

## Three-Dimensional Analysis of Reindeer Antler Regeneration using Stereophotogrammetry

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### Abstract

Reindeer antlers are the only mammalian organs that completely regenerate. The goal of this project was to define growth characteristics of the antler during regeneration. The regions of the antler found to have the highest growth rates would indicate the regions that are enriched with growth factors that control antler regeneration. The determination of these growth factors could lead to advances in regenerative medicine.

Antler growth rates in three reindeer were determined using stereophotogrammetry. Using two cameras, simultaneous images of the antlers were taken over 6 weeks. Markers with known coordinates were used to calculate the orientation parameters of the cameras. Distinct antler points were chosen in both images, and a least squares solution of the collinearity equations was used to calculate their 3D coordinates. Distances between points were compared between data sets to determine growth rates of portions of the antlers.

The results from both antlers of one reindeer are available with the following level of precision. The variances of the calculated distances were found to be at the millimetre level, with standard deviations at the centimetre level. Distances from the antler base to branching points remained relatively constant suggesting that growth occurs almost exclusively at the antler tips. The growth rates of the tips remained at approximately 0.5-1 cm of daily growth. However, the growth rate of the lowest branch tip began to decelerate by the end of the study.

Although this method had only the previously mentioned level of precision, this does not threaten the conclusions made. The results define the locations of highest growth, which could be used in the study of the growth factors controlling regeneration. If this project were to be repeated, changes could be made to improve accuracy, including placing visible markers on the antlers so that consistent points could be chosen.

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### References

1. Luhmann, T., Robson, S., Kyle, S. and Harley, I., Close Range Photogrammetry, Principles, Methods and Applications. Whittles Publishing, Caithness, UK, 2006. pp.(56-57; 59-67; 114-119; 202-203; 204-205; 212-213; 217-222; 234-236).