Short Communication

Degenerative Joint Disease in the Skeletal Remains of a Captive Bornean Sun Bear (*Helarctos malayanus euryspilus*)

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Abstract | The Bornean sun bear (*Helarctos malayanus euryspilus*) is recognized as the smallest bear species globally and is vulnerable to degenerative joint disease (DJD). This study presents the results of a detailed examination of the skeleton remains of one adult male captive Bornean sun bear obtained from the Bornean Sun Bear Conservation Centre (BSBCC), Sandakan, Sabah, Malaysia, specifically for DJD lesions. The examination revealed osteoarthritis in multiple sites of the appendicular joint, including the hip joint, stifle joint, elbow joint, and carpal joint, with bilateral involvement. Spondylosis deformans was observed in the cervical and thoracic vertebrae. The DJD changes include osteophyte formation, subchondral bone degradation, and joint remodelling. In conclusion, the findings provide valuable insights into the joint health of Bornean sun bear and highlight the importance of proactive measures to mitigate factors contributing to joint degeneration, such as optimizing husbandry practices and providing appropriate environmental enrichment.

Keywords | Bornean sun bear, Degenerative joint disease, Osteoarthritis, Spondylosis deformans, Captive wildlife, Skeleton

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INTRODUCTION

Degenerative joint disease (DJD) is a progressive condition that affects any joint in the body. Based on the involvement of the joint, osteoarthritis (OA) specifically targets synovial joints, whereas spondylosis deformans (SD) refers to the degenerative changes occurring in the vertebral column, including intervertebral discs, vertebral bodies, and surrounding structures. Osteoarthritis is clinically manifested by primary symptoms such as pain, stiffness, and locomotor restrictions. Osteoarthritis results in the progressive loss of articular cartilage structure and function, osteophyte formation, subchondral bone sclerosis, and synovial inflammation (Kim et al., 2018). Spondylosis deformans is characterized by the formation of osteophytes along the edges of vertebral bodies in the spine. Although the exact cause is unknown, individual-level factors such as age, sex, obesity, genetics, and diet are well-documented as predictors of DJD. Likewise, joint-level factors such as injury, overuse, and malalignment may also contribute to the development of DJD (Palazzo et al., 2016). Degenerative joint disease has been reported not only in domestic animals (Anderson et al., 2019; Baccarin et al., 2022) but also in wildlife (Kalogeropoulu et al., 2023).

The Bornean sun bear is the smallest bear species in the world. It is the subspecies of the Malayan sun bear (*Helarctos malayanus*) and is endemic to the island of Borneo (Wong, 2002; Meijaard, 2004; Kunde, 2017). Habitat loss and activities such as illegal hunting and trading constitute a significant threat to the population of Bornean sun bears (Gomez et al., 2020). Conservation efforts for this small bear species include the establishment of rescue and rehabilitation facilities, such as in the states of Sabah and Sarawak (Malaysia) and Balikpapan province in East Kalimantan, Indonesia. The Bornean Sun Bear Conservation Centre (BSBCC) in Sabah is the world's only sun bear rehabilitation centre. Degenerative joint disease is reported in Ursidae such as American black bears (Storms et al., 2004), sloth bears (Selvaraj et al., 2017), and brown bears (Witz et al., 2001; Aminkov et al., 2018; Hadziomerovic et al., 2019). An earlier study on palaeopathological examination revealed DJD in the dry skeleton of Malayan sun bears (Greer et al., 1977).

In this article, we report the presence of DJD in the skeletal remains of a captive Bornean sun bear from BSBCC in Sabah, Malaysia. To the best of our knowledge, this is the first documented report of DJD in this subspecies.

MATERIALS AND METHODS

We examined the skeleton of a male Bornean sun bear named "Gutuk", who was rescued in the year 2001 from illegal traffickers at an adult age and sent to Sepilok Orangutan Rehabilitation Centre, Sandakan, Sabah, Malaysia. Gutuk became a resident of the BSBCC after the sun bear center was established in 2008. Within the BSBCC, Gutuk was housed in a cemented cage (3m length x 2m width x 3m height). Dietary management consists of a variety of fruits, rice porridge, and cooked vegetables such as pumpkin, sweet potatoes, and mung beans. Health records indicated that the sun bear had partial blindness and chronic skin conditions, including dermatitis, alopecia, and pruritis. Neither locomotion difficulties nor lameness was observed before his death. In 2017, Gutuk experienced an injury and radiological findings revealed a comminuted fracture at the right carpus. Gutuk died a day after the general anaesthesia to assess the fracture condition. The carcass was macerated, and the bones were collected, dried, and kept at room temperature.

The skeletal remains were categorized and organized based on their anatomical regions, distinguishing between the appendicular and axial skeletons. The appendicular bones and vertebrae were examined macroscopically for evidence indicative of OA and SD, respectively. The presence of osteophyte formation, subchondral bone degradation, and joint remodelling was examined and recorded as present and absent for the available appendicular bones and vertebrae (Nganvongpanit et al., 2017). The width of the osteophytes extending from the bone surface was measured at its widest dimension using a ruler. All bones showing lesions were photographed.

RESULTS AND DISCUSSION

Osteoarthritis was observed in multiple sites of the joint (i.e., hip joint, elbow joint, stifle joint, and carpal joint) with bilateral involvement. Specifically, OA lesions were identified in various appendicular bones, including the femur, pelvis, humerus, radius, ulna, and carpal bones. The osteophytes were observed as new bone formations around the periphery of the joint, ranging in size from 0.5 to 2.0 cm. Osteophyte formation was identified at the femoral head-neck junction (Figure 1), along the trochlear margin of the distal femur (Figure 1), around the acetabular margin (Figure 2), on the proximal and distal radius and the distal ulna (Figure 3). Evidence of subchondral bone degradation was observed on the entire surface of the left and right acetabulum (Figure 2), femoral head, right medial femoral condyle (Figure 1) and radius. Joint remodelling was identified by assessing changes in the bone shape, and the event was observed in the acetabulum and right femoral head; both of these bones had extensive osteophyte formation (Figures 1 and 2). The right femoral head depicted a flattened shape, compared with the rounded appearance observed in the left femoral head (Figure 1).

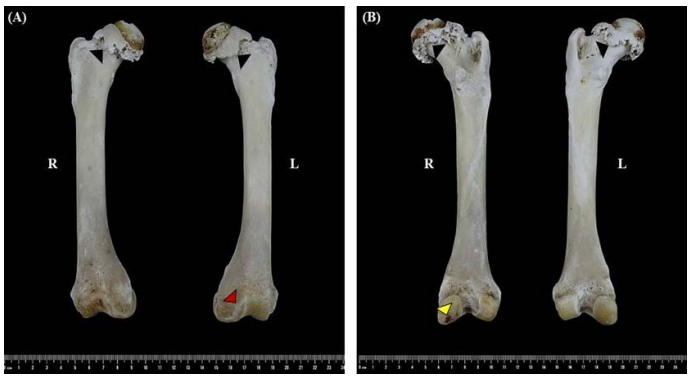

Figure 1: Osteophyte formation along the femoral head-neck junction (black arrowheads) and the trochlear margin of the distal femur (red arrowheads). The right femoral head showed a flattened shape, compared with the rounded appearance observed in the left femoral head. Evidence of subchondral bone degradation was observed on the surface of the right medial femoral condyle (yellow arrowheads). (A) cranial view of right (R) and left (L) femur. (B) caudal view of right (R) and left (L) femur.

Spondylosis deformans lesion characterized by the formation of osteophytes was observed at the edge of the lateral and ventral vertebral body of C6-C7, C7-T1, and T12-T13 (Figure 4). The size of the osteophytes ranged from 0.5 to 1.0 cm. Bone degradation, characterized

by erosion and roughened and irregular bone texture, was found on both the cranial and caudal intervertebral surfaces of all the affected vertebrae (Figure 4). Greer et al. (1977) reported DJD in wild mammals' skeletons, including three Malayan sun bears. They found severe SD affecting the lumbar vertebrae, along with OA present in the carpal joints. Additionally, they described DJD in the sun bears as being characterized by osteophyte formation on the vertebrae, with the fusion of three lumbar vertebrae, and on the long bones, particularly at the distal ends of the ulna.

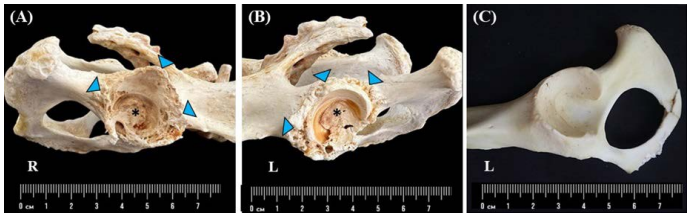

Figure 2: Degenerated acetabulum (A-B) undergoes remodelling, with severe osteophyte formation (blue arrowheads) at the cranial effective acetabular rim and caudal acetabular edge. Evidence of subchondral bone degradation was observed on the entire surface of the right (R) and left (L) acetabulum. A normal acetabulum (C) is characterized by smooth acetabular edge, surface and bone.

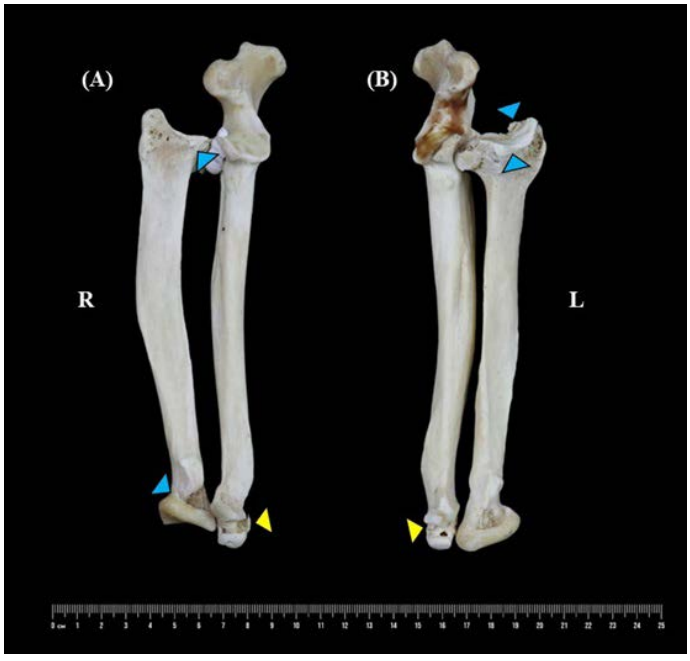

Figure 3: Osteophyte formation on the proximal and distal radius (blue arrowheads) and the distal ulna (yellow arrowheads). (A) Medial view of right radius and ulna. (B) Medial view of the left radius and ulna.

In this study, the most affected areas of SD in Bornean sun bear were the cervical and thoracic vertebrae with marked osteophyte formations at the edge of the lateral and ventral aspect of the vertebral body. The distribution pattern of osteophytes observed in Bornean sun bears in this study was similar to the pattern observed in both domestic animals and humans (Nganvongpanit et al., 2017).

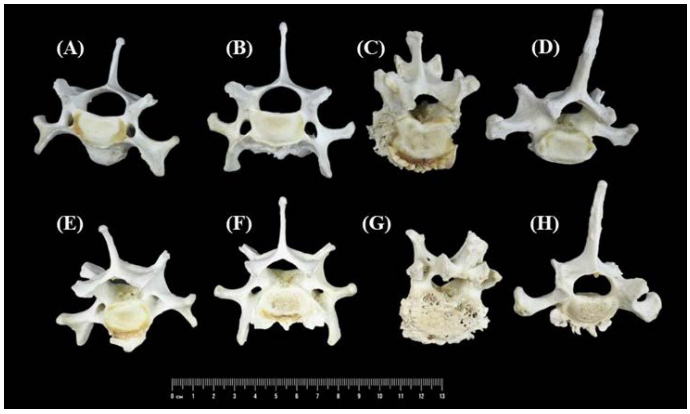

Figure 4: Spondylosis deformans lesion characterized by the osteophyte formation developed at the edge of the ventral vertebral body of C6 (A and E), C7 (B and F), T1 (C and G) and T12 (D and H). Bone degradation, characterized by erosion, roughened and irregular bone texture, was found on both the cranial and caudal intervertebral surfaces of all the affected vertebrae. (A-D) Cranial view; (E-H) Caudal view.

In companion animals, the presence of SD in the caudal cervical spine may be associated with cervical instability (Walker, 2002). Spine instability can occur at any vertebra along the vertebral column, resulting from trauma, ligament laxity, degenerative changes, and congenital abnormalities. Sun bears, like other bear species, possess high mobility in both their skull and cervical vertebrae (Endo et al., 2001), enabling them to scan their surroundings and track movements while foraging for food, climbing, and swimming. If cervical instability occurs, increased activity in the cervical region of sun bears may trigger the development of spondylosis. Furthermore, in captivity, limited exercise and sub-optimal nutrition could exacerbate spondylosis development and progression (Wagner et al., 2005).

Sun bears are semi-arboreal animals as they spend a significant portion of their time in trees for feeding, resting, and avoiding dangers. The hindlimbs are specialized for this arboreal lifestyle by having strong muscles to push the body off the ground and propel themselves upward while climbing (Sasaki et al., 2005). Additionally, the flexible hindlimb joints allow for a wide range of motion, especially when navigating through the branches and the trunks. Consequently, OA in the hindlimb joints can significantly impair their mobility, overall health, and welfare. In this study, severe OA lesions were observed in the hip joints. The presence of large osteophyte formations at the acetabular margin and the head-neck junction of the femoral head is an attempt to compensate and stabilize the compromised hip joints by increasing the surface area of the degraded acetabular and femoral head cartilage lining. Moreover, it

also contributes to enhancing support and joint incongruity, particularly during locomotion and climbing activities. Nevertheless, osteophytes can limit joint movement by encroaching on the joint space and irritating surrounding soft tissue, including ligaments, tendons, and nerves, leading to inflammation, pain, and discomfort. Examination of the skeleton also revealed subchondral bone degradation and joint remodelling, suggesting an advanced stage of joint degeneration. As cartilage deteriorates and exposes the underlying bone, the subchondral bone becomes susceptible to damage and degradation.

In this study, the sun bear experienced a fracture in the carpal region, ultimately leading to the development of secondary OA in the carpal joint. Osteoarthritis is a chronic progressive degenerative disease, and aging is recognized as a significant risk factor for its development in mammalian species (Baccarin et al., 2022). Changes associated with OA typically increase as animals age. At 17 years old at the time of its death, the sun bear may have developed OA at some point during its life, but no reports of chronic lameness were recorded previously. Wildlife can adapt to their environment and cope with injuries and discomfort. They appear to be moving normally or hide signs of lameness, making it difficult to recognize any joint issues (Bourne et al., 2010). As a result, OA may go undetected or be diagnosed at a later stage when clinical signs become more pronounced or when complications arise. The behaviour of bears with DJD often changes due to discomfort and limitation caused by the condition. Bears with DJD are less active, spend more time sleeping and resting, climb less frequently, and are more easily agitated (Bourne et al., 2010). Thus, monitoring the behavioural patterns can assist caretakers, researchers, and wildlife biologists in assessing the health and well-being of the bear population, both in captivity and in the wild.

Assessing lameness in bears involves understanding bear locomotion. Hunter-Ishikawa et al. (2023) developed a reliable Bear Lameness Scale for Asiatic black bears (*Ursus thibetanus*), and it has been used on other bear species, including the Malayan sun bear. The scale is based on visual observation of the bear's locomotion during walking, running, and any alteration in the stride. Moreover, the scale can be easily used to monitor both acute and chronic lameness, as bears share similar anatomy and locomotion patterns (Amanat et al., 2020). Frequent visual assessment, physical examination, and regular radiographic evaluation enable early detection and monitoring of disease progression (Bourne et al., 2010).

CONCLUSIONS AND RECOMMENDATIONS

Our study of DJD in skeletal remains of Bornean sun bears sheds light on the occurrence of this condition in these animals. The study identified characteristic signs of OA and SD, including osteophyte formation and changes in the bone morphology indicative of chronic joint pathology. Understanding the consequences of DJD in sun bears is crucial for their conservation and health management.

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NOVELTY STATEMENT

By documenting species-specific patterns of joint degeneration, the study reveals how captivity and increased longevity impact the skeletal health of Bornean sun bear, which offering insights that were previously unexplored. The findings not only contribute to our understanding of the evolutionary and behavioural implications of joint disease in these animals but also have practical implications for improving conservation strategies and developing targeted geriatric care protocols for wildlife in captivity.

AUTHOR'S CONTRIBUTION

STW, YBN, and NNS were involved in retrieving, cleaning, and preserving the skeletal remains. AHAJ, SMZA, and WMKA documented relevant information on each bone specimen and captured detailed photographs of the specimens. Authors AHAJ and SMZA wrote the first draft of the manuscript. Author SMZA edited the last manuscripts. All authors read and approved the final manuscript.

Conflict of interests

The authors have declared no conflict of interest.

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