Object: Garuda

Cultural attribution/provenance: Indonesia

Dimensions (HxWxD, inches): 17 7/8 x 15 x 7 1/8

Medium: polychrome wood

Current/past owners: Connecting Cultures Mobile Museum

Markings: Newsprint transfer and pencil markings on base

Date of examination: 12/14/2017

Conservator: Kasey Hamilton

Object Description:

Carved wooden statue of Garuda, painted with brightly colored and gold paints.

Materials and techniques:

The Garuda figure is carved from several pieces of tropical hardwood (tentatively identified as ramin, *Gonystylus spp,* see Appendix I). The body and base are carved from one piece, and several other pieces are attached via wood joints, including the proper left and proper right wings, the topmost feathered element, and the talons. The topmost feathered element is attached to the body with a mortise and tenon joint. The wings are attached behind the figure's shoulders, where rectangular grooves have been carved out of the wood to partially house the wings (similar to a dado joint). This joint is reinforced by a small peg protruding from the wing elements, meant to rest atop a curved groove at the top of the dado joint (fig. 1). The proper right wing is completely detached from the body.

Figure 1. Dado joint, back proper right shoulder with groove for peg to rest (left), and peg on proper right wing, sitting in groove (right).

The talons are formed from cylindrical pieces of wood, and have tapered, slightly curved ends, likely formed via whittling or carving. These appear to be attached with dowel joints (fig. 2). Each hand is meant to have two talons attached. The proper left hand has its original talons, while both are missing on the proper right hand. The innermost talon on the proper left hand has been replaced with a flexible wooden stick, painted white.

Figure 2. Dowel joint, proper left hand.

Several joints have been reinforced with a thick, yellowed adhesive, appearing similar to a commercial wood or carpenter's glue. A variety of compositions were found for commercial wood glues, including polyvinyl acetate, aliphatic resins, and urethanes. Animal glue is another possibility, given the color. Spot test results indicated that the adhesive is likely a polyurethane wood glue (see Testing & Analysis for further details).

The surface is painted with a glossy paint. At areas of loss a white ground layer is visible beneath the colored paints. Gold paint has been applied in some areas covering the colored paint. Thin black painted lines have been used for small details, such as the pattern on the Garuda's feathers. Attempts to characterize the paints further can be found in Testing & Analysis below.

Testing & Analysis:

Adhesive Identification

Microchemical spot tests for polyvinyl acetate, protein, and polyurethane (Odegaard, Nancy.; Carroll, Scott.; Zimmt 2015; Remillard 2007) were carried out on small samples of adhesive removed from a weakened repair on the detached wing . Solubility tests were also carried out in hopes of characterizing the adhesive. Small samples were immersed in warm water, acetone, ethanol, and mineral spirits. The adhesive did not dissolve in any of these solvents. Swelling appears to be observed in the warm water, ethanol, and acetone, but this observation is extremely subjective and difficult to confirm, especially with such small samples. Spot tests proved to be the most helpful in identifying the adhesive. The spot test results can be seen in Table 1. Descriptions of the tests can be found in Appendix B.

Table 1. Microchemical spot test results, adhesive samples from proper right wing repair.

Test	Results
PVA Test	Inconclusive
Protein Test	Negative
Polyurethane	Positive

Spot test results indicating that the adhesive is likely a polyurethane wood glue, such as Original Gorilla Glue or Titebond Polyurethane Glue.

Paint Layers

Solubility tests were conducted in order to characterize the paint layers and inform treatment decisions. Four solvents were used to test the solubility of each individual paint present

on the surface of the Garuda, as well as the white ground layer. The results can be seen in Table 2.

Table 2. Solubility test results. (I) indicates that the paint was insoluble in the given solvent, whereas (S) indicates solubility.

Paint tested	Water	Acetone	Ethanol	Mineral Spirits
Red	I	I	I	I
Blue	I	I – No paint is picked up, but surface is altered (clear haze)	S	I
Green	I	S	I	I
Black lines	I	I	I	I
Gold	I	S	S	I
White ground layer	I	S	I	I

Spot tests for carbonates and sulfates were carried out on small samples of the white ground layer. Descriptions of these spot tests can be found in Appendix A. The ground tested positive for carbonates and negative for sulfates. This suggests that the ground is prepared from CaCO3.

X-Radiography

X-radiography confirms that the base and body are fashioned from one piece of wood, as the grain runs continuously through. Wood joints (for instance, the mortise and tenon join) are not easily resolved in the x-ray image due to overlapping wood elements. Two areas were noted that are attached with nails, undetected in the initial visual examination. The first area is at the base of the object, just below the proper right foot. A blind crack surrounding an area approximately 3 cm in diameter appears to have been stabilized with three or four nails, which were subsequently painted over. Indentations at the entry points remain visible. A second area was found with nails joining the curling feathered element just above Garuda's head.

A vertical channel is visible in the x-radiograph, located within the figure's torso. A powdery material seems to be accumulated within, possibly sawdust. It is difficult to accurately identify where exactly the channel would be located, as the x-radiography in the torso is particularly difficult to interpret due to overlapping wooden elements.

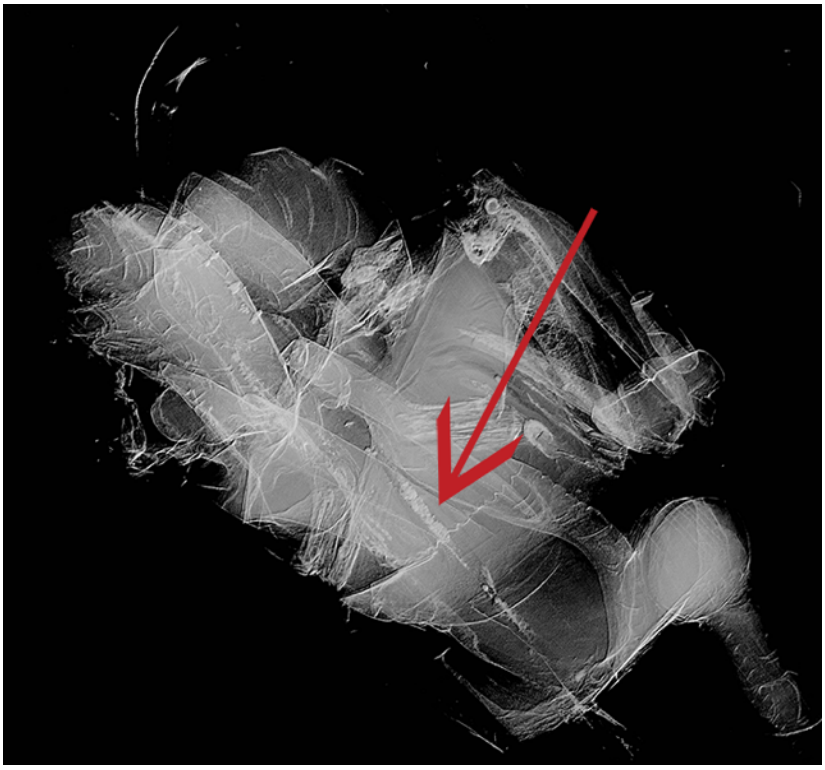


Figure 3. Red arrow pointing to loose, powdery material within channel located in figure's torso. X-radiograph taken at 30 kV, 5 mA, 1 min. 2.5 mm focal spot.

Condition

Structure

The object is in poor condition overall. The majority of damage to the wood is mechanical in nature, evident as breaks or losses. Several losses to the wood exist throughout, including the original talons from the proper right hand, no longer associated with the object. One talon has been replaced with a flat, flexible wooden stick, painted white and securely adhered. The proper right wing is completely detached. A large crack measuring ~6.5" long runs vertically along the proximal side of the proper right wing (fig. 4). Despite its size, the crack is actually quite stable and does not permit movement.

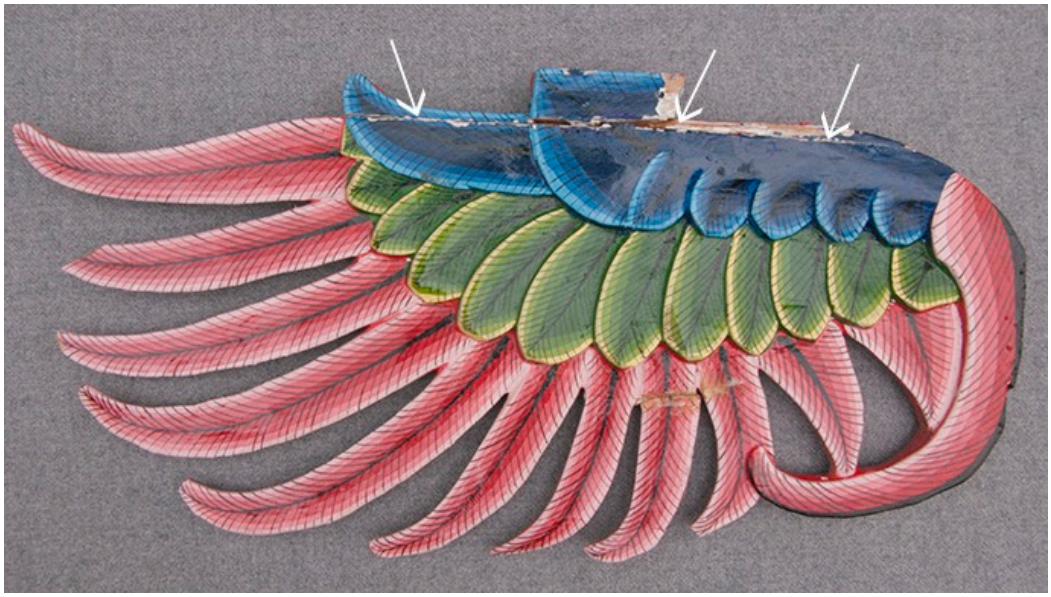


Figure 4. Before Treatment Photo, Proper Right Wing. Arrows indicate large vertical crack.

There are some losses to the pointed ends of the feathers. On each wing, one feather has broken near its proximal end, and have been misaligned and poorly repaired with yellowed adhesive. One feather near the top of each wing has suffered a loss to the distal end. The innermost edge of the proper right wing has split, but also appears to have been repaired. No traces of adhesive are visible outside the join, but the crack, despite being open, is quite stable.

Additional losses to the wood are present in the red crowning element above the Garuda's head. The hanging feather on the proper right side has been lost, as well as the proper left side of the red crown element.

There is additional damage related to the wood's responsiveness to environmental conditions, primarily cracking. There is one large crack in the radial direction at the base, extending through the proper left foot, approximately 5/16" at its widest point. A second, smaller crack is present in the base, behind the proper right foot.

Surface

The surface is dirty overall with localized concentrations of dust. Small losses to the paint layers exist throughout. Yellowed adhesive residues are present on several feathers on both wings. In areas of repair, large amounts of adhesive have seeped outside the joins and covered surrounding surfaces.

There are numerous losses to both paint and ground layers surrounding the crack on the proper right wing. Additional paint losses exist scattered throughout, including at high points on the crown element and the tips of feathers. Clear pressure-sensitive tape is present on the surface at Garuda's low back, as well as on the reverse of the repair on the proper right wing.

Figure 5. Details of losses to paint and ground layers surrounding crack on proper right wing.

Evidence of previous treatments

Some areas of breaks (including one feather on each wing) have been repaired with the polyurethane wood glue. These repairs are misaligned and excess adhesive was not cleaned from surrounding surfaces. A number of the wood joints have been reinforced with the same adhesive, including the mortise and tenon joint attaching the topmost feathered element to the body, as well as the proper left dado joint attaching the wing to the body. In these cases, adhesive was applied in excess and a great deal of additional adhesive has oozed out of the joint and hardened on the surface.

Figure 6. Details showing misaligned repair on proper right wing and excess adhesive surrounding join. Image at right includes a piece of pressure-sensitive tape adhered to the surface.

There is a loss to the outer talon on Garuda's proper right foot (fig. 7). The exposed wood was painted with a matching white paint to disguise the break. As mentioned previously, one of the proper right talons on the hand has been replaced with a flexible wooden stick, also painted white.

Figure 7. Detail of proper right foot. Arrow points to loss in talon that has been inpainted to conceal the break.

Condition Summary

The object is in poor condition, with the proper right wing detached, scattered losses throughout, and poorly executed repairs with an excess of yellowed adhesive. Paint loss and cracking is evident on the proper right wing.

Treatment proposal

1. Dry clean surfaces with a soft brush and vacuum.
2. Reduce engrained dust, dirt, tape and adhesive residues, if possible, from exposed surfaces, using appropriate solvents (as directed by solubility tests).
3. Consolidate flaking paint and ground layers using an appropriate adhesive.
4. Reverse unstable join on fourth feather from the bottom, proper right wing (fig. 6) and clean surface of adhesive residues via mechanical cleaning and softening with solvents. Reattach feather using an appropriate adhesive.
5. Reattach proper right wing to the figure. This may require mechanically cleaning the edges within the dado joint to improve fit.
6. Inpaint areas of paint loss on proper right wing along crack.
7. Create appropriate housing for storage and transport using archival materials.

Treatment:

The surface of the sculpture was cleaned with a soft brush and vacuum. Engrained dirt was further removed using latex-free cosmetic sponges, soot sponges[1], and Groom/stick[2] molecular trap. Where necessary, further cleaning was carried out using microswabs dampened with deionized water. Adhesive residues present on the surface were removed mechanically under the microscope, using a microscalpel and softening with hot water. Pressure sensitive tape was removed by softening the adhesive using the Leister hot air tool, and gently working a microspatula underneath the tape. Care was taken in all above steps not to abrade the original paint layer. In some cases, it was determined unsafe to continue adhesive removal, for risk of removing original paint (as was the case on the back side of the top feathers on the proper left wing, fig 8). Flaking paint and ground layers along the crack on the proper right wing (fig 5) were consolidated with 3% sturgeon glue[3].

Figure 8. Detail of reverse of proper left wing after treatment. Note adhesive residues still present on feather at upper left corner of image. Adhesive was reduced in this region but was not taken any further than this point, as removal was beginning to pick up original paint layers.

The unstable join on the fourth feather from the bottom, proper right wing was reversed by softening the polyurethane adhesive with a heat spatula with pointed tip, and mechanically removing the adhesive with a microscalpel. The feather was reattached using 20% rabbit skin glue[4]

[1] Soot sponges are natural, vulcanized rubber sponges used for cleaning.
[2] Groom/stick is a tacky, malleable, non-abrasive, unvulcanized natural rubber material used for dry surface cleaning.
[3] Sturgeon glue (or Isinglass) is a transparent, colorless, water soluble adhesive made from dried sturgeon bladders.
[4] Rabbit skin glue is a strong, water soluble adhesive obtained from the skin of rabbits, and is composed of gelatin, collagen, keratin, and elastin.

bulked with sifted Whatman cellulose powder[5], and the join was held in place using a rubber band and Teflon tape[6] (fig 9).Additional bulked rabbit skin glue was applied to the interior of the crack on the proper right wing (fig 10). Thin strips of toned Japanese tissue were applied to either side of the join and painted with acrylics, in order to visually integrate the surface and impart some additional strength.

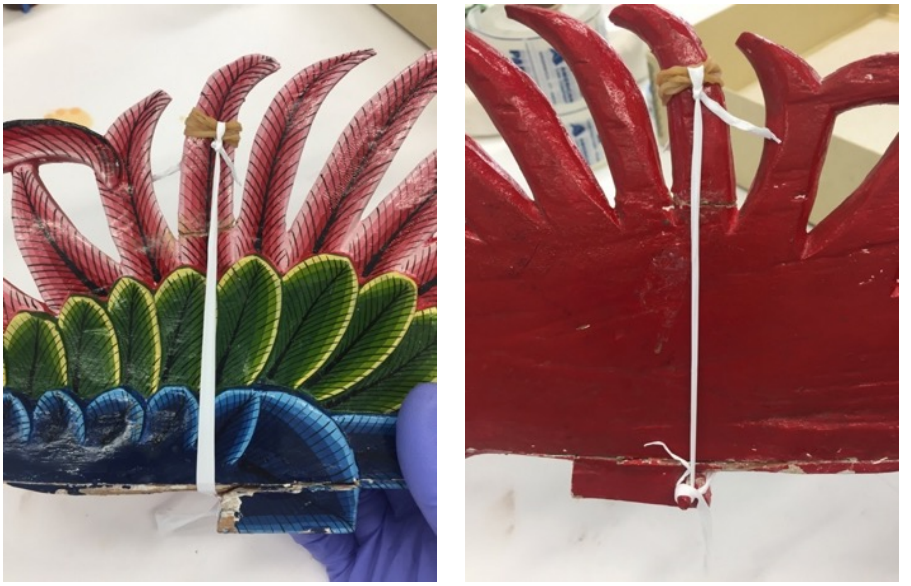


Figure 9. During treatment, reattachment of feather on proper right wing (left and center).

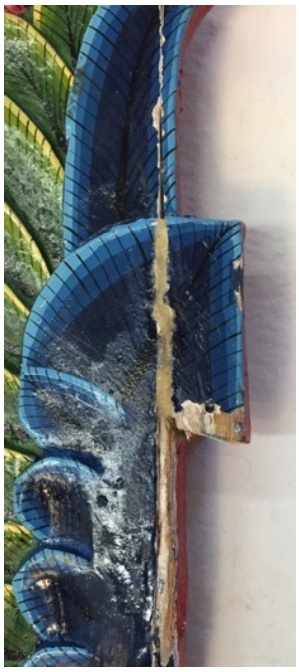


Figure 10. Bulked rabbit skin glue applied within crack on proper right wing.

The adhesive joining the detached feather on the proper left wing was removed using a combination of hot air, heat spatula with pointed tip, and scalpel. The feather was reattached and surrounding areas inpainted using the same methods described above.

[5] Whatman cellulose powder
[6] Teflon tape is a PTFE (polytetrafluoroethylene) non-adhesive backed material, also referred to as plumbers tape.

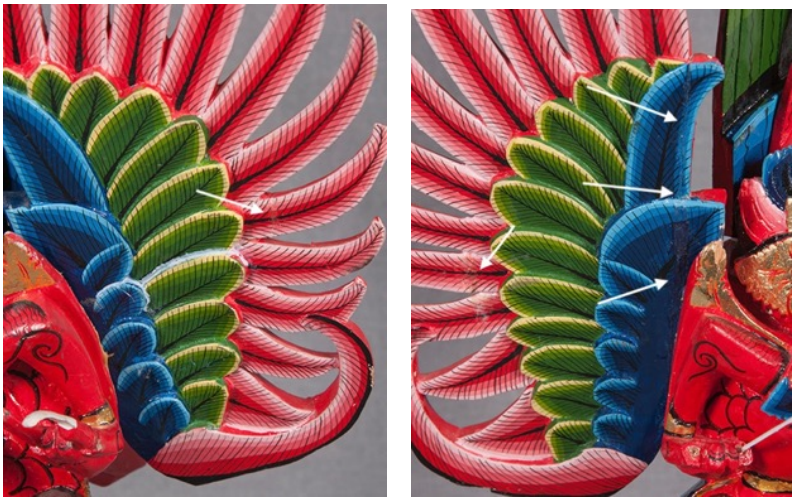


Figure 11. After Treatment, white arrows indicating areas with toned tissue fills. Proper left wing (*left*) and proper right wing (*right*).

Excess adhesive on joins that could not be reversed was softened using cotton poultices with warm water, and then removed mechanically with a microscalpel. Japanese kozo paper[7] (hereafter Japanese tissue) was toned to match surrounding areas. Strips of the toned tissue were placed over the remaining visible glue line in order to visually integrate the surface (fig 12).

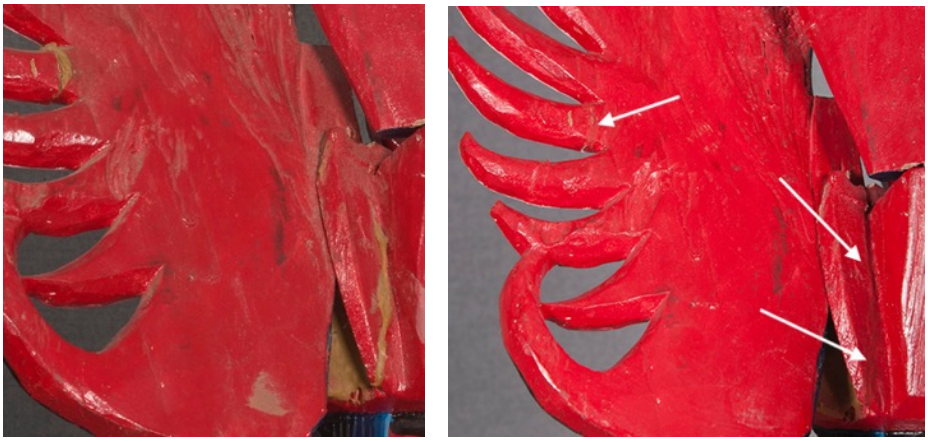


Figure 12. Before Treatment (left) and After Treatment (right). White arrows indicate areas with toned tissue fills corresponding to feather reattachment (top) and adhesive reduction (bottom two arrows).

In order to reattach the proper right wing to the figure, excess material within the dado joint on the body had to be removed. When possible, paint flakes were preserved and reattached to their original location. This was achieved by attaching a Japanese tissue/methyl cellulose[8] facing to the

[7] Kozo is a type of handmade Japanese tissue paper, made from the mulberry bast fibers.
[8] Methyl cellulose is a cellulose ether derived, water soluble adhesive.

back of the paint chip and softening the front with acetone, then gently freeing the chip from the dado joint using a scalpel. Paint chips were reattached using methyl cellulose. Remaining excess material (dirt, strongly bound paint and ground layers) was removed using a microscalpel, until the wing could be inserted into the join. Once this was possible, it was apparent that the crack was in a very vulnerable location and seemed to flex somewhat upon insertion. Additionally, it was clear that much of the paint loss and cracking was still very visible. A second campaign of 20% rabbit skin glue injection was undertaken in order to fill remaining open areas along the crack.

Inpainting areas of paint loss along the crack on the proper right wing was completed before reattaching the wing to the body. 3% methyl cellulose bulked with Whatman cellulose powder was applied to surface losses and leveled using a scalpel and micromesh, taking care not to abrade surrounding paint layers. Japanese tissue was toned and attached to the surface of the fills using 3% methyl cellulose (fig 13).

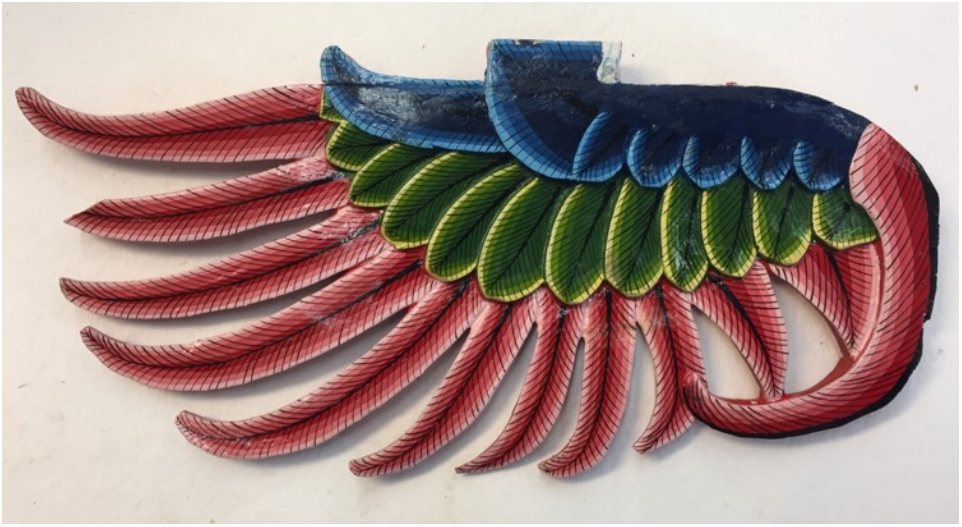


Figure 13. During treatment, proper right wing after applying toned tissue surface fills and inpainting.

The wing was reattached within the dado joint using 20% rabbit skin glue bulked with cellulose powder. Additional adhesive (20% rabbit skin glue, unbulked) was injected into remaining open areas, and gentle pressure was exerted by wrapping the object in Coban[9] medical bandage (fig 14). Japanese tissue toned with Liquitex acrylic paint was applied to the back of the feather in order to reinforce the join, again with methyl cellulose.

[9] Coban is a self-adherent wrap made of a porous, non-woven polyester material.

Figure 14. During treatment. Rabbit skin glue drying while join was supported via gentle pressure exerted by Coban.

Housing:

Custom housing was constructed to permit safe travel, storage, handling and display. A double walled box was constructed, with an outer box made of Fome-cor[10] and an inner box made of archival corrugated board[11]. Three 2" Ethafoam[12] braces padded with batting[13] and covered with Tyvek[14] were strategically placed within the inner box to limit movement and reduce vibration during transit. Braces were chosen over cavity packing due to the object having so many delicate protruding elements. Initially the brace was planned to be attached to the front door of the box, attached by a hinge on the left and securely closed with Velcro on the right.

Upon execution of this idea, it became clear that this would result in risk of the object torqueing when opening and closing the door, and also limits the user's ability to observe whether or not the braces slot in to the correct spot. Some thought was given to a door with hinge at the top of the box, and Velcro on the bottom, but there was then worry that the user might tilt the box backward in order to release the Velcro. In the end, it was decided that the brace was preferable, and will be extensively labeled and identified in hopes that it will not be separated from the rest of the housing.

[10] Fome-cor is the tradename for an acid free, laminated foam board, with a rigid polystyrene core.
[11] Archival corrugated board is a lightweight, acid and lignin free cardboard, also referred to as blue board or B-flute.
[12] Ethafoam is a flexible, closed-cell polyethylene foam.
[13] Batting is a light weight polyester cushion of loosely matted fibers.
[14] Tyvek is a flash-spun high-density polyethylene (HDPE).

A removable base was constructed in order to be used for transport as well as display. The base is constructed from two layers of archival corrugated board, with 1" Ethafoam adhered on top with 3792LM low melt adhesive[15]. A custom well was carved as close to center as possible, while still allowing for adequate space between the object and the walls of the box on all sides.

The Ethafoam was covered with ¼" black Volara[16]. The tray can be removed and used for display of the object. While care was taken to center the object as much as possible, the center of gravity is still not perfectly centered and the object is able to move somewhat when the tray is lifted. Care should be taken when handling to support the object as well as the tray. Further investigation needs to be carried out in order to devise a method of better securing the object to the base.

Figure 15. Garuda packed inside inner box, with Ethafoam brace.

Figure 16. Garuda on display base.

In order to unpack the object, the front door of the box should be opened and the brace removed. The removable base can then slide out. **The object is not entirely secured to its base at present, and therefore must be supported during moving!**

[15] 3792LM Low melt adhesive is a hot glue produced by 3M, and is an ethylene-vinyl acetate polymer with hydrocarbon resin.
[16] Volara is a closed cell polyethylene.

Future Recommendations & Stability:

Repair locations are inherently weak and vulnerable to damage, despite conservation efforts. Rabbit skin glue was selected for its strength, but considerations were also made to ensure that the adhesive not be stronger than the surrounding wood. This ensures that should failure occur, the object would undergo minimal additional damage. For these reasons, it is imperative that these repair locations (both repaired feathers and both wings) be treated with the utmost care. The Garuda figure should ***never*** be laid down on its back, as this places a substantial amount of pressure on the wings and repaired feathers, and is likely the reason that damage occurred in the first place.

Excessive handling is the most likely cause for further damage to this object. Care should be taken when removing the object from its storage box. If necessary, the object may be handed by cupping area around the legs, below the waist. The object should **never** be picked up from the wings.

Rabbit skin glue is reported to have good long term stability, although it may become brittle over a long period of time. It may expand or contract in response to humidity fluctuations, however it is reported to be less responsive to fluctuations than other animal glues (Down 2015).

Ideally the object should remain in an environment with minimal fluctuations in relative humidity and temperature. However, because of the way these objects are used, it is unlikely that ideal environmental conditions will be met. The double walled housing should assist with buffering environmental fluctuations. It is important that the object be kept in the box whenever it is not being displayed, and that the box be shut tightly. This will allow for some protection from environmental fluctuations, and also reduces the risk of mishandling.

Appendix I. Wood Identification

Research was conducted to investigate characteristics of native Southeast Asian tropical hardwoods. Reference tranverse sections were, available online, were examined in comparison to the exposed transverse section on the base of the object. In order to obtain a legible, magnified transverse view, photos were taken using a Nikon D90 DSLR camera equipped with a Micro-NIKKOR lens. This allowed for photographs that captured a high level of detail at a very small scale, providing more information than that obtained through visual examination alone.

These photographs revealed the presence of clustered pores (Fig I), and provided a better image for comparison with the references. Of the reference woods found, ramin, or *Gonystylus spp*., appeared to be the closest match (Fig II). While there are some notable differences, including the presence of winged parenchyma, and more visible rays, there are close to 30 different species within the *Gonystylus* genus, and it is possible that there may be some slight differences between species. A reference photomicrograph of *Gonystylus confuses* was found that does not appear to have winged parenchyma (Fig III).

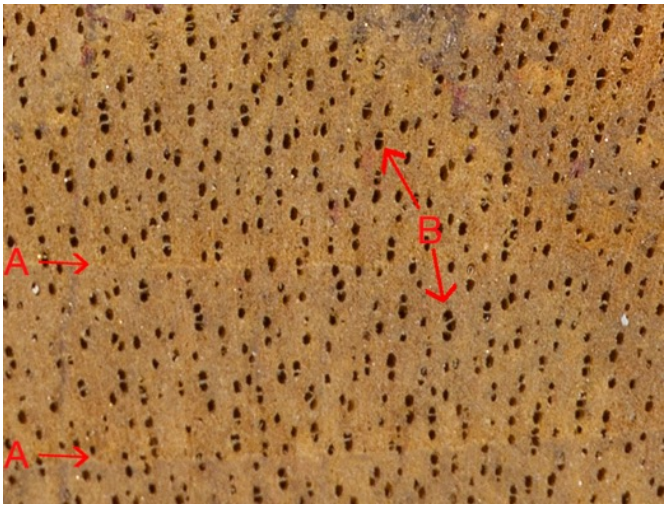


Figure I. Macro photograph, transverse section visible on the base of Garuda. **(A)** illustrates indistinct growth rings, and **(B)** indicates some areas with clustered pores.

Figure II. Reference image of ramin (unknown species) illustrating faint, yet visible rays, as well as clustered pores and winged parenchyma. Courtesy of *wood-database.com*.

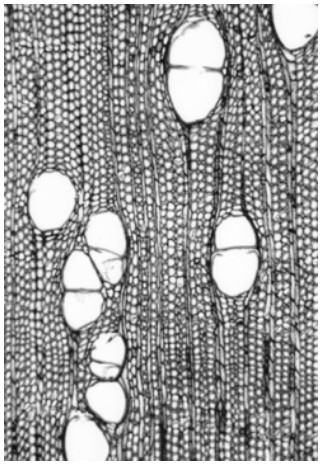


Figure III. Reference image of *Gonystylus confuses* without winged parenchyma. Courtesy of Bill Dickison, University of North Carolina Chapel Hill.

Appendix II. Microchemical Spot Test Procedures

Iodine/potassium iodide test for PVA

A small sample was placed on a glass side. Two drops of acetone were added to the sample. The solvent was allowed to evaporate. A solution of seven parts potassium iodide/iodine solution was mixed with 10 parts 1:1 glacial acetic acid:deionized water. One drop of this solution was added to the sample. If the sample is a polyvinyl alcohol-derivative, a color change will occur. The colors observed can include green, purple, blue, red, yellow, or in-between.

Biuret test for proteins

A small sample was placed on a glass slide. A drop of 2% aqueous copper (II) sulfate was added to saturate the sample. After two minutes, excess copper (II) sulfate was removed using blotting paper. A drop of 5% 1.2 M NaOH is applied to the sample. The sample will turn purple if proteins are present.

Dimethylaminobenzaldehyde test for polyurethane

The capillary end of a pipette is first heat sealed, and a small sample is placed inside. A cotton swab is wet with two drops of 14% w/v p-dimethylaminobenzaldehyde in ethanol, and one drop of concentrated hydrochloric acid. The swab is inserted into the pipette, suspended over the sample. The top of the pipette is sealed with plasticine. The sample is heated over an alcohol lamp. Vapors react with the dampened swab, and the swab will turn canary yellow in the presence of polyurethanes.

Test for carbonate using hydrochloric acid and barium hydroxide

A small amount of sample was placed in a glass test tube. Two drops of concentrated HCl were added. If carbonate ions are present, the solution will effervesce vigorously.

Test for sulfates using barium chloride

A small sample was placed in a glass test tube. A few drops of distilled water was added to the tube, followed by a few drops of concentrated HCl. A pH strip is used to check and make sure that the solution is acidic. Two drops of $BaCl_2$ are then added to the test tube. If sulfate ions are present, a white precipitate or haze should form after a few minutes.

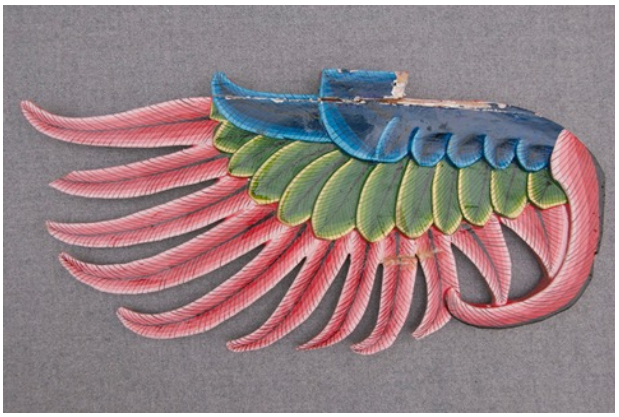
Appendix III. Before Treatment Photography

Garuda, overall, before treatment, front side.

Garuda, overall, before treatment, proper right side.

Garuda, overall, before treatment, back side.

Garuda, overall, before treatment, proper left side.



Garuda, proper right wing, front, before treatment.

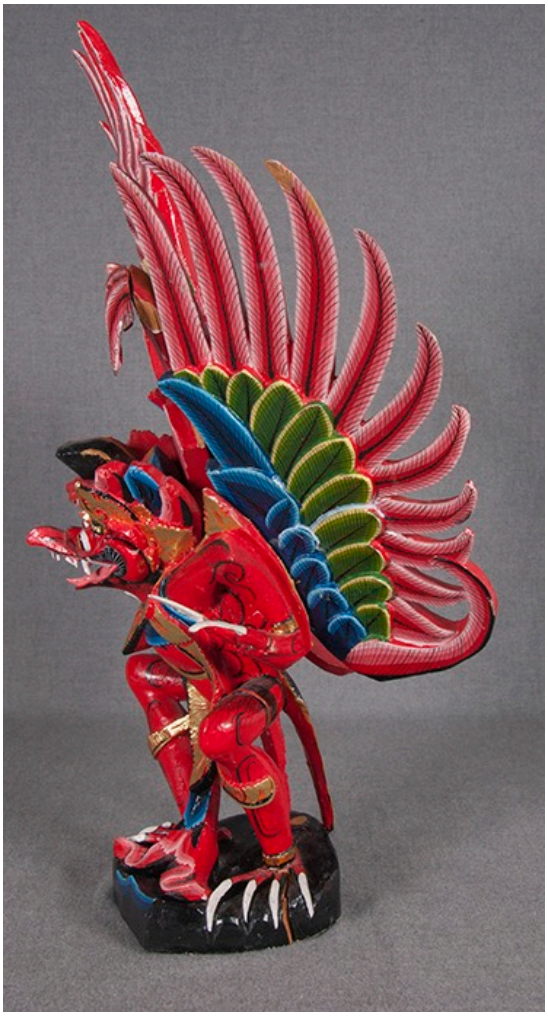
Garuda, proper right wing, back, before treatment.

Appendix IV. After Treatment Photography

Garuda, overall, after treatment, front side.

Garuda, overall, after treatment, proper right side.

Garuda, overall, after treatment, back side.



Garuda, overall, after treatment, proper left side.

References

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Odegaard, Nancy.; Carroll, Scott.; Zimmt, Werner S. 2015. *Material Characterization Tests For Objects of Art and Archaeology.* Archetype Pubns.

Remillard, F. 2007. "Identification of Plastics and Elastomers." *Centre de Conservation Du Quebec*. https://moodle2.sscnet.ucla.edu/pluginfile.php/425602/mod_resource/content/0/microtest_ang.pdf.