The conservation of an ethnographic multi-material shield made in Malaysia by the Dayak tribe: pictorial surface cleaning and feathers restoration

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Abstract

Ethnographic artifacts are intrinsically fragile, due to the natural constituent materials degradation. A polychrome and polymateric ethnographic shield from Borneo, owned by the National Prehistoric Ethnographic Museum "Luigi Pigorini" in Rome, has been carried out to restoration regarded mainly the painted surface cleaning and the feathers recovery, following criteria such as adopting not invasive methods to preserve the original materials and using eco-sustainable products.

Keywords

Ethnographic arts, Feathers conservation, Funori consolidation, Gellan gel, Cleaning.

Introduction

The paper describes the conservative intervention of an ethnographic polychrome and polymateric artifact, a ceremonial shield coming from Borneo island and made at the end of the 19th century (Figure 1). The shield is made of natural materials: wood, pigments and binder, feathers, different types of vegetable fibers and bamboo. Over time, these materials have degraded, in particular the painting layers, feathers and the plant fibers. The conservative restoration required targeted actions on each material by adopting specifically designed operations.

The *Dayak* shield: description

The shield comes from Borneo, in the Pacific Ocean, dates back to the late nineteenth century and was made by the warrior "Dayak" tribe. The Dayak are the native people of Borneo, located principally in the central and southern interior of the island.

Since 1910, the shield has become part of the collection of the "Luigi Pigorini – National Prehistoric Ethnographic Museum" in Rome, purchased directly in Borneo from the collector Giovan Battista Bettanin.

The artifact, a single rectangular block wooden sculpture and convex externally, is polychrome and multi-materic: the structure is in wood while the decoration is made of pigments and binder, different types of plant fibers, feathers and bamboo (Figure 1). The wooden structure is *dyera costulata* species, an arboreal plant present in the Borneo forest (Theissen, 2016).

Rattan vegetable fibers (two above and two below, parallel to each other) are bonded in a woven pattern. Two bamboo canes are attached to the sides of the shield by means of rattan vegetable fibers, red and black tufts of vegetable fibers are also present. The floral pictorial decoration, in red, green, black and white colors for the background, is painted on the front of the shield. The back is all painted in white except for the green and red handle. In the upper part, in the center, there is a feather composition: the largest feathers are of Argus bird. The morphology of the wooden substrate was investigated by SEM analysis (Figure 2).

Figure 1 – Front and back side view of the "Dayak ethnographic shield.

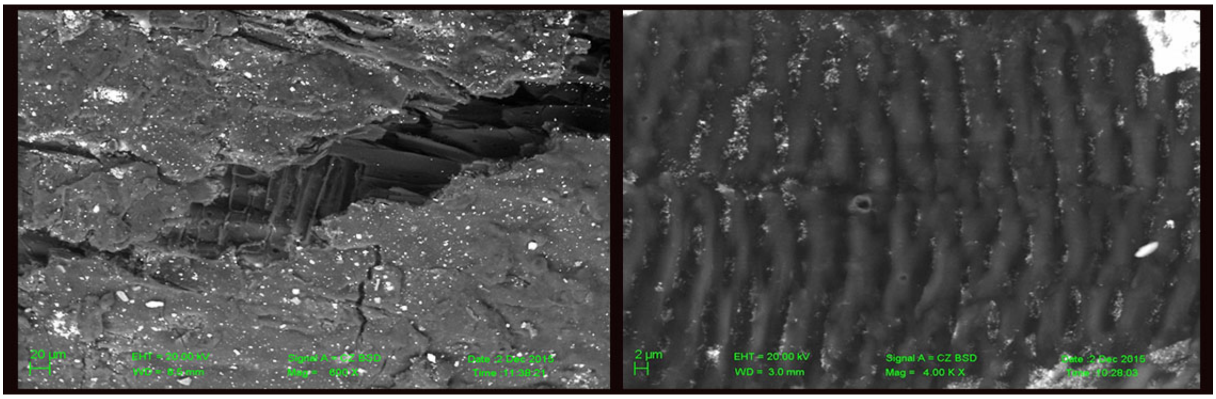


Figure 2 – SEM images of the *dyera costulata* wooden substrate: the low magnification micrograph (left) shows the highly irregular surface, at high magnification (right) the porous structure of the wood is highlighted.

Analysis and characterization of materials

In order to identify the nature of pigments and binders, a characterization campaign was conducted on micro-samples taken from the paint film. The samples were analyzed by SEM-EDS, FTIR, and Raman spectroscopy[1]. The pigments identified were: zinc white (zinc oxide ZnO), vermillion (mercury sulphide HgS), lamp black (elemental carbon with O, H, S and various impurities) and green earth (silicate-earthy compounds). Different binders were used for the pigments: oil for the white and vegetable gum for the other pigments. The vegetable fibers were observed by SEM, whereas the colours were analyzed by FTIR (Figure 3) and by SEM with the aid of EDS probes (Figure 4) - i.e., vermillion for red and lamp black for black (Bevilaqua, Borgioli, & Gracia, 2010).

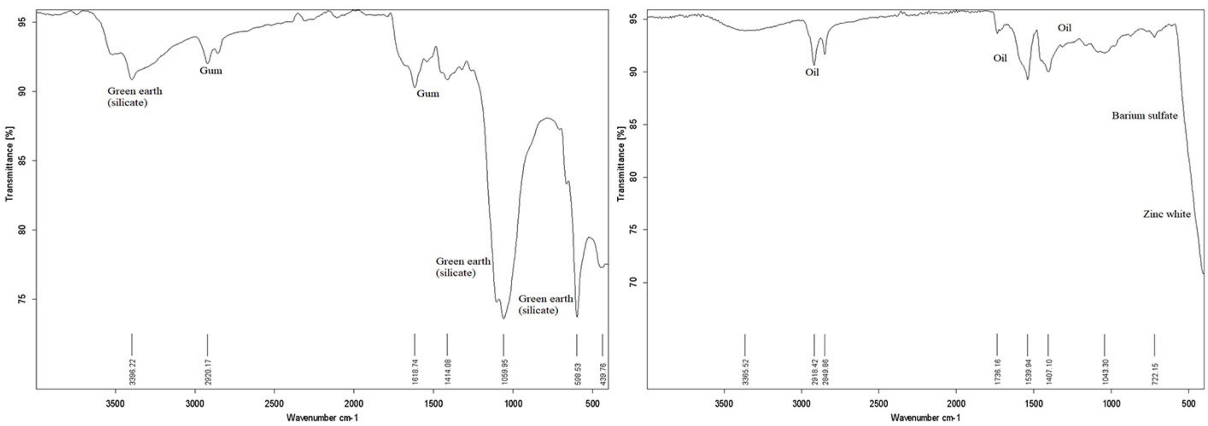
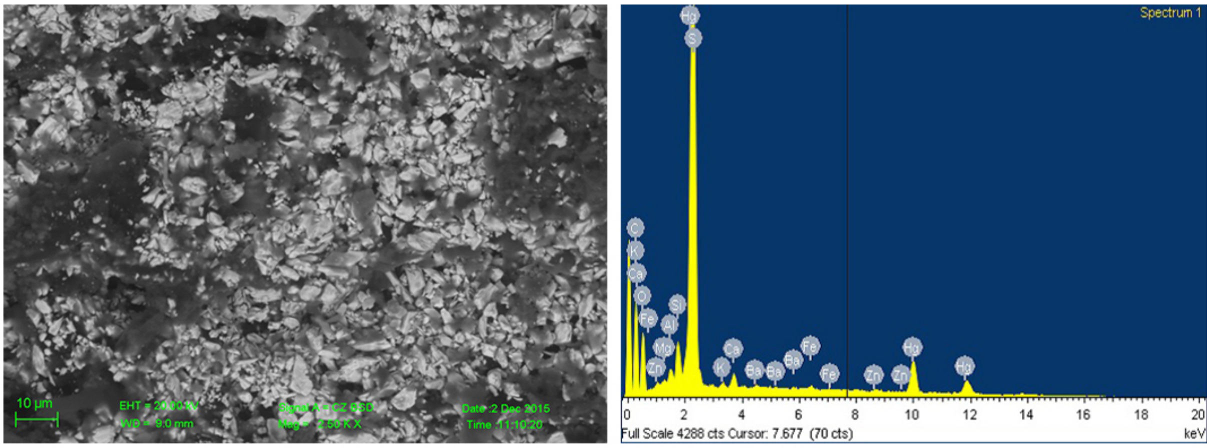


Figure 3 – FTIR spectroscopy of the green pigment sample - green earth - with gum binder (left) and of the white pigment sample - zinc oxide - with oil binder (right).

[1] The spectrometric analyzes were conducted at the Laboratory of the Interdepartmental Center of Raman Spectroscopy of the University of Bologna, instrument used: FTIR Bruker ALPHA spectrometer in ATR mode and with a spectral resolution of 4 cm^{-1}, Jasco micro-Raman spectrometer NRS 2000C equipped with a 532 nm green laser and a 100X objective optical microscope (laser power of 25 mW and each spectrum is the average of 8 measurements with a spectral resolution of 4 cm^{-1}).



Processing option : All elements analysed (Normalised)

Spectrum	In stats.	C	O	Si	S	K	Ca	Fe	Zn	Hg	Total
Spectrum 1	Yes	42.10	32.83	1.76	4.74	0.69	4.95	0.94	1.19	1.67	100.00
Spectrum 2	Yes	47.66	35.32	2.13	2.19	0.67	2.17	1.09	0.57	6.47	100.00
Spectrum 3	Yes	40.98	36.28	4.01	2.44	1.29	2.92	1.92	0.90	6.00	100.00
Spectrum 4	Yes	39.19	27.24	1.69	**5.26**	0.60	2.06	0.75	0.50	**20.74**	100.00
Spectrum 5	Yes	39.18	25.07	1.37	**5.41**	0.57	1.79	0.72	0.54	**24.02**	100.00
Mean		41.82	31.35	2.19	4.01	0.76	2.78	1.08	0.74	11.78	100.00
Max.		47.66	36.28	4.01	5.41	1.29	4.95	1.92	1.19	24.02	

All results in weight%

Figure 4 – SEM image recorded and qualitative and partially quantitative EDS micro-analysis of the white pigment sample. From the analysis the presence of zinc (Z), oxygen (O) barium (Ba) and sulfur (S), due to zinc white (zinc oxide) with percentage of barium sulfate, is detected.

State of conservation

The whole surface of the shield was dirty due to sedimented dust. In particular, the background white was the dirtiest paint since it was formed by oily binder[2]. The composition of the feathers was in a bad state of conservation (Figure 5). The higher degradation was structural due to the broken rachides and quills in different areas. The barbs and the barbules were broken, depolymerized, uncombed and dirty due to dust. Finally, the tufts of vegetable fibers on the sides of the shield were dehydrated, broken, tangled together and subject to shattering already at the slightest mechanical stress.

[2] The oil is a non polar and water repellent substance but it changes over time in contact with the atmosphere and with the pigments in which it is bounded. Fragmentations occur with ageing, with consequent formation of organic acid residues, such as the carboxylic functional group (-COOH), or of free radicals (–COO-), due to oxidative and hydrolytic processes that can occur at the inside of the crosslinked structure of the polymer. These radicals attract mono-, bi- and tri-valent metals from atmospheric particulate matter or from the paint film because they have a free electron: therefore, the atmospheric particulate adheres to the surface of the pictorial film of the artifact.

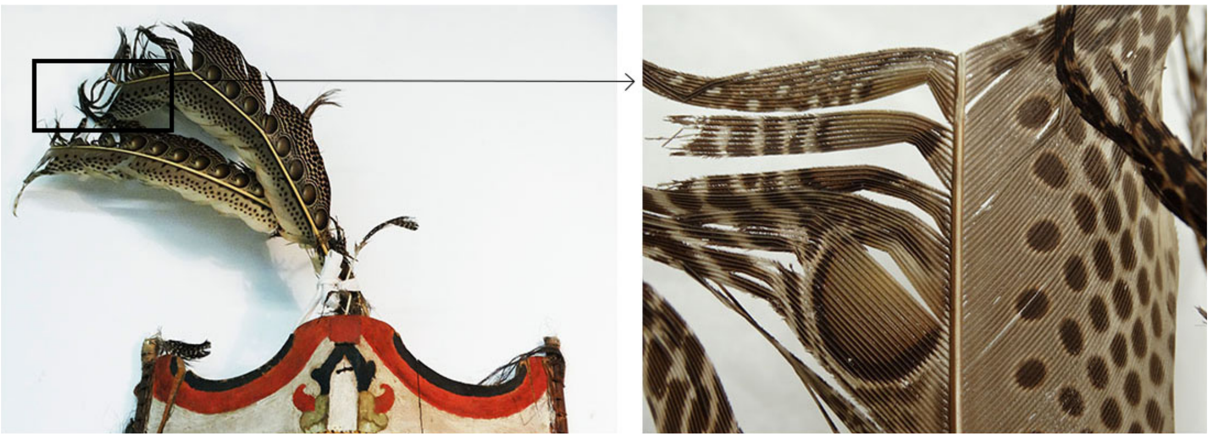


Figure 5 – Feathers state of conservation: feathers composition with broken rachides (top-left), terminal part of a broken rachis and mechanical disorder of the barbules (top-right).

Preliminary tests

In order to better characterize the pictorial surface, as well as to define the intervention methods, three tests were carried out: of dustiness degree, of solubility and of wettability. The test of dustiness degree had been executed by a dry swab swirled on each of the four colors and observing the surface of the swab by microscope. The red, green and black paint were slightly powdery caused by the low amount of binder. The solubility test (Coladonato & Talarico, 1997) was conducted by using four solvents of different polarities - demineralized water, ethanol, acetone and isooctane. The swab was moistened with each solvent and rubbed on all four colors: the test confirmed the solubility of red, green and black with polar solvents, while the white was not soluble. Finally, in order to characterize the surface hydrophobicity and to determine the pictorial surface water tolerance threshold, the wettability test (Cremonesi, 2011) was carried out (Figure 6). The test showed that the white paint was hydrophobic, while the red, green and black paints were hydrophilic[3] (the water absorption rate was higher for these colors than for the white paint).

[3] The contact angle measurements on the white background showed a partial wettability with an average high contact angle of 83° in the first 5 seconds and of 68° after 60 seconds). Therefore, the observations showed that the white paint film was hydrophobic due to the 90° contact angle, unlike the red and green backgrounds that were more hydrophilic.

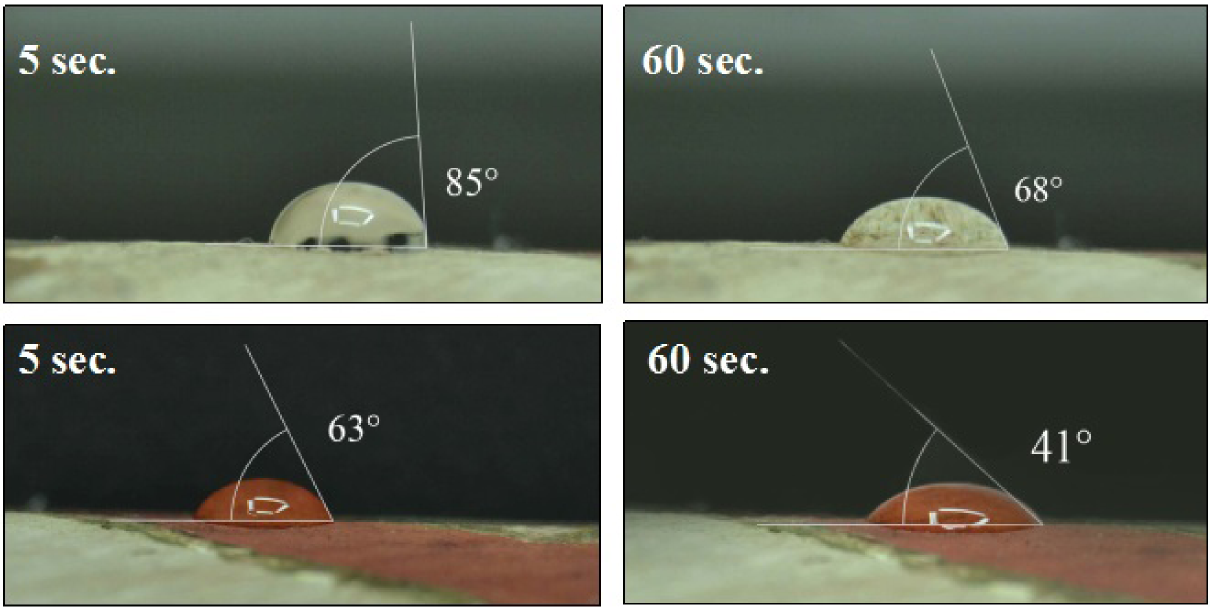


Figure 6 – Time evolution of white (top) and red (bottom) paint contact angle.

Conservative intervention on vegetable fibers

The first operation was the intervention on the fibers. They had been rehydrated and disentangled through humidity by an ultrasonic vaporizer[4]. The minimum amount of humidity generated by the instrument was evenly distributed over the fibers to allow the gradual absorption of water within the cellulose structure of the fiber. The fibers knots were untangled by means of thin-tipped pliers, thus the dirt between the fibers was removed.

After this operation, it was possible to consolidate the fibers (Figure 7). We needed a product able to give both strength and flexibility to the fragile cellulosic structure, being chemically stable and with good viscosity for a better penetration (Barclay, 1986). The polymer poly-oxazoline (Aquazol® 200) dissolved in demineralized water had been selected and applied by means of ultrasonic mister, preceded by a humidifying treatment in order to convey the solvent. Finally, the fibers had been protected with Japanese paper.

[4] U1000 ultrasonic vaporizer by C.P.R. Roma, variable power.

Figure 7 – Treatment of hydration performed on the vegetable fibers by an ultrasonic vaporizer and their protection with Japanese paper.

Pictorial surface cleaning and consolidation

Regarding the painting, the red, green and black layers of colour had to be consolidated (Lorne, 1995). In order to select the most suitable consolidant, tests were carried out on polychrome wooden samples (where Arabic gum was used as binder) made with the same materials of the shield. Four consolidants had been chosen basing on parameters such as non-toxicity and compatibility with the pictorial surface, i.e. methylhydroxyethylcellulose (Tylose MH300P®), hydroxypropyl cellulose (Klucel G®), polyvinyl alcohol (Gelvatol) and acrylic resin (Acrilmat®). All these products were soluble in water and in a water-alcohol solution.

Hydroxypropyl cellulose gave the best results: no alteration of the underlying color scheme was revealed, providing also excellent adhesive and cohesive properties. Therefore, red, green and black paints had been consolidated with 1,5% Klucel G® in water-alcohol solution[5] applied by brush with interposed Japanese paper.

[5] Demineralized water and ethanol (50:50).

After the consolidation, it was possible to clean the white paint. Four solvents with different polarity had been tested[6]: water gave the best results. However, as the mechanical action by swab induced stress to the surface paint, rigid gels had been selected. In particular the Gellan® gum[7] was taken in consideration and chosen for its excellent properties, such as the controlled release of water and the total transparency of the gel (Iannuccelli & Sotgiu, 2012). The contact angle test determined that the white paint medium was highly hydrophobic. Therefore, it was chosen to use Gellan at 4%[8,9] concentration (Figure 8).

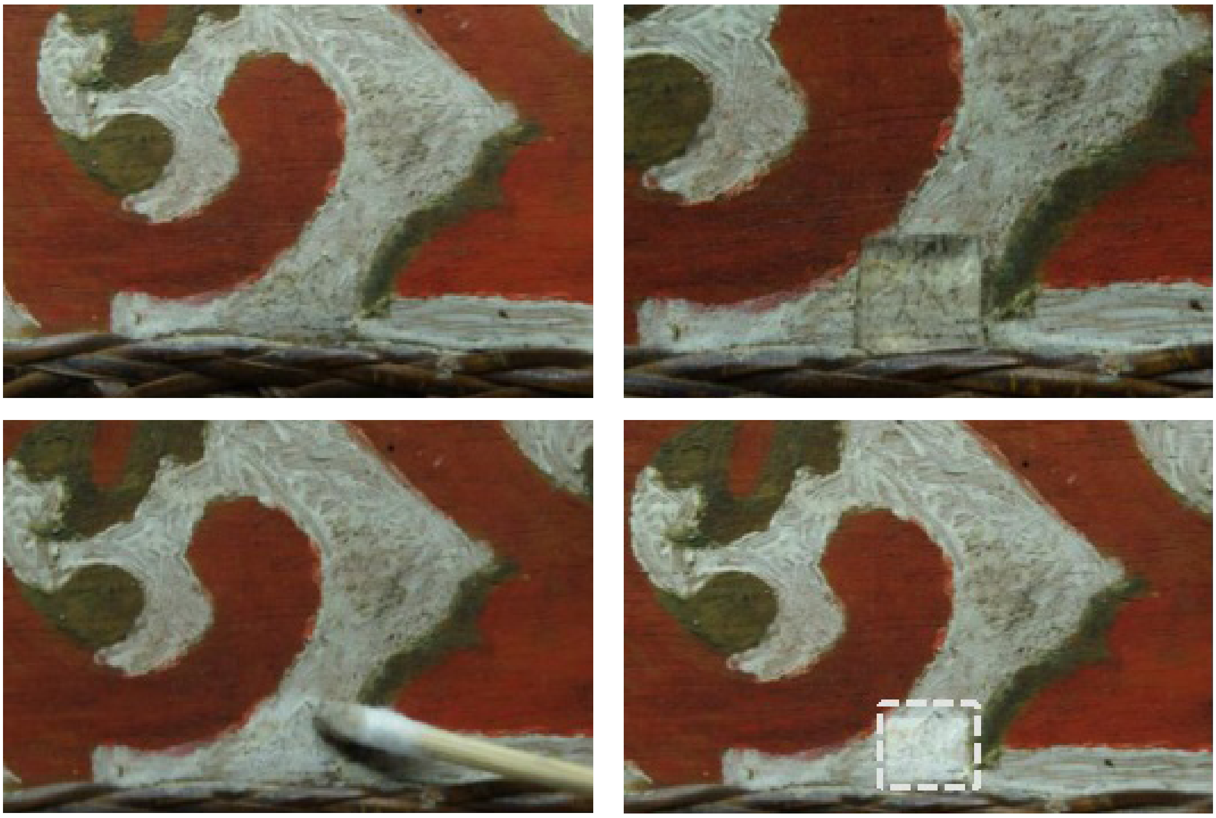


Figure 8 – Tests of Gellan® gum over paint layers.

However, for the water gel cleaning of the white paint, it was decided to isolate the red, green and black paint layers due to their sensitivity to water. The fixative and temporary protective Cyclododecane[10] was chosen to waterproof the paint (Boschetti & Borgioli, 2007).

6 The solvents tested were: water, water-alcohol solution (50:50), ethanol and isooctane.
7 Gellan gel is a water-soluble anionic polysaccharide produced by the bacterium *Sphingomonas elodea*.
8 Gellan gel preparation: demineralized water and 4% of Gellan. Heat the mixture by stirring occasionally. When there is a change of state and color - from greyish transparent solid to amber liquid - the gel is ready. Then pour the liquid into a rigid container of the shape you want to give to the gel. In a few minutes it cools, solidifying into the desired shape. The sol-gel transition process occurs at 30-40 °C. The temperature and the presence of mono or divalent cations in the water condition the gel formation mechanism. The gel can be stored in the refrigerator for up to a week / ten days.
9 Gellan is used from 1 to 5%.
10 Cyclododecane ($C_{12}H_{24}$) is a molecule of 12 carbon atoms and is cyclic and branched. It is soluble in non-polar and aromatic solvents, scarcely soluble in polar solvents and insoluble in water: for this reason, it is a strongly hydrophobic molecule. It has the characteristic of sublimating, therefore passing from the solid state to the gaseous state. This property depends on the magnitude of the intermolecular attraction forces.

The product was applied by brush in the molten state only on water-sensitive paint (Figure 9). The Gellan dowels were applied over the paint surface (Figure 10) and covered with polyethylene film and weights to exert a constant pressure in order to ensure maximum contact and a gradual release of water. After a twenty minutes application, the Gellan dowels were removed and the swollen dirt could be easily pulled off using cotton tampons moistened with demineralized water. The cleaning effectiveness is shown in Figure 11.

Figure 9 – Cyclododecane application above the water-soluble painting.

Figure 10 – Placement of Gellan® gum over the entire surface paint.

Figure 11 – Pictorial surface during cleaning.

Conservative intervention on the feather's decoration

Regarding the feathers, the first operation was the dry cleaning to remove the coherent and incoherent deposits between the barbs and along the rachides (Gowers, 1972). The dirt has been removed by an aspirator with micro-spouts regulated at minimum power. Light pressure with a polyurethane *make- up* sponge was performed on the feathers for a more detailed refinement. Wet cleaning was performed by cold ultrasonic nebulized mister[11] and the dirt swollen by moisture has been removed using a dampened pad (Figure 12). The dirt has been removed with moistened swab alternating hydroalcoholic solution and deionized water with anionic surfactant[12] controlling the neutral pH[13] (Green & Storch, 1988; Mason, 1990).

[11] A high temperature catalyzes the chemical reactions in the structure of the feather.
[12] 2% Tween® 20 in demineralized water.
[13] The pH is an important parameter for the conservation of feathers, as a basic pH causes the chemical decomposition of keratin, leading to the weakening of the feather.

Figure 12 – Treatment on the feather's decoration: micro aspiration of dirt and dry cleaning with a *make-up* sponge above the rachides.

The rachis of the three feathers in the center were broken in several points. Therefore, the structural intervention was performed using needles and thread. In particular, a beige polyester yarn was inserted by means of a curved surgical needle and a wooden element was added to the sides of the seam to reinforce the spine (Figure 13). In one of the feathers, since the inside of the spine was hollow, a small wooden pin was inserted and fixed with nitro-cellulosic adhesive: the two ends of the spine of the feather were connected. As far as the broken quills are concerned, antique toothpicks made from quills and produced in the 1950s have been used. They were carved with a scalpel in order to obtain ad hoc shapes and then fixed by nitro-cellulosic adhesive (Figure 14). Since the barbules and beards were depolymerised, it was decided to perform a restoring treatment. Preliminary consolidation tests were conducted on a detached feather fragment in order to choose the best adhesive (Wright, 2002). The selected products were Funori® and Aquazol® 200, both in a water-alcohol solution, applied by using an ultrasonic aerosol nebulizer. The observation of the feather under a microscope allowed us to observe optical alterations that occurred on the surface of the feather. The Funori® did not alter the surface and gave strength and tenacity to the structure of the beards and barbules. Therefore, the consolidating treatment was performed with Funori®. After consolidation, before the consolidant evaporation and drying, the barbules were untangled by the insertion of thin entomological pins on a polyethylene support (Figure 15); they were left for about forty-eight hours, in this position.

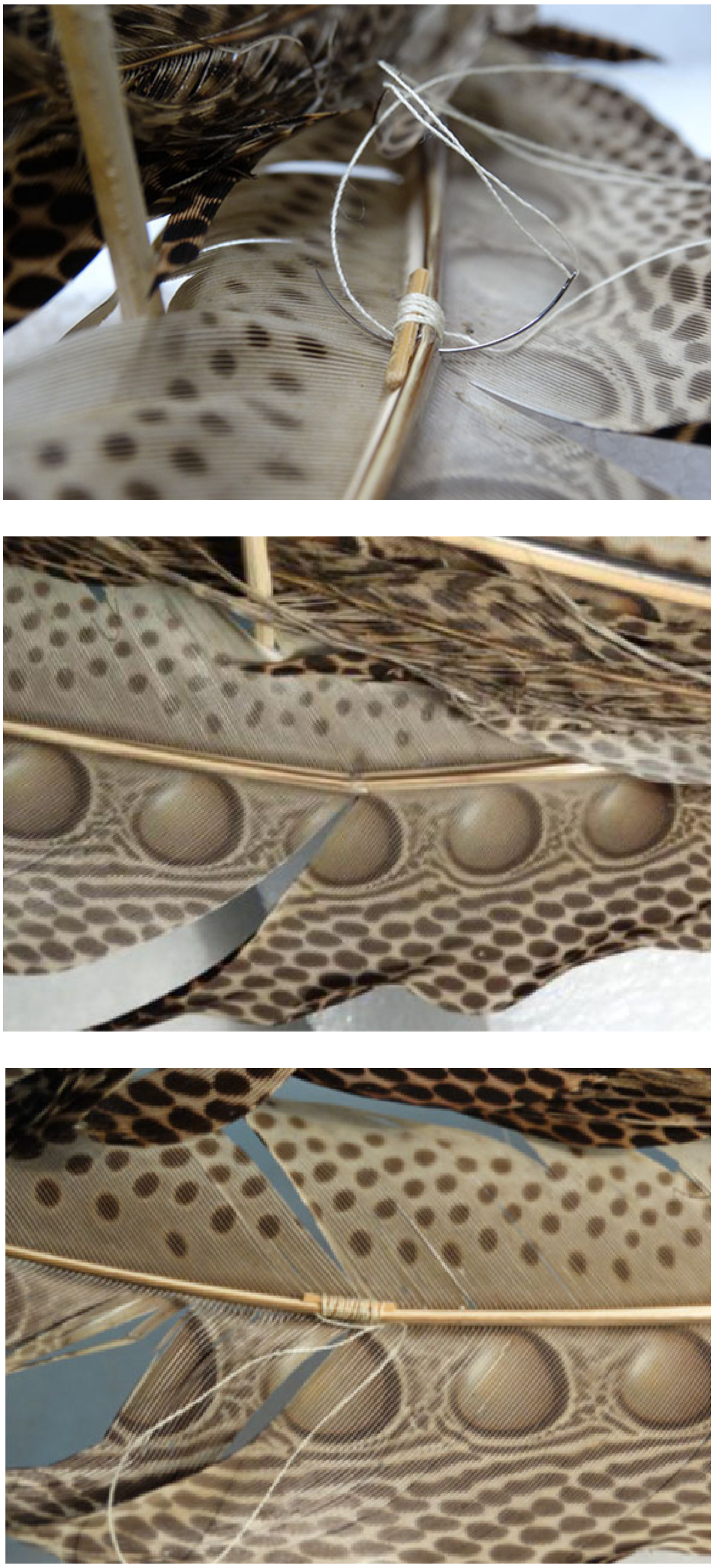


Figure 13 – Broken rachis seam by curved surgical needle and polyester thread, before and after sewing.

Figure 14 – Toothpick calamus datable of the 1950s: carving and inserting into the damaged feather.

Figure 15 – Barbs consolidation by nebulizer and correct positioning of the barbs by inserting thin pins between them.

Conclusions

The research carried out on the materials and on the execution techniques had the purpose of expanding the historical-ethnographic knowledge on the technique of making Borneo wooden shields. The restoration intervention (see Figure 16) was based on the principle of minimum intervention respecting the material history of the object, trying to combine the needs required by its polymateriality, with the simultaneous safeguarding of those signs that represent the historical and cultural heritage of the artifact. The selected products were chosen on the basis of non-toxicity and compatibility with the materials of the object for a sustainable restoration with alternative materials and products. The use of Gellan® rigid gel was particularly noteworthy, even regarding its unusual use in the polychromy on a wooden support field: combined with the action of Cyclododecane as temporary protective agent during the selective removal of surface deposits on juxtaposed and otherwise sensitive areas, such methodology proved to be totally effective. The methodology adopted by using the Gellan® rigid gel or in preformed plates combined with the protection offered by the Cyclododecane, has proved to be decisive.

The specific needs of each material have encouraged us to search for original solutions, such as the intervention carried out on feathers, characterized by the structural restoration of the quills through the use of antique toothpicks of the same material, the stitching of the broken rachis with curved surgical needles, up to the consolidation of the beards and barbules using the product of natural origin derived from the Funori algae through aerosol nebulization.

Figure 16 – Front and back side of the Dayak shield after restoration.

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