ARMATURE DAMAGE TO A MOUNTED SPECIMEN

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ABSTRACT

AMNH 11262 is a skeleton of the glyptodont *Hoplophorus ornatus*. This skeleton was mounted, without the carapace, by Adam Hermann in 1918. Although we have a published account of Hermann's mounting technique, it is necessary to reverse engineer the mount in order to understand the condition of the specimen. The mounting process began with the development of internal supports that link the bones of each limb. These internal supports are mostly wires plastered into holes drilled into the articular surfaces between bones. These wire and bone limbs were then stiffened by the addition of plaster to all the joint spaces. A quadrupedal external armature was shaped and attached to a wooden base. Finally, the limbs were attached to the armature using another set of holes drilled through the bones. Importantly, the mounting of this specimen involved generous numbers of drill holes perforating poorly-mineralized bones.

A detailed damage report on this specimen reveals some of the resulting problems. Many digits of the feet demonstrate bone breakage away from the wires that run down the axes of the digits. The right ilium displays a wide break that follows the armature in both directions from a screw hole. A break in the third cervical bone passes through a screw hole. The break in the right tibia is maintained at an offset of 10 mm by the armature. A break in the left femur cannot be reduced because of armature offset. The left femur also has a conchoidal fracture placed directly over the bend in bolt that passes through the neck of the femur. A screw head on the left ischium is surrounded by radiating cracks. In sum, this damage report demonstrates an unhappy association between damaged bones and adjacent portions of the armature. A hypothesis of armature damage is the most reasonable explanation for most of the damage that is present in this specimen. Multiple repairs to some of these breaks suggest that this problem is of long standing. The mounting process significantly destabilized this specimen. The armature has caused, and will undoubtedly continue to cause, the deterioration of the bones of this skeleton.

INTRODUCTION

AMNH 11262 is a nearly complete skeleton of the glyptodont *Hophophorous ornatus*. This skeleton was collected by Florentino Ameghino in 1877. Ameghino's (1881) report on the collection insures that a complete individual is represented. The carapace was discovered upside down in the bank of the Rio Lujan. The skeleton was contained within a contrasting matrix, found only within the carapace. Ameghino attempted to collect the carapace and skeleton in one piece, but a tropical downpour at the end of the first day of work threatened the specimen. Ameghino collected the skeleton in pieces the next day, while the rains continued. Unfortunately, the carapace broke into many pieces.

Ameghino offered the specimen for sale at L'Exposition Universelle, held in Paris in 1878. Ameghino's (1878) catalog for his collection lists the specimen under eight different specimen numbers. Ameghino's collection was purchased by Edward Drinker Cope, and the specimen was shipped to Philadelphia. The American Museum of Natural History purchased the skeleton from the Cope estate in 1899.

The specimen languished in the AMNH collections until 1916, when it was prepared and mounted by Adam Hermann. Hermann's training under O. C. Marsh did not include mounting techniques, for Marsh believed that articulated skeletons were best preserved in museum drawers, where they could be studied most easily by paleontologists. Hermann developed his own skeleton mounting technique when employed by the American Museum. His first free mount, a skeleton of *Patriofelis ferox,* was completed in his second year of employment in New York. Hermann (1908 and 1909) described his general technique, but never documented any of the problems that he encountered or resolutions that he discovered at the level of the individual specimens that he mounted. Hermann devoted 170 days preparing and mounting AMNH 11262 in 1916 and 1917. It was the last of forty-six mammals and ten dinosaurs that he mounted.

Adam Hermann at work on the tail club of AMNH 11262 in 1917. Image #3371, American Museum of Natural History Library.

AMNH 11262 is the only mounted specimen of *Hoplophorus* in the world. It is also the only specimen of a glyptodont mounted without the carapace, thus highlighting the bizarre postcranial skeleton. The skeleton demonstrates broad flat femora, broad flat humeri, and and a highly fused vertebral column. The vertebral column consists of only eleven bones, and six of these are caudal vertebrae. Based on the presence of intervertebral foramina on the ventral surface, the three cervical bones seem to consist of an atlas, a fused second and third cervical vertebrae, and a fused third cervical to first thoracic vertebrae. Except for the intervertebral foramina, all traces of fusion are wanting from the third cervical. In particular, the huge spinous process of the third cervical appears to be a single, robust process with a knobby end. This is in contrast to the second cervical bone, where traces of the fusion of two spinous processes are apparent. Both the second and the third cervical bones bear ribs. Aside from the first thoracic vertebra, which is fused into the third cervical bone, all the thoracic vertebrae are fused into a dorsal tube (Scott, 1905). The lumbar and sacral vertebrae are fused into a synsacrum. Sadly, no one has published a functional study of this highly derived axial morphology.

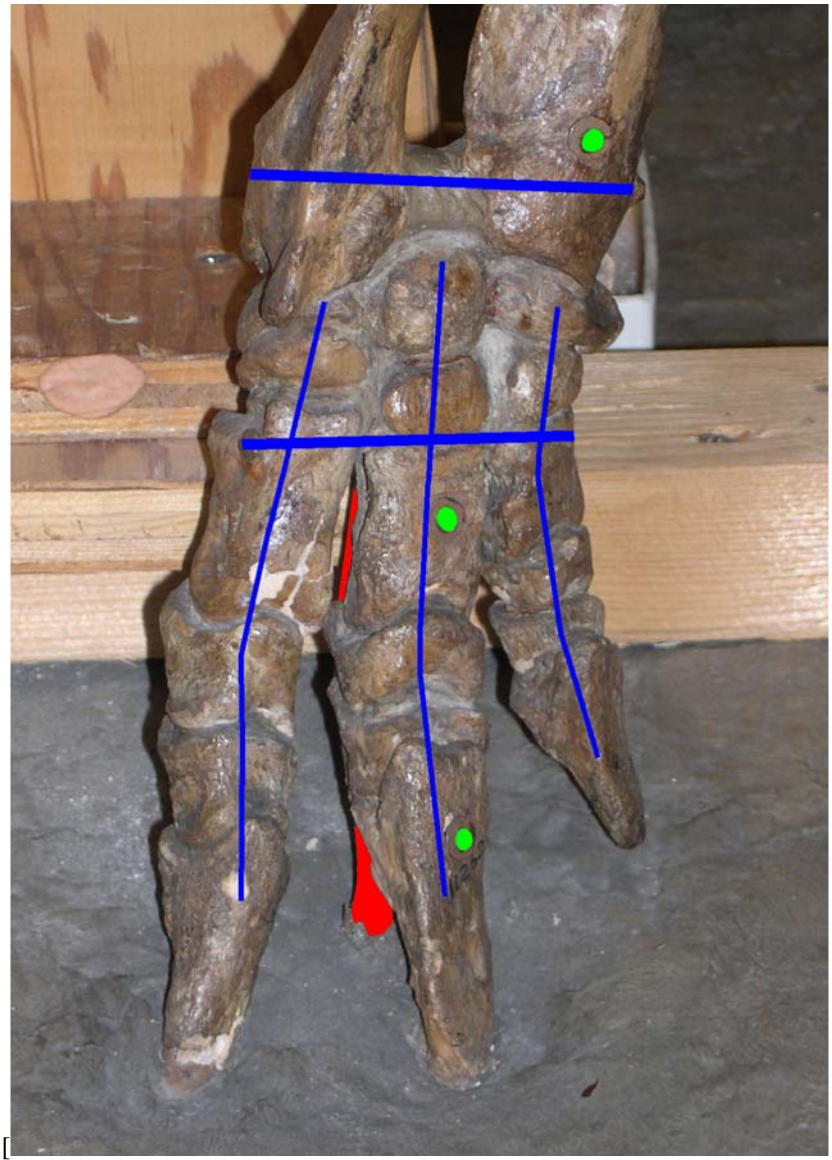
REVERSE ENGINEERING THE HERMANN MOUNTING TECHNIQUE

The Adam Hermann technique (Hermann, 1908 and 1909) for free mounts generally included four steps. The first step involved the fusion of the bones of the skeleton into five subunits (the backbone and each individual limb) using internal armatures. The second step involved the filling of the joint spaces in these subunits with plaster. The third step was the development of an external armature for each limb and the backbone. The final step was the attachment of the external armature onto a base, and the assembly of the skeleton onto the external armature. Because Hermann never documented this process for any of the individual skeletons he mounted, and because his second step is clearer in his mounts than in his papers, it is necessary to reverse engineer the Hermann mounting technique in order to gain an accurate assessment of the condition of AMNH 11262 as a specimen.

STEP 1 – The internal (inside the bones) armature

The Hermann mounting process begins with the development of an internal armature that links the bones of each limb. These internal supports are mostly wires plastered into holes drilled into the articular surfaces between articulating bones. Some joints (the knee, the elbow) typically required several wires. Generally speaking, larger bones were joined by larger wires, and smaller bones by smaller wires. The wire joins were universal. Even the carpals of the wrist and the tarsals of the foot were first connected by wires before being cemented together by plaster.

The many wires of the internal armature of AMNH 11262 cannot be observed directly, except where the bone was so severely compromised that it has broken away from the wire. In several cases the presence of an internal armature can be inferred from the present condition of the specimen. For instance, the right scapula remains in place atop the right humerus, despite a smooth circumferential crack that separates the head of the humerus from the plaster that fills the glenohumeral space. A knob of wire projects from the left femur just above knee, precisely where a wire might have been drilled to articulate the knee joint.



Locations of the internal armature of the left manus (inferred from the exposed armature of the right manus) are shown in blue. The vertical supports down the axis of each of the digits are thick wires. The horizontal supports across the proximal metatarsals and the distal radius and ulna are 1/8-inch bolts. The external armature is colored red. The heads of three bolts fastening the limb to the external armature are colored green. It is likely that the six separate bones of the carpus are also linked by smaller wires, but their specific locations are so conjectural that they are excluded from this figure.

Better estimates of the location of the wires of the internal armature can be generated by examining the partially disarticulateted skeleton AMNH 11872, a plaster cast of *Onohippidion.* AMNH 11872 is one of three mounted specimens that have been disarticulated at the American Museum, and is the only dismounted specimen that has a size comparable to *Hoplophorus.* Approximately two hundred holes were drilled into AMNH 11872 for the placement of the wires of the internal armature. Approximately half of the holes drilled in the *Onohippidion* cast were drilled into the vertebral column and ribs. As only two pairs of ribs are present in *Hoplophorus,* and the vertebrae are highly fused, these vertebral holes would not be necessary in AMNH 11262. Thus we can estimate that approximately one hundred holes were drilled into AMNH 11262 for the placement of the wires of the internal armature, even though few of these wires are visible.

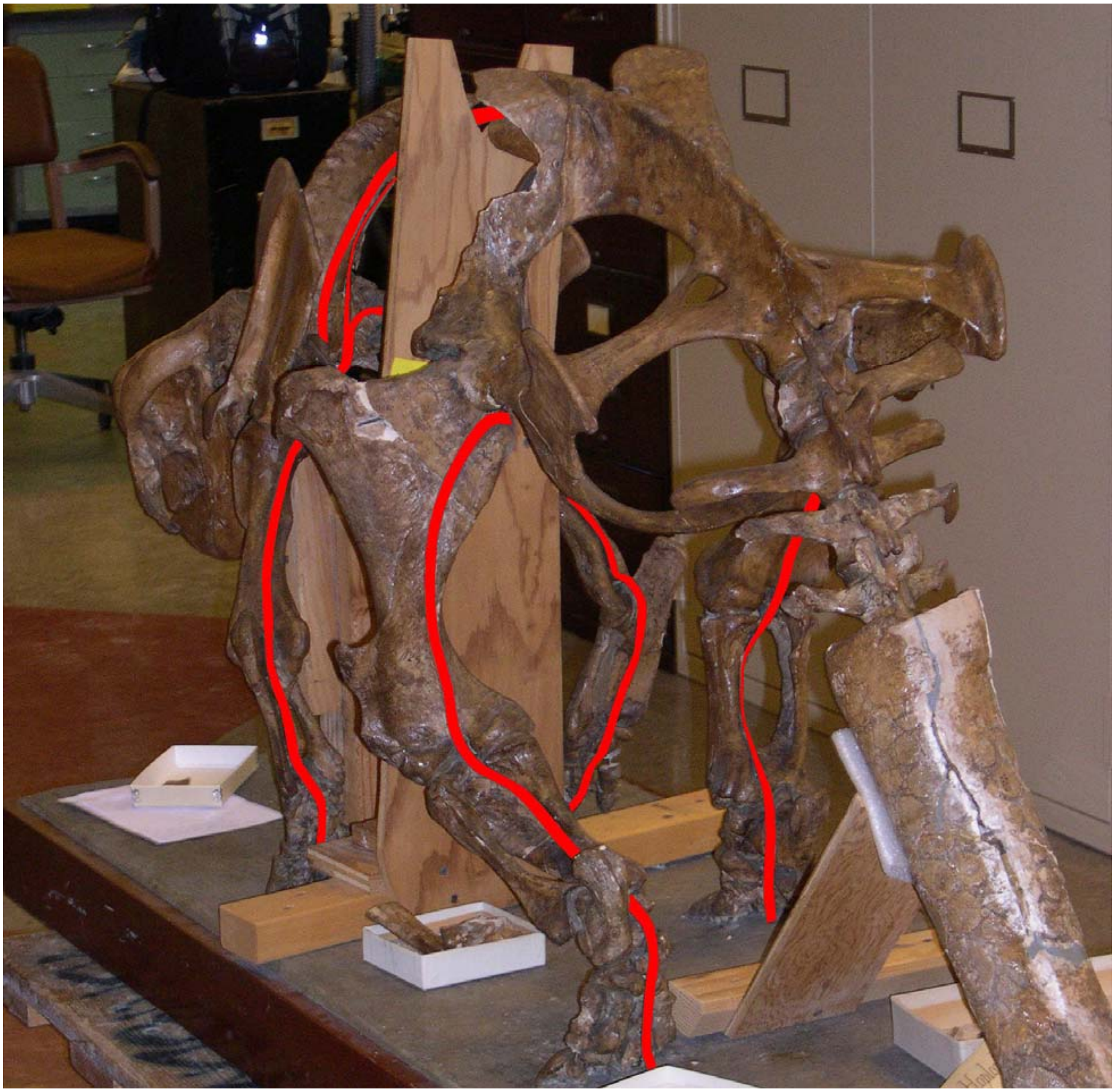
STEP 2 – Hiding the internal armature

The wire and bone limbs produced in Step 1 were then stiffened by filling all the joint spaces with plaster. This step is nowhere made explicit in either Hermann (1908 or 1909), but is a constant feature of his mounted specimens. We can speculate that the plaster filling had two desired effects, one cosmetic and one structural. Cosmetically, the plaster fill had the effect of hiding all of the wires of the internal armature from view. Structurally, the addition of plaster to all of the joint spaces in a limb would weld the bones of the limb together into a fragile yet rigid unit. This structural rigidity was absolutely necessary before the Step 3 could be contemplated. Step 3 involved the molding and casting the limb, followed by the shaping of the metal of the external armature using this cast as a form. An armature could only be developed in this manner if the limb was stiff enough to withstand the rigors of molding, and stable enough to maintain its shape permanently.

At the same time that we recognize the beneficial effects of filling the joint spaces with plaster, we should note that for all practical purposes, the mounting process became irreversible at this step. Yes, the plaster can be removed from the joint spaces, just like the removal of matrix in normal preparation. And yes, the internal armatures can then, with difficulty, be cut. But the investment in preparator time would be enormous. Hermann's free mounts are beautiful but permanent works.

STEP 3 – The external (outside the bones) armature

Hermann gave his mounts structural integrity by fashioning steel armatures to support the skeleton. In the case of AMNH 11262, the armature is constructed of steel bars shaped to the back of each of the limbs, the inside of the pelvis, and either side of the vertebral column from skull to pelvis. The caudal vertebrae are strung on a steel rod. The tail club rests upon the plaster bed of the mount. The anterior end of the rod upon which the caudal vertebrae are strung is incorporated into the plaster that covers the ventral surface of the pelvis.



The external armature is highlighted in red.

The true art in Hermann's free mount technique is found in the design of the external armature. The inside or back of each of the unitary limbs was molded, then cast, in plaster. The steel bar of the armature was then shaped with hammer against anvil to conform closely to this plaster pattern. Hidden on the inside or back of the limb and conforming closely the various shapes of the bones, these armatures become virtually invisible when painted the same color as the bone.

STEP 4 – Assembly

Each of Hermann's free mounts was originally displayed on a cherry wood base. This base contained wooden structural elements that were more substantial than the cherry-wood suggested, including stout planks to which the external armature was screwed. Hardware cloth was attached to the top of these planks and the inside of the cherry wood base. This hardware cloth was covered with plaster and painted to form the ground beneath the mount. When I treated this specimen in 2008, I removed four brass wheels from the underside of the base. These wheels had originally permitted movement of the mount without any additional equipment.

Just as the external armature was securely screwed to this base, each of the limbs was secured to the armature by a series of nuts and bolts. These nuts and bolt required that another set of holes be drilled into the skeleton.

Bolts attaching specimen to the external armature are located at arrows.

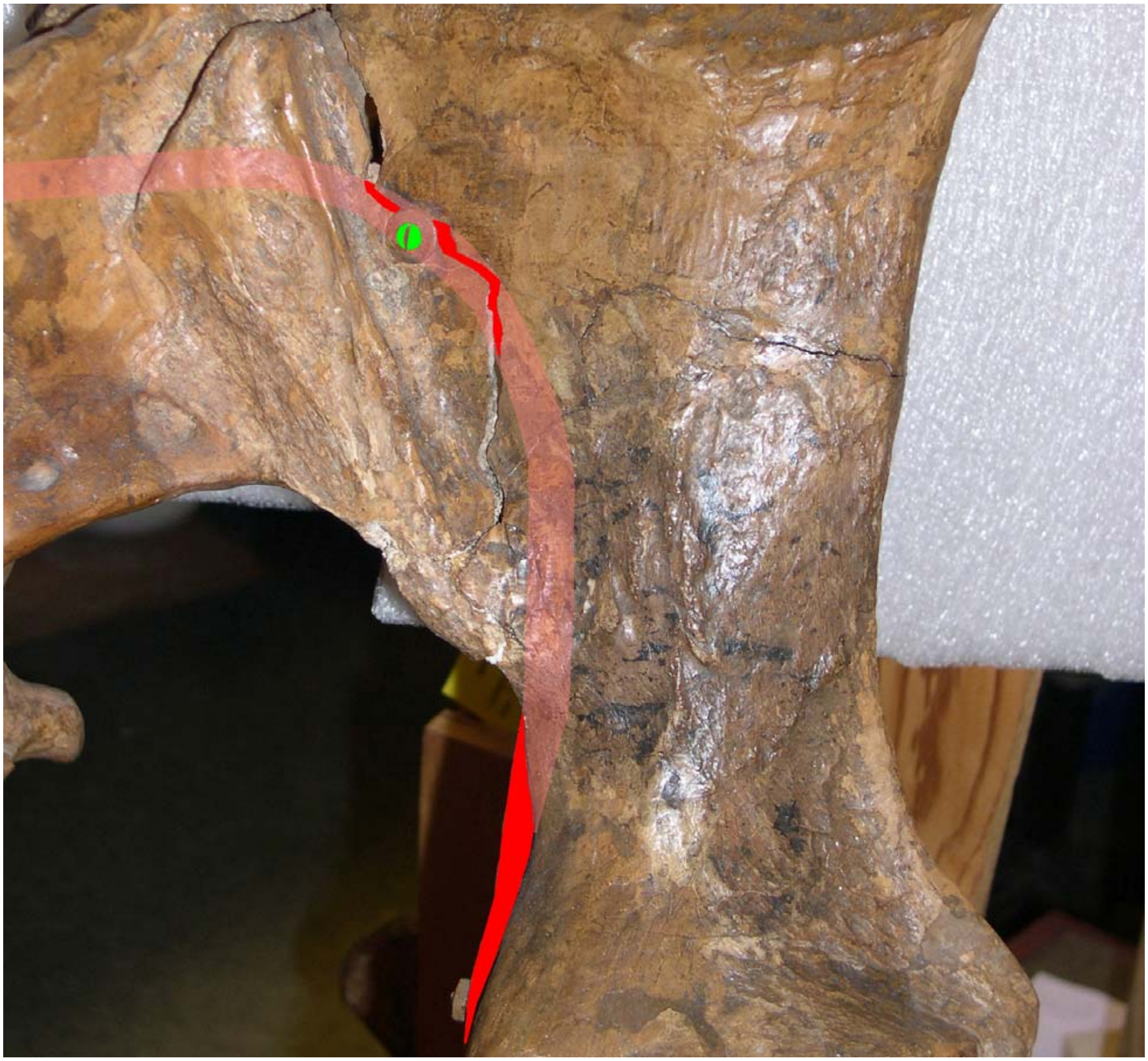
The completed mount was a single structural unit of bone and plaster, in that the phalanges of the limbs were plastered to the ground of the base, and each of these limbs was a stiff structural unit in its own right. Structurally, the total final effect was one of hoops of bone and plaster rising from, and firmly attached to, the structural planks hidden in the base. This made the whole structure extremely fragile, as a blow anywhere would be felt throughout the specimen. The structural fragility of these bone and plaster hoops made the steel external armatures an absolute necessity.

THE MAJOR SUMMARY OBSERVATION ON THE HERMANN'S MOUNTING OF AMNH 11262 IS THAT IT INVOLVED GENEROUS NUMBERS OF HOLES DRILLED INTO POORLY MINERALIZED BONES.

WHAT DOES ARMATURE DAMAGE LOOK LIKE?

The third metacarpal of the right manus is a small bone, approximately 4 centimeters in length and a couple of centimeters in width. Yet it was perforated by an armature wire running the length of the bone and a bolt running the width of the wrist. Most of the third metacarpal has broken away from these armatures, and is now missing from the specimen.

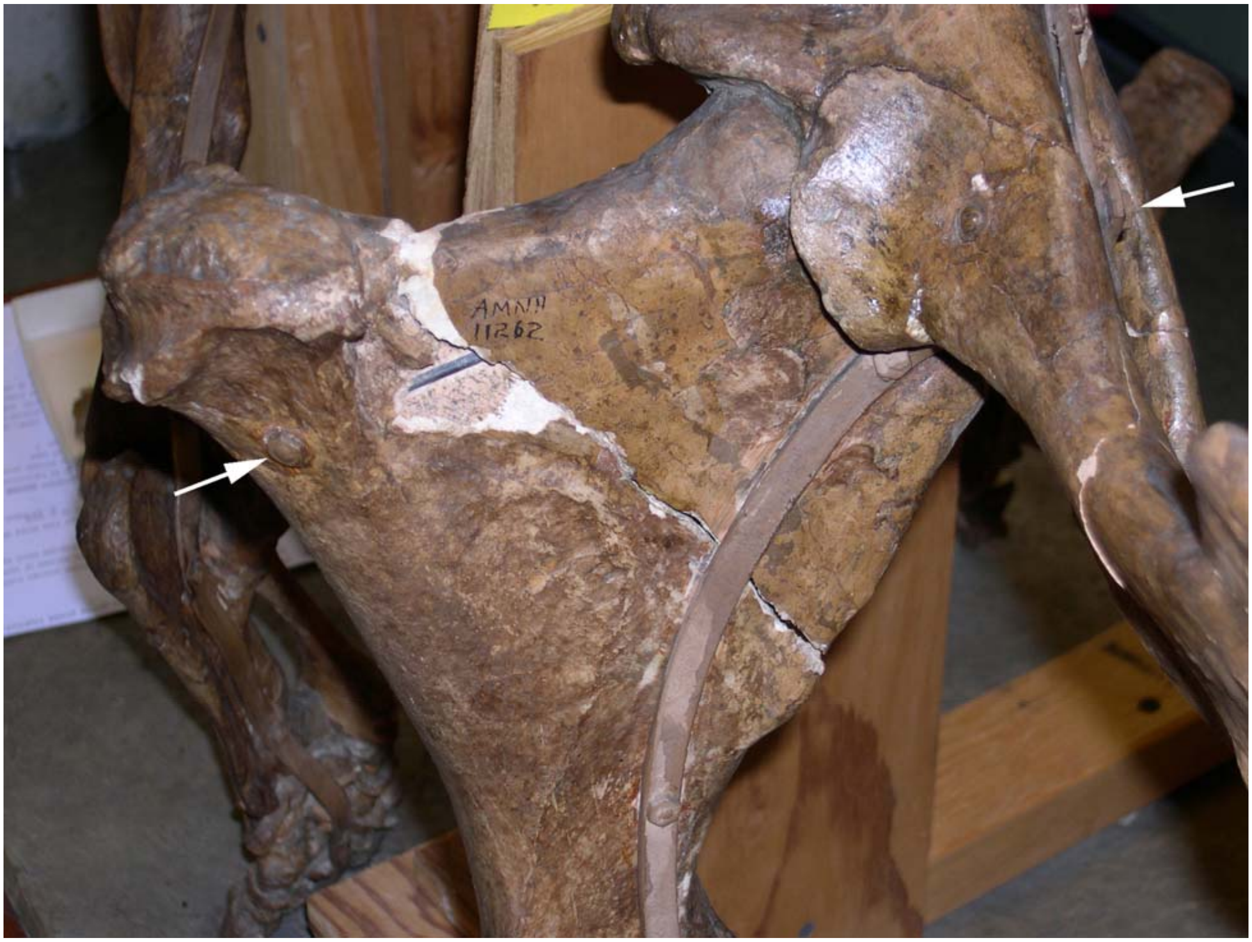
The bolt that attaches the left ischium to the armature serves double duty, as it also attaches the armature that runs up the left hindlimb to the armature that runs around the inside of the pelvis. Thus the nut (arrow) was tightened aggressively in order to assure that these two lengths of the armature were joined securely. The stresses at the head of the bolt resulted in a series of cracks radiating from the head of the bolt.



This crack in the right ilium follows the course of the armature, which is shown in pink because it is on the opposite side of the bone. The break is nucleated at a bolt hole (green). This crack is maintained at a width of 8mm by the armature.

This break in the lamina of the third cervical bone passes through a bolt hole (arrow), at which it probably nucleated. This break has a long history, as three previous repairs (one in tan-colored plaster, one in white plaster, and one in a clear resin) are present.

This break across the neck of the left femur is maintained at an offset of 10 mm by the armature. It takes substantial forces on the armature to reduce this offset. Undoubtedly, the substantial forces from the armature that are maintaining this offset contributed to the genesis of the break. White plaster present on the margins of this break suggests a history of previous repairs to this location.

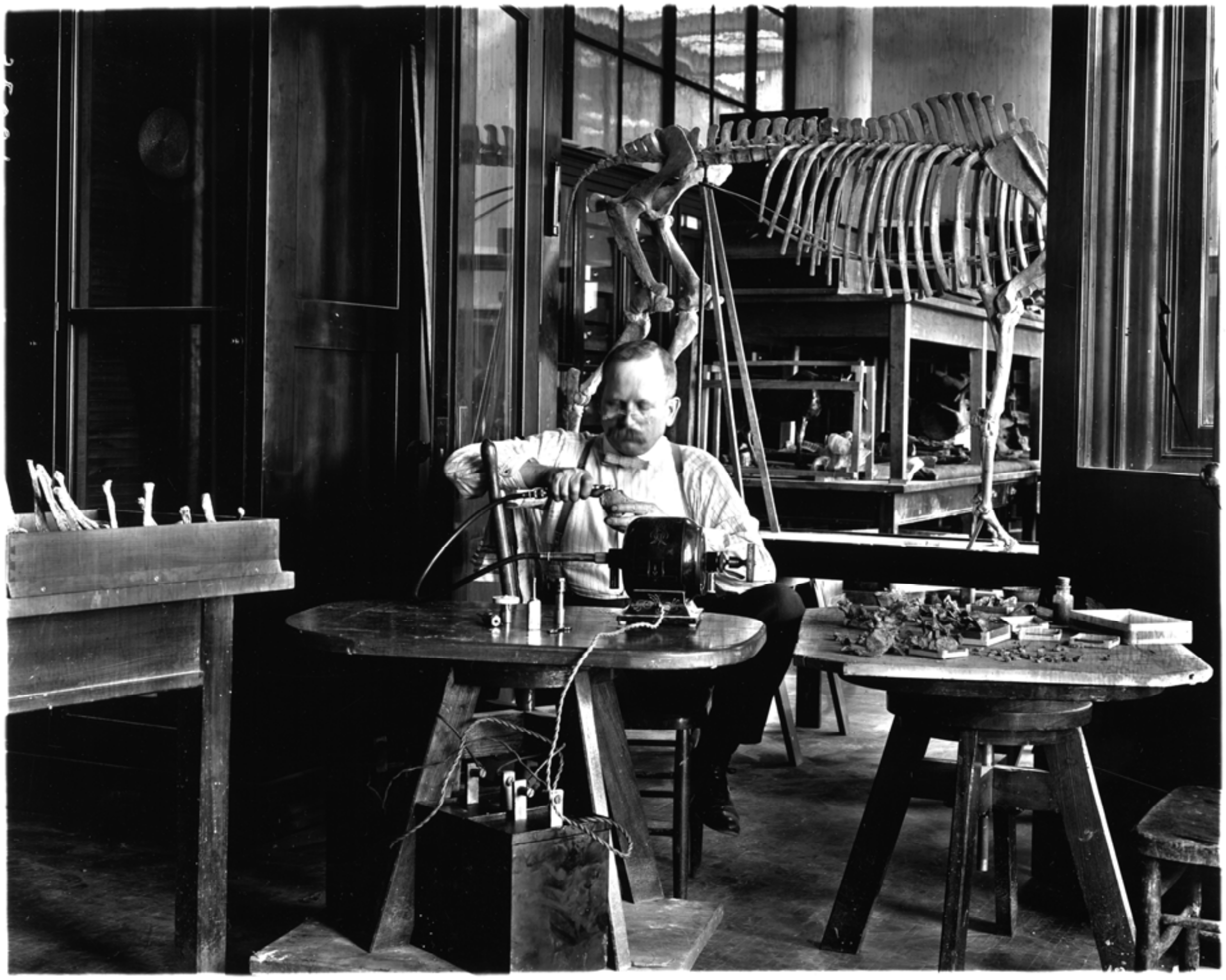


A concoidal flake of bone was ejected from the back side of the left femur, exposing the bolt that connects the left femur to the armature. This bolt is a remarkable 19 cm in length (the entire distance between the two arrows)! The course of this bolt is not straight, but is concave posteriorly. As a result, when the bolt was tightened, it pressed against the posterior lamina of the bone. The pressure from the tightened bolt caused the ejection of the concoidal flake of bone.

PRELIMINARY CONCLUSION

Adam Hermann's free mounts are deceptive. The bones appear to be gently mounted upon cleverly-hidden external armatures closely shaped to the bones. The few visible drill holes seem to be attaching individual bones to this external armarture. In fact, the process of making these free mounts involved literally hundreds of holes drilled into the articular surfaces bones. An internal armature composed of two or three wires crossing from bone to bone across each joint is an integral feature of Hermann's mounting technique. These wires were then hidden beneath plaster that fill the joint spaces. The invisibility of this internal armature is core deception in Hermann's mounts.

This largely unseen internal armature is also a key to the instability of this specimen. These many holes not only compromised the durability of the individual bones, but the wires and bolts that filled these holes formed nucleation points for the generation of cracks, then breaks in the weakened bones. The stiffness of the limbs, which Hermann desired as part of the mounting process, proves harmful over the longer life of the mount.



Adam Hermann and his electric drill. Note the voltaic power supply in the foreground. Hermann advocated use of the electric drill for fossil preparation in both his 1908 and 1909 contributions to the literature. His generous use of this drill to adapt bones for the production of mounted skeletons compromised the strength of the bones being mounted. This photograph is undated, but the skeleton of *Hypohippus osborni* that Hermann mounted in 1902 is seen in the background. Image #35001, American Museum of Natural History Library.

CONCLUSIONS SPECIFIC TO AMNH 11262

The wires and bolts of the internal armature and the steel bar of the external armature are both stronger than the bone of which this specimen is composed. Where ever bone comes into contact with the armature, the potential for damage to the bone exists.

Holes drilled into the specimen for attachment of limbs to the armature seem to have functioned as nucleation sites for cracks in the bone. The several breaks that pass through drill holes cannot all be coincidence.

Damage to the specimen is exacerbated by the degree to which all of the nuts and bolts in this specimen were tightened. In more than one instance, snug bolts rigidly attaching bones to the armature literally pulled bones apart.

The conversion of disarticulated bones to a series of large, convolute hoops of bone and plaster invites the failure of those hoops. This specimen had few ways to bend, but many ways to break.

CONCLUSIONS OF WIDER IMPORT

As the last specimen mounted in Adam Hermann's long career, AMNH 11262 represents the culmination of Hermann's technique. Evidence documented in this poster demonstrates that the durability of specimens clearly decreases when mounted in Hermann's free mount technique. The rigors of a traveling show may be inappropriate for any of these artificially fragile specimens.

The AMNH has twenty name-bearing specimens, seven of which are types for genera, mounted by Adam Hermann or his students. In some measure, Hermann's mounting has adversely affected scientific access to these specimens, which will never be freely available to study in the disarticulated state. Individual postcranial elements cannot be extracted easily. Realistically, these mounts are permanent. Sometimes, but not always, the mandible and the skull are less difficult to remove than postcranial elements.

The AMNH houses sixteen free mounts on its mammalian storage floors. Three other free mounts besides AMNH 11262 have needed repairs within the last decade. This somewhat anecdotal evidence suggests that free mounts do not survive well on storage floors, where they are subject to unsupervised study by research paleontologists.

Adam Hermann was not alone in his generous use of an electric drill in the mounting process. Preparators from other institutions have described mounting techniques that showed less respect for the integrity of the fossil than Hermann's technique. Both Converse (1984) and Schultz and Reider (1943) relied on robust internal armatures drilled down the shafts of long bones for the structural integrity of their mounts, rather than employing the external armatures used by Hermann. The modern emphasis on mounts that do not damage bones has a recent genesis (Bessom, 1963; and Barthel, 1966). Thus the mounted specimens seen in the museums of the world may be more fragile than they appear.

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