



Paleopathological analysis of a sub-adult *Allosaurus fragilis* (MOR 693) from the Upper Jurassic Morrison Formation with multiple injuries and infections
by Rebecca Rochelle Laws

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Earth Sciences
Montana State University
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Abstract:

A sub-adult *Allosaurus fragilis* (Museum of the Rockies specimen number 693 or MOR 693; "Big Al") with nineteen abnormal skeletal elements was discovered in 1991 in the Upper Jurassic Morrison Formation in Big Horn County, Wyoming at what became known as the "Big Al" site. This site is 300 meters northeast of the Howe Quarry, excavated in 1934 by Barnum Brown. The opisthotonic position of the allosaur indicated that rigor mortis occurred before burial. Although the skeleton was found within a fluviially-deposited sandstone, the presence of mud chips in the sandstone matrix and virtual completeness of the skeleton showed that the skeleton was not transported very far, if at all. The specific goals of this study are to: 1) provide a complete description and analysis of the abnormal bones of the sub-adult, male, *A. fragilis*, 2) develop a better understanding of how the bones of this allosaur reacted to infection and trauma, and 3) contribute to the pathological bone database so that future comparative studies are possible, and the hypothesis that certain abnormalities characterize taxa may be evaluated.

The morphology of each of the 19 abnormal bones is described and each disfigurement is classified as to its cause: 5 trauma-induced; 2 infection-induced; 1 trauma- and infection-induced; 4 trauma-induced or aberrant, specific origin unknown; 4 aberrant; and 3 aberrant, specific origin unknown. This study gives a detailed picture of the pathologies of this individual and some of its probable behaviors. The lifestyle and behavior of a carnivorous dinosaur probably predisposed it to injury. "Big Al" is an 87% grown, sub-adult, male, *A. fragilis*, who may have incurred some injuries during competition with other males and pursuit of prey, and some infection while standing on carcasses, feeding. Additionally, bones exhibiting chronic, localized infection indicate that allosaurs possessed an immune response which allowed them to live with microbial infection in their bones, probably by keeping it localized. This study serves as a basis for future paleopathological analyses. The significance of this allosaur's abnormalities will be better understood once a comprehensive paleopathological study of a large sample of allosaur bones is completed.

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MONTANA STATE UNIVERSITY-BOZEMAN
Bozeman, Montana

December 1996

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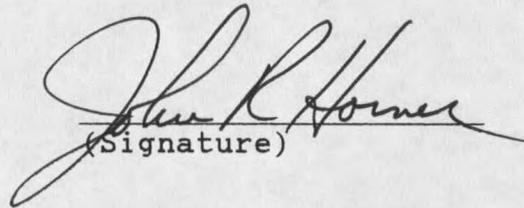
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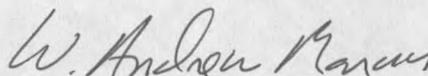
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Date 9 DECEMBER 1996

ACKNOWLEDGEMENTS

Funding was provided by Ben and Dorothy Laws, the D.L. Smith Memorial Scholarship, Jack Horner, Museum of the Rockies, Ben and Kathy Laws, a Department of Earth Sciences Teaching Assistantship, and Sigma Xi.

Thanks to all my family members who continually supported me and my quests. David Hanna provided constructive comments and endless moral support. Museum of the Rockies paleontology staff and students gave assistance and answered questions. Special thanks go to Bob Harmon, who first brought some of Big Al's maladies to my attention.

I would also like to give thanks to my committee. Jim Schmitt took the time to carefully edit several drafts of my thesis, and was helpful in the organization of ideas. Susan Gibson assisted with editing, provided me with the necessary histological background to understand bone microstructure, and made me laugh. Finally, Jack Horner gave me the opportunity and resources to study dinosaur paleopathology, which is what I originally set out to accomplish.

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ABSTRACT

A sub-adult *Allosaurus fragilis* (Museum of the Rockies specimen number 693 or MOR 693; "Big Al") with nineteen abnormal skeletal elements was discovered in 1991 in the Upper Jurassic Morrison Formation in Big Horn County, Wyoming at what became known as the "Big Al" site. This site is 300 meters northeast of the Howe Quarry, excavated in 1934 by Barnum Brown. The opisthotonic position of the allosaur indicated that rigor mortis occurred before burial. Although the skeleton was found within a fluvially-deposited sandstone, the presence of mud chips in the sandstone matrix and virtual completeness of the skeleton showed that the skeleton was not transported very far, if at all. The specific goals of this study are to: 1) provide a complete description and analysis of the abnormal bones of the sub-adult, male, *A. fragilis*, 2) develop a better understanding of how the bones of this allosaur reacted to infection and trauma, and 3) contribute to the pathological bone database so that future comparative studies are possible, and the hypothesis that certain abnormalities characterize taxa may be evaluated.

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INTRODUCTION

Purpose

Paleopathology is the study of disease (congenital, infectious, traumatic, toxic, endocrine/metabolic, neoplastic, and systemic disorders) (Mann and Murphy, 1990) in the fossil record. These abnormalities preserved in bone reflect life events because they formed while the animal was alive. Thus, generally speaking, pathological bones can be used to reconstruct lifestyles.

Additionally, certain abnormalities may characterize taxa. If this is true, then frequency of abnormalities and location in the body may be diagnostic of behavior, environment, and physiology. If certain abnormalities do not distinguish taxa from one another, then what are the implications for vertebrates as a whole?

This study gives a detailed picture of the pathological bones in one sub-adult, male, *Allosaurus fragilis* (Museum of the Rockies specimen number 693 or MOR 693; "Big Al") and based on the abnormalities, inferences are made to some of its probable behaviors. In addition, this study serves as a basis for future paleopathological analyses. The significance of this allosaur's abnormalities will be better understood once a comprehensive paleopathological study of a large sample of

allosaur bones is completed.

The sub-adult *A. fragilis* (Figure 1) with nineteen abnormal skeletal elements was discovered in 1991 in the Upper Jurassic Morrison Formation in Big Horn County, Wyoming at what became known as the "Big Al" site (Figure 2). Affected bones include five dorsal ribs, cervical vertebra 6, dorsal vertebrae 3, 8, and 13, caudal vertebra 2, chevron 2, gastralia, scapula, manus phalanx I-1, pes phalanx III-1, pes phalanx II-3 (ungal), metatarsal III, metatarsal V, and ilium (see Fig. 1). The objective of this study is to describe these bones by comparison of the abnormal elements to normal analogues, and interpret their origin. Pathological abnormalities are also present in some of the theropod bones from the Cleveland-Lloyd dinosaur collection housed predominantly at Brigham Young University (BYU) and the University of Utah (U of Utah) (Petersen et al., 1972; Madsen, 1976); comparisons are made to bones similar in morphology to those of MOR 693. The cause (etiology) of the bone affliction is diagnosed as resulting from trauma, infection, trauma and infection, or aberrancy. The specific goals of this study are to: 1) provide a complete description and analysis of the abnormal bones of the sub-adult, male, *A. fragilis* (MOR 693), 2) develop a better understanding of how the bones of this allosaur reacted to infection and trauma, and 3) contribute to the pathological bone database so that future comparative studies are possible, and the hypothesis that certain

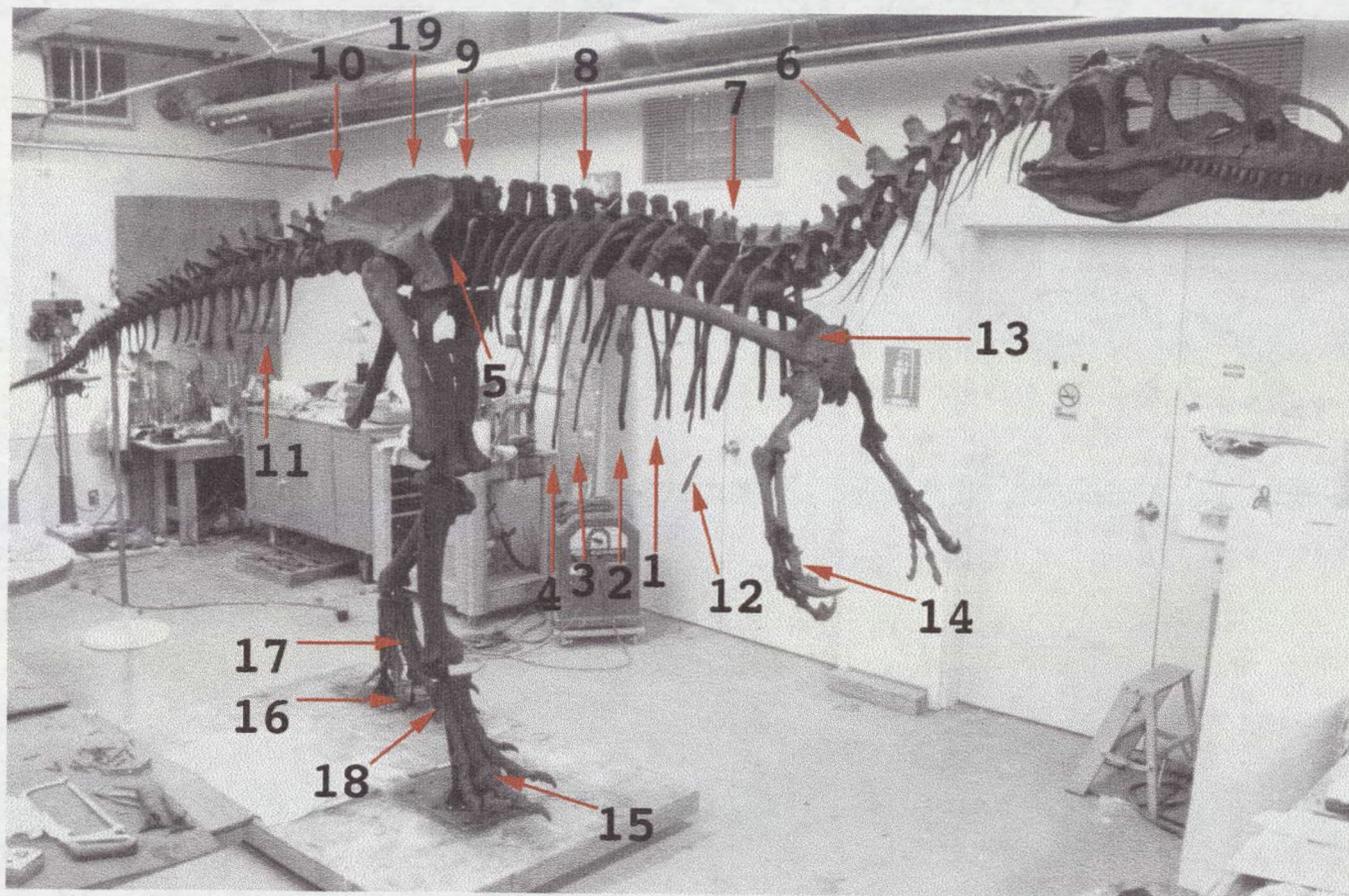


Figure 1: Skeleton of the sub-adult allosaur (MOR 693), "Big Al," from Big Horn County, Wyoming (Copyright Museum of the Rockies, Bruce Selyem photo) showing location of the 19 abnormalities. 1 = dorsal rib 3; 2 = dorsal rib 4; 3 = dorsal rib 5; 4 = dorsal rib 6; 5 = dorsal rib 14; 6 = cervical vertebra 6; 7 = dorsal vertebra 3; 8 = dorsal vertebra 8; 9 = dorsal vertebra 13; 10 = caudal vertebra 2; 11 = chevron 2; 12 = gastralia 5; 13 = scapula; 14 = manus phalanx I-1; 15 = pes phalanx III-1; 16 = pes phalanx II-3 (ungal); 17 = metatarsal III; 18 = metatarsal V; 19 = left ilium.

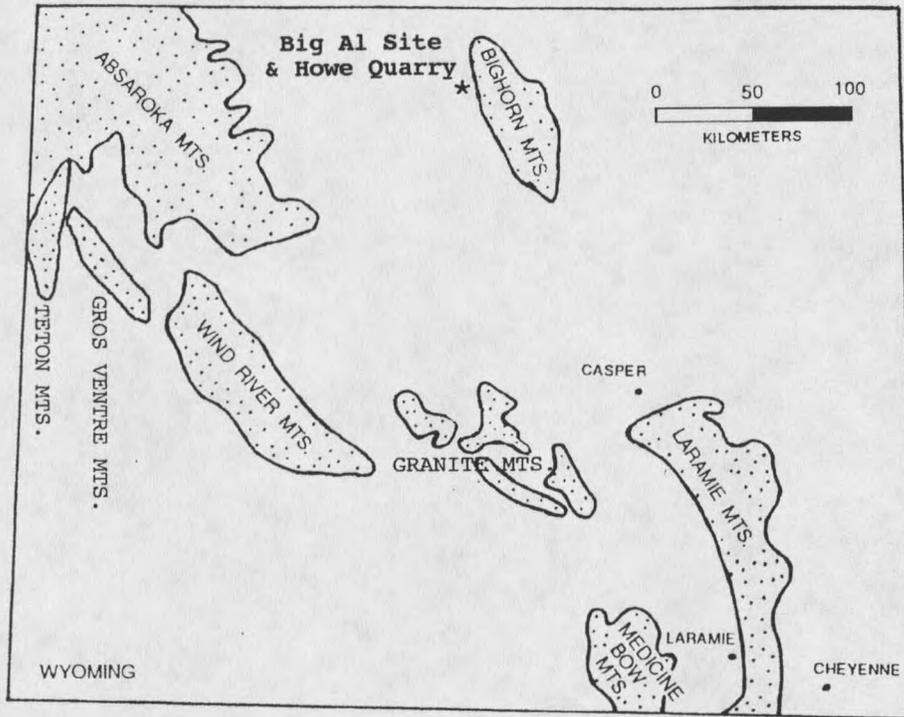


Figure 2: Location map of Big Al site and Howe Quarry in Wyoming (modified from Fiorillo, in press, Fig. 1).

abnormalities characterize taxa may be evaluated. In addition, this analysis provides insight into physiology, behavior, and environmental influences since bone abnormalities record life events.

Although some pathological allosaur bones have been described (Moodie, 1918a; Petersen et al., 1972; Madsen, 1976; Rothschild and Martin, 1993), thorough examination of the frequency of damaged bones has not been done, and thus the occurrence and nature of these abnormalities remains poorly understood. If paleontologists identified, described, and (when possible) interpreted the cause of abnormalities, then a database of the frequency and skeletal distribution of pathologic theropod bones could be compiled. Evaluation of these data would reveal which abnormalities are common for *Allosaurus* and would be useful for future intraspecific comparative studies because the frequency of pathology varied significantly between individuals. Inter-specific comparison of the frequency and anatomical position of pathological bones may show that certain abnormalities characterize taxa and are diagnostic of their lifestyle.

Paleopathology

The term "paleopathology" was first applied by Sir Marc Armand Ruffer in 1910 with respect to his study of ancient Egyptian mummy pathogenesis (Ruffer, 1910; Swinton, 1981).

