to our understanding of the conditions and needs for the long term preservation of our textile heritage, as we can predict behavior of these dyes to light and air, many of which are fugitive and/or fragile. Those of us who have the privilege of working with collections of ancient and historic textiles can contribute this first-hand knowledge of dyes and colors that, in collaboration with our scientific and art historian colleagues, brings new levels of understanding through technical studies that span between the physical work of art and the history of cultures around the world.

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