The Planet of the Humans!? The Effects of Anthropogenic Environments on Great Apes

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Introduction

As human populations grow and evolve, they are changing the world along with them: technology is advancing, medicine is improving exponentially, and food attainment strategies are shifting. The current epoch or geological age, the Anthropocene, is marked by the steadily increasing abundance of anthropogenic environments—those that are created, altered, or transformed by humans. These changes in our world are not only affecting human health but the health of our non-human relatives as well. Within recent history, despite many diseases and illnesses being reduced, the prevalence of complex diseases and auto-immune disorders has increased (1, 2).

Apes are experiencing similar changes in health, both in captivity and in the wild. In part, this study investigates the factors that are related to these changes. This study collects pathologic and demographic information of the cranial primate collection at the National Museum of Natural History. In this survey, the health of great apes (including chimpanzees, bonobos, orangutans, and gorillas) is examined through the visual analysis of their crania (**Figure 1**). These analyses focus on determining age-at-death, the presence and severity of dental calculus (calcified plaque), the presence and severity of cranial pathology, and captive or wild status. Health in this study is defined by presence and severity of dental calculus and cranial pathology; specimens with higher frequencies and severity of calculus and pathology are considered less healthy.

Figure 1. Crania of a gorilla (top), an orangutan (center), and a chimpanzee (bottom). Photos by: Tiia Monto.

Materials and Methods

In this study, a total of 286 great ape crania were surveyed and their characteristics recorded (see **Table 1**). Within this sample, 121 were of the genus *Gorilla* (30 *Gorilla berengei*, 91 *Gorilla gorilla*), 111 were of the genus *Pongo* (22 *Pongo abelii*, 89 *Pongo pygmaeus*), and 54 were of the genus *Pan* (53 *Pan troglodytes*, or chimpanzees, 1 *Pan paniscus*, or bonobo).

To conduct this study, crania were analyzed following a systematic 47-question survey regarding taxa, sex, age, locality (origin of specimen), presence of bony pathologies, teeth presence, and presence of dental calculus. Age was assessed using tooth development schedules and each specimen was determined to be infant, juvenile, or adult. Teeth were counted and identified as either deciduous or permanent. Missing teeth were noted as missing postmortem or antemortem depending on the amount of bone resorption observed (3). Dental calculus is calcified plaque that accumulates over time and is more abundant in carbohydrate heavy diets (4). Presence of dental calculus was examined visually and scored on a scale of "0-4": "0" is no dental calculus, "1" is minimal to trace amounts of calculus, "2" is a small to moderate amount of calculus, "3" is noticeably large amounts of calculus, and "4" is a severe amount of calculus (**Figure 2**).

Pathology in this survey is defined as abnormal bony features, including excessive porosity, additional bone growth, bone destruction, healing (from injury or infection), and resorption (3). Presence of bony pathology was observed visually and scored on a scale of "0-3": "0" being no pathology, "1" is small amounts of pathology, "2" is moderate pathology, and "3" is severe pathology (**Figure 3**).

A specimen's captive status was determined by where individuals were born, where they were collected from, and where they died. This information was gathered from the USNM database. An individual was of "captive" status if he/she lived under human care during any phase of life. "Wild" individuals are those that were born, raised, then died in the wild.

Taxon	Total (N)	F/M (%)	Adult/Subadult (%)	Calculus Present (%)	Pathology Present (%)	Captive/Wild (%)
Gorilla	121	36/52	87/13	56	7	4/90
Pan	54	39/37	72/28	81	4	9/81
Pongo	111	50/45	70/29	58	5	10/86
Total	286	42/47	78/22	62	5	7/92

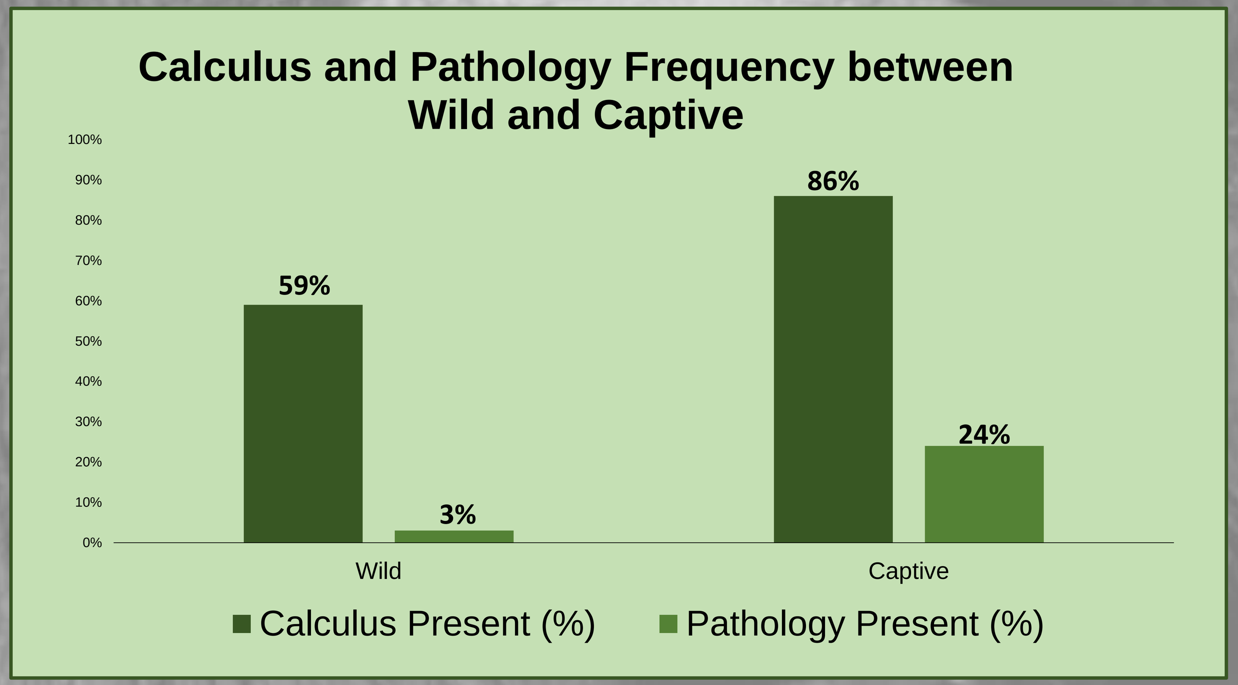
Table 1. Frequencies of sex, age, calculus presence, pathology presence, and captive/wild specimens. Pathology is considered present when there is a severity score of 2 or more. Calculus is considered present when there is a severity score of 1 or more.

Results

When examining calculus within the overall sample, 62% of all specimens exhibited some amount of calculus (where calculus severity was "1" or greater). When observing calculus presence within each genus (**Table 1**): 56% of *Gorilla*, 58% of *Pongo*, and 81% of *Pan* specimens had calculus present. Overall, 5% of the specimens showed cranial pathology with a severity rating of "2" or more (**Table 1**). Examining cranial pathology for each genus: 7% of *Gorilla* specimens, 5% of *Pongo* specimens, and 4% of *Pan* specimens showed signs of pathology with a severity score of 2 or greater.

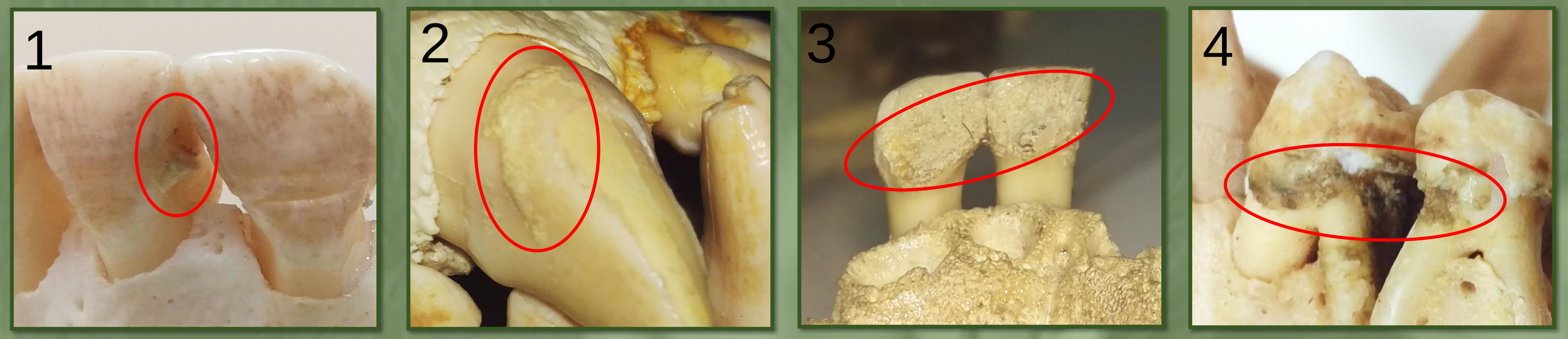
Within the total sample, 7% were captive (4% of *Gorilla*, 9% of *Pan*, and 10% of *Pongo*). Of those, 89% had calculus present and 24% had pathology present. Among wild specimens, 59% had calculus present and 3% had pathology present (**Graph 1**).

A traditional statistics test to examine the independence of two categorical variables is a chi square test (5). Chi square tests were performed to investigate correlations between the main variables of interest in this study: pathology, calculus, sex, taxon, and captive status. Statistically significant associations (a=0.05) were found between sex and pathology (p=0.016), taxon and calculus (p=0.007), captive status and pathology (p<0.00001), and captive status and calculus (p=0.019). The results of the chi square tests performed in this survey suggest that captivity status does influence health.



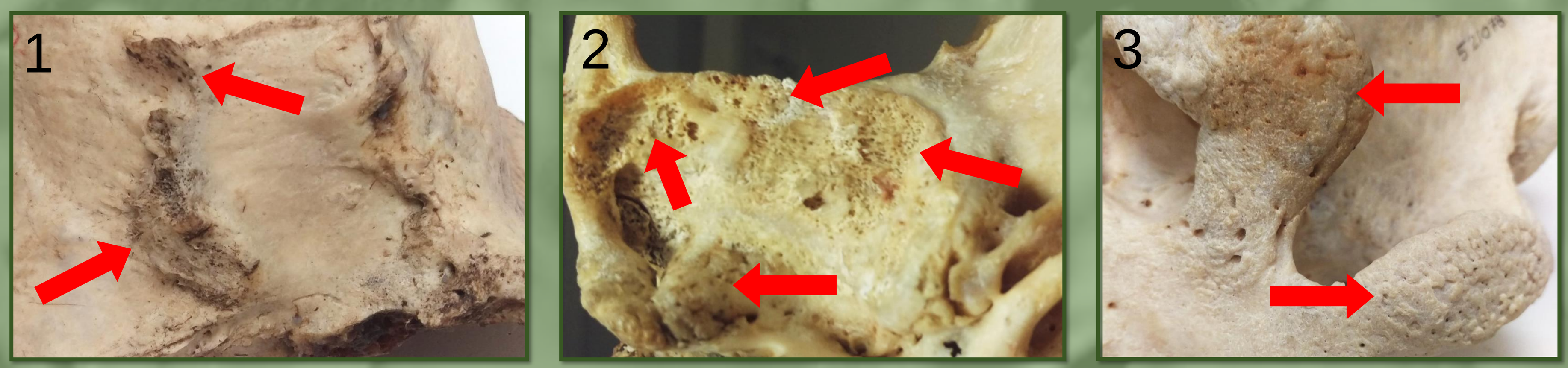
Graph 1. Comparison of calculus and pathology frequencies (%) between wild and captive groups.

Figure 2. Severity scale for calculus presence



(1) Minimal degree of calculus on incisors, scored as a 1. **(2)** Small amount of calculus on a canine, scored as a 2. **(3)** Moderate amount of calculus on incisors, scored as a 3. **(4)** Severe amount of calculus on premolars, scored as a 4.

Figure 3. Severity scale for pathology presence



(1) Minor pathology on left posterior parietal, lateral to sagittal suture, scored as a 1. **(2)** Moderate pathology on right mandibular fossa (the joint of the jaw), scored as a 2. **(3)** Severe pathology on left lateral orbit and left zygomatic arch, scored as a 3.

Future Directions

Within the total sample, only a minority exhibit pathologies, while slightly more than half present calculus (62% of all apes). Among the total sample, a small minority of them were of captive status (n=21 captive, n=249 wild). However, captives have a larger proportion of pathology and calculus than their wild counterparts (**Graph 1**). To examine the relationship between these main variables more precisely, further research with larger sample sizes of captive specimens are necessary.

Modern apes live in human managed captive locations. Likewise, modern humans live in our own self-imposed captivity. The advanced technology that is the defining characteristic of our society now allows individuals to live longer with diseases or injuries, that in the past would have shortened their lifespans. Medical intervention in captivity allows for individuals with fatal illnesses or injuries to live longer, therefore allowing the illness to manifest to more severe stages (**Figure 4**). Whereas in the wild, illnesses are more likely to kill individuals before they can advance to the dramatic stages seen in captive specimens.

This survey is a part of a larger parent study titled, EMPHASIS: Environmental Mismatches in Primates and Humans: Anthropogenic Settings and Impacts Survey, created by Andrea Eller (6). The overarching goal of the project is to examine the effects of an anthropogenic environment on primates—including humans. To do this, researchers are comparing the health profiles of captive apes, monkeys, and humans to those of wild apes, monkeys, and humans. The portions of the health profile that the researchers are focused on are the oral microbiome, growth and development, and skeletal pathology. Researchers, like myself, hope to discover how primates have been affected by human-constructed environments and create an understanding of the health effects anthropogenic environments can produce in all primates, including humans. As a portion of this larger study, the data collected during this survey will be used to help EMPHASIS further investigate the differences between captive and wild primates.

Figure 4. Wild versus captive orangutan specimens:
Left: A wild, juvenile, male orangutan, approximately 7 years old (USNM #143595).
Right: A captive, juvenile, male orangutan, also roughly 7 years old. Specimen has enlarged cranium, dental abnormalities, and mild porotic hyperostosis (3) (USNM #273165).
Photo credit: Smithsonian Institution

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