Journal of Natural Science Collections

Title: Conservation of extensively falling out hairs and feathers in a Rowland Ward's 19th century diorama

Author(s): Castelain, L.

Source: Castelain, L. (2024). Conservation of extensively falling out hairs and feathers in a Rowland Ward's 19th century diorama. *Journal of Natural Science Collections*, *Volume 12*, 126 - 135.

URL: http://www.natsca.org/article/2849

Conservation of extensively falling out hairs and feathers in a Rowland Ward's 19th century diorama

Liévin Castelain

Natural history conservation and restoration, Rue de Buay 7, 4219 Wasseiges, Belgium

Email: sponte.naturae@gmail.com

Received: 20th Oct 2023

Accepted: 21st Feb 2024

Citation: Castelain, L. 2024. Conservation of extensively falling out hairs and feathers in a Rowland Ward's 19th century diorama. *Journal of Natural Science Collections.* **12.** pp. 126-135.

Abstract

Pest attacks can lead to severe damage for taxidermy specimens. It is particularly damaging for items that have scientific or historical value. In a monumental diorama signed by Rowland Ward (1848-1912) that had been attacked by moths, important conservation measures had to be carried out. The entire fur of one koala and two fruit bats were completely detached from the skin, and two birds were losing their wing plumage. Fortunately, hairs and feathers were still located in their proper place. Tests were implemented in order to find a solution to preserve and undertake remedial conservation on the specimens. The method needed to be as least invasive and as most reversible as possible, and easily practicable because most of the work had to be done inside the undismantlable diorama (e.g. hair gluing was performed vertically and upside down). A mix of methyl cellulose with white glue was chosen to glue fur, while wings were injected with low viscosity hydroxypropyl cellulose diluted in acetone. The final result was very productive, and allowed for recolouring of the specimens.

Keywords: Natural history; taxidermy; conservation; restoration; adhesive; diorama; Rowland Ward

Introduction

Highly degraded taxidermy specimens can be a serious issue for conservation and restoration in natural history collections. Pest infestations have caused severe damage to taxidermy mounts in museums across the world, with historically specimens showing very sever deterioration. Pests are especially damaging because they eat every type of organic material on a specimen that has not been poisoned. Pests targeting taxidermy mounts can essentially be divided into two groups: dermestid beetles and moths (Pinniger and Harmon, 1999).

In birds, the wing bones and feet are dried flesh, and similarly in mammal taxidermy mounts and study skins, the feet and hands are dried, so these are edible to pests. In most cases, bird skulls are still inside and may attract parasites when they are not perfectly cleaned during skinning. The same is true for small mammals. Hooves, claws and whisker pads are often a source of problems, as well as tails and pads (mammals) and the base of tail feathers (birds) that must be degreased as much as possible. The inner layer of mammal skins is still consumable after tanning when not properly thinned down, and hair will fall out where moths have eaten the thin layers of flesh holding the hairs to the skin. Finally, the plumage can be entirely consumed if not de-greased.

Through centuries many different types of preservatives were used to prevent insect damage (Williams and Hawks, 1987). Alum tanning bath (mammals) and arsenical soap (all animals) were probably the most common techniques used, sometimes combined with other heavy metals (e.g. mercury), leading to adapted collection management in museums (Marcotte *et al.*, 2017). Arsenic is currently not used, due to health and safety issues, and has been replaced with borax and other commercial products.

This paper examines how two different types of taxidermy specimens were treated after very serious infestation within a mounted diorama. Mammal specimens (a koala and two bats entirely losing their fur), and two birds (with the feathers very loosely attached) showed extreme deterioration after pest infestation. It was evident that infestation had stopped a long time ago, probably when all consumable materials had been exploited, thus pest management was no longer necessary. The majority of feathers and hairs were still present inside the case.

The aim of this case study was to find suitable solutions to reattach the fur and the feathers to the specimens. The historic significance of the diorama and the specimens themselves meant that the solutions had to combine sufficient strength and practicability, and at the same time following principles of invasiveness and reversibility.

Background and state of conservation

The case study presented here is part of a larger project: the restoration of a Rowland Ward's 19th century cased diorama displaying 24 animals from Australia, dated from c1892. Measurements without base and pediment are about 2.4 m long, 2 m high and 1 m deep (Figure 1). This diorama is currently held in a private collection.

Rowland Ward (1848-1912) was a renowned English taxidermist, who inherited his skills from his father. He created a famous workshop in the centre of London, The Jungle, where this diorama was mounted. The expanding British empire allowed him to supply museums and collectors with specimens from around the world (Morris, 2003).

Figure 1. Diorama, displaying a large range of species from Australia, before restoration. © TEMA Production, 2022.

The animals of this diorama were collected in Australia during a hunting trip in 1892 made by a Shropshire gentleman named Hugh Lewis Heber-Percy (1853-1925) (Tennants Auctioneers, 2021). Clues obtained from marsupials in the same diorama indicate that the conditions and/or techniques prior to mounting were not ideal; some legs and feet were cut off or covered with extra fur, as was the marsupium of the female kangaroo. It is likely that an improper skinning process led to maceration. The techniques used for preservation in Australia and the conditions during shipping to England are unknown; salt was a common practice, but Ward recommended alum for mammals and Taxidermine for birds (see below; Ward, 1890). Another method consisted of immersing skins in an alum-salt bath ("brine", "liquor", "pickle"; Ward, 1890); skins were arranged in a barrel for storing or transit, or dried and packed after a few days of immersion. But this operation, "*if imperfectly carried out the consequence may be ruinous*" (Ward, 1890). At this time, Australian skins might have been preserved by "*vegetable curing*", a method that Ward (1890) considered to be deleterious. In Ward's book, it is also recommended to pour turpentine onto the fur once the skin was fleshed, preserved and dried, in order to prevent insect attacks before shipping to England. "*I have sometimes unpacked trophies to discover the hair entirely removed from the pelt by the exertions of the Dermestes*" (Ward, 1890). Perhaps dermestid beetles damaged the skins before they arrived in England, but they didn't take part in further damages as none were found.

Ward abandoned the arsenical soap as early as 1890 (Morris, 2003). He developed and sold his own preservative in various forms: (i) Taxidermine n°1 was a paste which recipe remains a mystery, (ii) Taxidermine n°2 was a powder that seems to contain alum (Ward, 1890), and (iii) Taxidermine n° 3 was a special drying powder for birds (presumably borax; Morris, 2022, pers. comm.) that was to be applied after Taxidermine n°1. In the end, it seems that no preservatives are able to prevent pest attacks in the long term, and whatever the preparation method, adequate preventive conservation measures are pivotal (Hendry, 1999).

According to the auction hall which sold the diorama in 2021, the building that housed the diorama became a convalescent home for wounded officers around the first world war, and the taxidermy collection was moved to the stables, that were later converted into a garden tea room (Tennants Auctioneers, 2021), "*cold and damp most of the time*" (Morris, 2022, pers. com.). It is difficult to estimate the role played by humidity in the deterioration of furs: a few traces of mould could be identified on birds' feet and beaks, but it didn't seem to be serious. However, it is clear that it was not stored in good environmental conditions for some time.

Contacting the initial owning family revealed that the case had been opened about twenty years ago (c2000) in order to clean the cloudy inside of the windows and "*remove a very decayed creature*". No other information is available in living memory and archives. Considering that one side glass is not original, and that at least three specimens are missing (indicated by holes and traces in branches), it is more than likely that the diorama case had been opened several times since arriving in England.

In summary, we can conclude to unknown methods of preservation followed by about a hundred years of bad conditions for conservation. The examination of a few moths inside the showcase indicated that the webbing clothes moth (*Tineola bisselliella* Hummel, 1823), the most common species (Querner, 2015), was the voracious destroyer (NHM, undated).

Condition of the specimens

The specimens in the diorama were fixed into the case, with only two animals that were removable, which resulted in the other specimens having to be treated *in situ*. The whole project took about 120 hours, including cleaning, repairing bird feet, hair addition, recolouring of faded specimens, restoration of vegetation and multiple other interventions. The fine work of stabilization of loose hairs and feathers was the main issue and needed some reflection.

Reptiles (a goanna *Varanus sp.* Merrem, 1820, a bearded dragon *Pogona sp.* Storr, 1982 and an undetermined species of python) were in a good condition, except the fingers and hands/feet of the goana where flesh was crumbled between skin and bones. The inside surface of the skin of kangaroos (*Macropus rufus* Demarest, 1822) was eaten, resulting in loss of hair, particularly near the tail. The koala (*Phascolarctos cinereus* Golfuss, 1817) and fruit bats (*Pteropus sp.* Erxleben, 1777) had only the inner side of the skin affected, but, considering the presence of dejections between leather and hairs, the epidermis was also eaten resulting in the majority of the fur falling off (Figure 2).

Birds seemed to be in a very good condition except a few obvious damages (nibbled feet, fallen off primaries). However, it became evident that a

Figure 2. (Left) Hands and feet are the only parts of the koala where hair had fallen off. Fingers were dried but had not been opened during field preservation and process of preparation. (Right) Shedding of all the fur of the koala except around the nose, chin and eyes. © Liévin Castelain, 2022.

major problem was the integrity of one kookaburra (laughing kookaburra *Dacelo novaeguinea* Hermann, 1783) and one tawny frogmouth (*Podargus strigoides* Latham, 1802): skin, flesh, ligaments, tendons and bases of primaries were lost due to the larvae (Figure 3). But nearly all feathers (coverts, primaries, alula) were still located in correct position. These two birds were mounted with their wings open. Two other specimens of kookaburra (blue-winged kookaburra *Dacelo leachii* Vigors & Horsfield, 1827) and frogmouth displayed in the showcase with closed wings were not affected by moths. The Australian pelican (*Pelecanus conspicillatus* Temminck, 1824) was entirely free of any pest damage, with only the structure of small feathers had changed with the light and became brittle.

Conservation of hairs

Hair is a very fine material that is very difficult to reattach to dried skin. Injection was not possible: the risk of soiling the hairs by capillarity was considered too high in combination with a low control of the manipulation. Instead, the fur had to be lifted, the naked leather smeared with adhesive, and the fur put back in position.

Raw leather was used to undertake different testing to determine the best method of reattaching hair for the specimens in the diorama. Sheep skin was used, and it was macerated in water just long enough to make the hair slip. The skin was then fleshed and tanned in an alum bath, stretched on a plane structure and left to dry. After these operations a piece of skin was obtained with the expected texture, i.e. raw leather without hairs like a taxidermy mount which suffered from hair loss.

Different adhesives were applied to find the most suitable solution to reattach hairs, at the same time combining three characteristics: strength,

Figure 3. (Left) Frogmouth wing: bones were cleaned, skin replaced by frass, bases of primaries consumed (the first primary was still in place thanks to an iron wire added upward for the purpose of an opened-wings mount). (Right) Kookaburra wing: wrist zone (shoulder at right, last finger at left) showing that every single feather was separated. © Liévin Castelain, 2022.

Table 1. Tested adhesives with concentrations (v/v = volume per volume, w/w = weight per weight).

Adhesive	**Concentration**	**Cleaning solvent**
Methyl cellulose	18,6 g/l **(stock solution)**	Water
Methyl cellulose + ethanol*	Stock solution + ethanol (9 % v/v)	Water
Polyvinyl acetate (PVAc, white glue)	Regular commercial viscosity	Water
Methyl cellulose + PVAc	Stock solution + PVAc (11, 22 and 33 g/l of PVAc)	Water
Methyl cellulose + PVAc + ethanol*	Same as above + ethanol (9 % v/v)	Water
Hydroxypropyl cellulose (Klucel E)	2 % w/w in acetone	Acetone
Paraloid B72	30 % w/w in acetone	Acetone
Paraloid B72	50 % w/w in acetone	Acetone

* methyl cellulose was diluted with water, and PVAc with methyl cellulose stock solution, before addition of ethanol
* stock solution of ethanol is a regular laboratory 96° denatured solution

reversibility and practicability. Polyvinyl acetate and Paraloid are documented for this purpose (Graham, 2014) but it was decided to test also other adhesives commonly used in restoration, i.e. cellulose-based adhesives. Each spot received the same amount of fox pelt hairs.

After drying the hairs spots were removed to assess where gluing was efficient. The area was then cleaned by applying the appropriate solvent (water or acetone) and gently scratching with a soft plastic scalpel.

The tested adhesives and their concentrations are presented in Table 1. The addition of ethanol in water-soluble adhesives aimed to increase their wetting ability; the hypothesis was that a higher wetting ability would enhance the contact between the glue and the bases of hairs (due to increased capillarity; Ben Jazia *et al.*, 2013), and thus the efficiency of the process.

Hairs: tests

As can be seen in Figure 4, the methyl cellulose appeared too weak. The addition of ethanol as a wetting agent was not more successful, with a large proportion of hairs easily removed. Hydroxypropyl cellulose was completely inefficient, contrary to polyvinyl acetate (PVAc) which was the strongest glue and retained hairs against intensive ripping.

Paraloid B72 was the least practicable; 50 % was too thick and the rapidly drying surface did not attach the hairs. 30 % Paraloid B72 was quite efficient but has less viscosity to work vertically. The methyl cellulose-PVAc mix produced very acceptable results, even more so with higher concentrations of PVAc. Similarly to the methylcellulose, the addition of ethanol did not lead to a better result.

With the appropriate solvent, all adhesives were cleanable. Methyl cellulose and mixes of

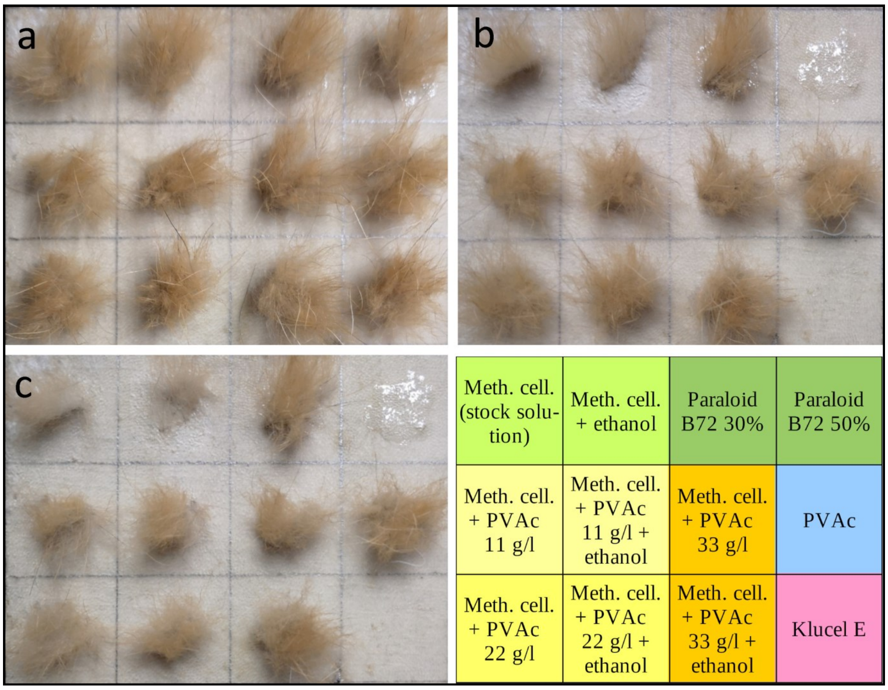

Figure 4. Hairs tufts (a) after drying, (b) after gentle pulling out, (c) after more intense pulling out. Coloured grid corresponding to the adhesives used in the photographs. All adhesives could be easily cleaned by soaking with the appropriate solvent and mechanical scratching. We can see on (c) that Paraloid B72 (at 30%), PVAc and methy cellulose + PVAc 33 g/l (with or without ethanol) are the strongest adhesives. © Liévin Castelain, 2022.

methyl cellulose-PVAc were entirely and easily removed with water. Paraloid (acetone) and PVAc (water) were more difficult to clean demanding mechanical scratching. Soaking at the base of the tuft soiled the hairs by capillarity, especially with Paraloid, and tufts could be removed (except with Paraloid and PVAc) without substantial damage by pulling out the hairs when adhesives were dried; subsequently, dried glue could be easily removed from the skin.

The final choice was the strongest mix of cellulose-based adhesive (methyl cellulose) diluted in water with a small amount of white glue (polyvinyl acetate, at 33 g/l). The benefits of this mix are the following: (i) the white glue is unnecessarily strong while the cellulose glue is too weak so the mix provides a sufficient result that is still easily removable, (ii) the mix seems to have a good wetting ability providing good attachment, (iii) if necessary, the cellulose adhesive can be thickened in order to acquire the suitable viscosity for vertical working. Regarding the reversibility and efficiency of the adhesive, a higher concentration of PVAc into the methyl cellulose didn't seem necessary.

Koala and bats

The procedure was the following: using tweezers the fur was opened in order to lift the hairs about ~2-3 cm, enough to apply glue on the skin with a paintbrush (Figure 5). The hairs were then placed back and pushing softly with the flat hand to ensure the contact between hairs and glue. This was continued, zone by zone, until completion.

Due to debris and irregularity of the fur coat (hair bases not arranged regularly on a plane surface), it was necessary to test where reattachment was efficient and renew the process wherever required. The whole process was time consuming; about 10 hours for the koala and 15 hours for the two bats, without counting the addition of fur and recolouring.

Nevertheless, the result was very successful. Although hairs were removable when ripped out, they were sufficiently strongly attached to the skin. Not every single hair is actually adhered to the skin. But during the adjustment of colours, no problem was encountered (final result in Figure 6). Further, these specimens will not be manipulated in the closed diorama in the future.

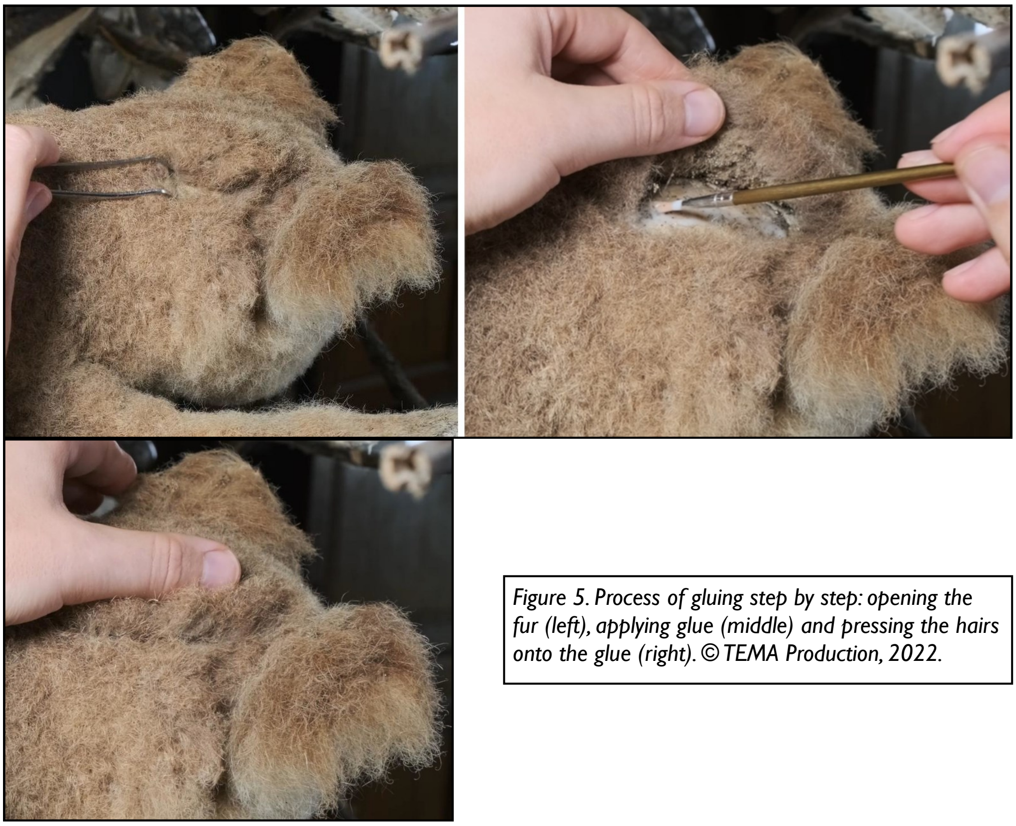

Figure 5. Process of gluing step by step: opening the fur (left), applying glue (middle) and pressing the hairs onto the glue (right). © TEMA Production, 2022.

Figure 6. The koala before (left) and after (right) gluing of the fur. Hands were covered with fur and the colour was revived all over. © TEMA Production, 2022.

The leather of the animals differed from those used for testing in being drier (or "more porous"), which should not be a problem; at most the leather would be consolidated. The moisture contained in the water-based adhesive probably relaxed the skin but no deformation was noted and a quick drying was ensured to avoid any side effects. Consolidation may be necessary if the leather has become very brittle due to humidity and mould (Dignard and Mason, 2018). This might complicate the gluing of the entire fur. Holes and cracks may be filled with Japanese paper (Moore, 2006) -as done for the flying bat- before the fur is put back. Repairs and adhering can be done at the same time.

It is possible to remove the entire fur in multiple pieces in order to thoroughly clean all the debris, repair the leather and possibly improve the control of the gluing process. It would require extreme care and a lot of time. It should be mentioned that such considerations are only applicable with dense fur where the hair mats still stick together; otherwise, hairs would simply drop individually.

Conservation of feathers

There were multiple problems with regard to the feathers. First, the only hard structure left by moths in the wings were the bones, which made it impossible to remove the feathers, apply adhesive, and replace the feathers. Second, the membrane between wrist and shoulder (propatagium and propatagial ligament) was partially eaten and had to be reconstructed if feathers were to be removed, which would have been a very challenging task. Third, an adhesive of high viscosity would not have been practicable because feathers debris would have stuck to the brush, preventing a controlled coating.

Consequently, injection seemed to be the only practicable possibility, not to exactly reattached the feathers, but to fix the plumage in its current position. The adhesive should be stable, reversible and invisible (e.i. non plasticiser). The choice went to a cellulose-based adhesive diluted in an organic solvent: low viscosity hydroxypropyl cellulose (Klucel E, 7 mPa.s) was mixed at 2% w/w in acetone, following the specification of the supplier. With a very low concentration the risk of soiling the feathers was reduced, and the process could be repeated several times to obtain the desired result. The injection of a strong and thick adhesive would have been dirty and uncontrollable. The wetting ability of acetone ensured the penetration through porous materials (duvet, frass, tissue residues, cocoons etc.). Moreover, acetone has the benefit of being very evaporative. Water - and, to a lesser extent, alcohol- may trickle for a long time if too much quantity is injected.

To test the technique, I injected the wing of a common wood pigeon (*Columba palumbus* Linnaeus, 1758). I also found a Eurasian curlew (*Numenius arquata* Linnaeus, 1758) of neither scientific nor historical value. This bird is not fluffy enough for deep injection but has a brown-and-white pattern looking more or less similar to frogmouths and kookaburras, suitable to test the surface soiling. Finally, several independent white feathers were glued together and then separated: this was done with the aim to assess how the feathers and duvet would react to the adhesive. The objective was to see if the surface of the plumage could be soiled by capillarity or droplets and if so, how easy it was to reverse the operation.

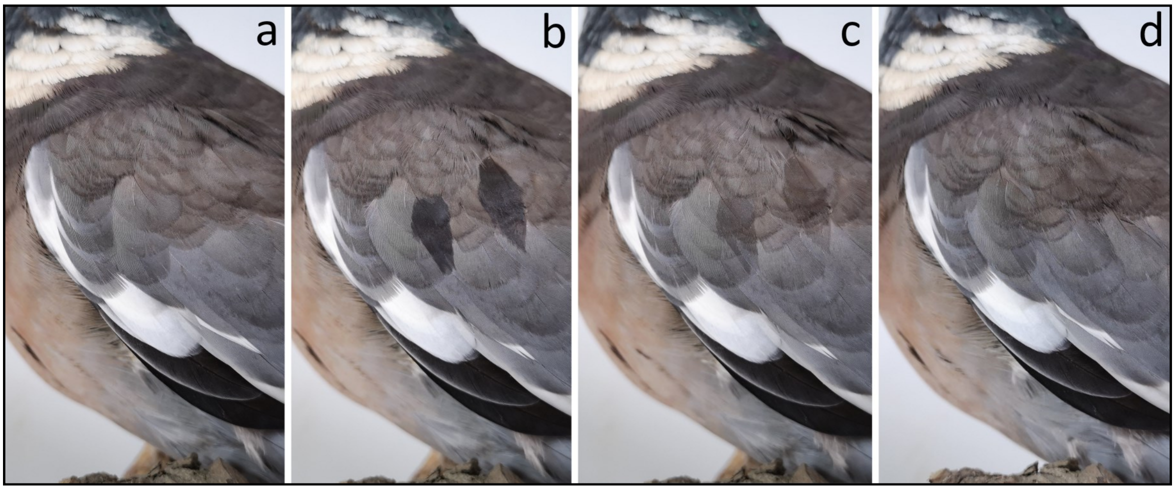

Figure 7. Wood-pigeon wing (a) before injection (the deep injection is not visible at all), (b) with two fresh spots intentionally made at the surface, (c) then after drying, and finally (d) after cleaning. © Liévin Castelain, 2022.

Feathers: tests

After a single injection in the pigeon wing, the duvet at the base of feathers began to make them stick together. They were still separable using tweezers without being visibly damaged. With caution, it was possible to inject without causing any infiltration at the surface. Nevertheless, when spilled intentionally, the adhesive produced dark stains at the surface of the plain grey colour of the common wood-pigeon (Figure 7). These stains were easily washed by rubbing cotton wetted with acetone, water or alcohol. At the end of this cleaning process, some feathers look darker than before treatment (Figure 7d) which is likely due to fat migration from the greasy duvet.

Unlike the pigeon there were very few visual effects on the spotted plumage of the curlew even if soaked with adhesive. Dark sports became darker which was hardly recognisable. Plumage colour may also change if the bird had not been washed during the taxidermy process, or if it was dirty (remaining grease, depositional grease, dust) or dyed. Such cases would demand some further testing. As well as for the pigeon, feathers adhered to each other and could easily be separated.

To further test the effect of the adhesive on feathers, a few were adhered together, then separated mechanically and cleaned (Figure 8). Mechanical separation was very easy and resulted only in "dirty duvet" (i.e. barbs sticking to each other). Mechanical cleaning, i.e. brushing more or less intensely with a toothbrush, already gave good results but cleaning using a solvent was more efficient and less abrasive to the fine barbs (acetone cleaning followed by water cleaning and drying; Figure 8).

Frogmouth and kookaburra

The process was extremely simple. Small amounts of hydroxypropyl cellulose were injected into the plumage with a syringe (Figure 9), step by step, as deep as possible in order to avoid any potential spots at the surface, even if it is a problem only with dark and plain plumage. Palpation showed that

Figure 8. Reversibility test with independent feathers. (a) Before gluing, (b) after gluing, (c) after mechanical separation, and (d) finally after mechanical cleaning (the two at left) and acetone and water cleaning (the one at right). © Liévin Castelain, 2022.

Figure 9. Kookaburra during injection (left) and after drying (right). © TEMA Production, 2022 (left) and Liévin Castelain, 2022 (right).

the feathers adhered to each other as expected; they were fixed in their current position. The plumage remains flexible and smooth with visual wholeness. Feathers are still separable from each other. Two series of injections were considered sufficient. The whole process took only a few minutes. After injection the wholeness of the plumage is preserved (Figure 9 and 10).

The choice of hydroxypropyl cellulose diluted in acetone at a low concentration has multiple benefits: (i) it is liquid enough to be injected deep into the plumage with a syringe, (ii) it has a high wetting ability to penetrate porous materials, (iii) the operation can easily be repeated to achieve the desired result, (iv) it is non-plasticising and thus invisible at the surface of light coloured feathers and spotted patterns if capillarity occurs, (v) the product is cleanable and reversible and (vi) the product remains stable over time.

Even if reversible, the conservator should keep in mind that *theoretically reversible* doesn't mean *practicably reversible*. This is why as little adhesive as possible was injected, i.e. achieve the lowest sufficient level of strength needed to stabilise the plumage.

Conclusion

Birds and mammals that have been severely damaged by moths are generally disposed of, or are stored out of view for decades. Fortunately, in the present case, nearly all feathers and hairs were still in place, and it was a challenge to deal with such an uncommon issue. Rather than a problem, it was an opportunity to save most of the material of an impressive composition signed by a major taxidermist studio.

It should be noted that the technique used to stabilize feathers has only been tested on a low variety of types and colours. It is probably not applicable with greasy plumage because the solvent may cause the fat to appear on the surface. Gluing large surfaces of hairs may not be convenient with

Figure 10. Frogmouth wing before (left) and after (right) injection. Hanging feathers of the wrist and alula (left) were glued before injection. © Liévin Castelain, 2022.

all types of furs. Conservators-restorers should implement the proposed methods only following thorough consideration and appropriate testing.

The procedures proposed here are as least invasive as possible; feathers are still removable without being damaged, at most soiled with a very small amount of cleanable adhesive, and hairs can also be removed (and preserved) by pulling out and gentle scratching. The idea was to keep manipulations to the strict minimum so that the present stabilization will not be troublesome for potential future interventions.

Acknowledgements

I thank Pat Morris for the interesting correspondence we had about Rowland Ward, and Carolin Mayer (Institute of Life, Earth and Environment – University of Namur) for reviewing the manuscript. I thank Sophie Fert and Aubin Mangeot of TEMA Production (tema-prod.com) for providing me good quality pictures of the conservation process. A documentary depicts all the conservation and restoration process. It was produced by Guy Kuypers, whose patience allowed appropriate testing. It is available on Youtube (Tema Production and Castelain, 2023).

References

Ben Jazia D., Vonna L., Knopf S., Schrodj G., Nouali H., Lebeau B., Holl Y. and Haidara H. 2013. Absorption of water/ethanol microdroplets into model porous networks. Colloids and Surfaces A: Physiochemical and Engineering Aspects, 436: 363-370.

Dignard C. and Mason J. 2018. Caring for leather, skin and fur. Canadian Conservation Institute, Ottawa. Last modified December 14th 2018. Available on https://www.canada.ca/en/conservation-institute/services/preventive-conservation/guidelines-collections/caring-leather-skin-fur.html#a20901 Last consulted February 20th 2024.

Graham L. 2014. A different approach for treating skin loss on taxidermy. In ICOM-CC 17th Triennial Conference Preprints, Melbourne, 15–19 September 2014, ed. J. Bridgland, art. 1201, 8. pp. Paris: International Council of Museums.

Hendry, D. 1999. Vertebrates. In: Carter, D. and Walker, A. (eds). 1999. Chapter 1: Care and Conservation of Natural History Collections. Oxford: Butterwoth Heinemann, pp. 1-36.

Marcotte, S., Estel, L., Minchin, S., Leboucher, S. and Le Meur, S. 2017. Monitoring of lead, arsenic and mercury in the indoor air and settled dust in the Natural History Museum of Rouen (France). Atmospheric Pollution Research, 8: 483-489.

Moore S. 2006. Japanese Tissues; Uses in Repairing Natural Science Specimens. NatSCA News, 7 8-13.

Morris, P. 2003. Rowland Ward: Taxidermist to the world. MPM Publishing, Ascot, UK, 164p.

Morris, P. 2022. Discussion about Rowland Ward's techniques and history of the diorama. [e-mail] (Personal communication, 19 February 2022).

NHM. Undated. Clothes moths identification guide. Identification & Advisory Service, Natural History Museum, London. Available on https://www.nhm.ac.uk/take-part/identify-nature/common-insect-pest-species-in-homes/clothes-moths-identification-guide.html Last consulted September 6th 2022.

Pinniger, D. B. and Harmon, J. D. 1999. Pest management, prevention and control. In: Carter, D. and Walker, A. (eds). 1999. Chapter 8: Care and Conservation of Natural History Collections. Oxford: Butterwoth Heinemann, pp. 152-176.

Querner, P. 2015. Insect Pests and Integrated Pest Management in Museums, Libraries and Historic Buildings. Insects, 6 : 595-607

Tema Production and Castelain L. 2023. Restoration of a Rowland Ward's monumental diorama of the Australian fauna, c.1892 [video]. Youtube. 14:31 minutes. URL: https://www.youtube.com/watch?v=Ht7LlsxsemU

Tennants Auctioneers. 2021. The historical collection of natural history & taxidermy from Hodnet Hall. The Auction Centre, Leyburn, UK, 69p.

Ward, R. 1890. The sportsman's handbook to practical collecting, preserving, and artistic setting-up of trophies and specimens. London, Fifth edition, 143p.

Williams, S.L. and Hawks, C.A. 1987. History of preparation materials used for recent mammal specimens. In: Genoways, H.H., Jones, C. and Rossolimo, O.L. (eds). 1987. Mammal Collection Management. Texas Tech University Press, Lubbock, pp. 21-49.