by Adam F. Smith

Photogrammetry for Wildlife Data Collection–A 'non-invasive' method for measuring deer antlers

Gathering information about physical traits in wildlife, such as horn length or body sizes, is commonly done by measuring live-captured or deceased animals. Photogrammetry—extracting real-world measurements from photographs—makes it possible to do this without capture or mortality.

Europe's largest enclosed city park is 707 hectares (1,750 acres) of rolling meadows, pine and oak woods and hidden glens. The Phoenix Park is a green blanket woven into the cityscape of Dublin, the capital of Ireland. It holds a significant population of wild, free-living fallow deer. They were introduced to the park in the 1660s by the Duke of Ormond, for hunting, and today they hold a significant place in the culture and ecology of modern Dublin.

Over recent decades, behavioral studies have been conducted in the park, and now long-term monitoring of the animals is led by Dr. Simone Ciuti and the University College Dublin Laboratory of Wildlife Ecology and Behavior. Since nearly every deer in the Park is ear-tagged at birth, it is possible to study individuals over their entire life spans. This presents an unmissable opportunity to trial new methods in wildlife monitoring.

Amid the wealth of behavioral data available from Dublin's fallow deer was the reality that we had no way to measure the antler sizes of individual bucks. Good science is often limited by what one does not or cannot know, so we asked ourselves: Are deer antlers important enough that we need this information?

The answer has many levels rooted in evolution, ecology and animal behavior. Antlers evolved primarily as weapons and ornaments for contests, as males compete to display their fitness to rivals and mates. Antlers are a product of sexual selection, a process contributing to the overall fitness of an animal through its mating success.

As true bone, antlers take immense investment to grow and re-grow every year. If a male deer can do so, it signals his health and quality to other animals, and tells us researchers something about the resources available in his environment. Poor food and parasites should affect animal fitness, thereby affecting antler size and mating success.

In a study led by PhD student Laura Griffin, we are quantifying the general public's fascination with feeding the wild deer in the Phoenix Park, which could directly affect health, fitness and, importantly, antler size. For these reasons, we decided to prioritize measuring the antlers of Phoenix Park fallow deer.

Pinch points

Researching large wild mammals involves a number of pinch points for collecting data, based on what is ethical, reasonable and affordable. Common opportunities for data collection in wildlife research include animal captures and animal deaths; both allow us to gather data about the physical features of the subject—in this case, the information we were missing on our Phoenix Park deer. We can observe the antlers, but we cannot measure them on a free-ranging wild animal.

Animal deaths, both natural and human-influenced, provide data anchored around the time point when the animal died. Although this information is relevant for that moment, it fails to be as useful for studies done over many years on the same individuals. Since fallow deer grow and shed a new pair of antlers every year, antler size at death captures just a small data point—an unfortunate and literal "dead end." So we had to explore other avenues for measuring antler.

Could we catch the deer? Nearly all animal captures involve collecting genetic samples or body measurements. In most circumstances, this would be an ideal opportunity to measure antlers, too. The animal is then released back into its environment. Unfortunately, the expense of doing this—in time, money and people-power—is substantial and goes up with every capture.

As well, capture is undoubtedly an "invasive" method for antler measurements; the stress could potentially bias animal behavior and health. Then, in the subsequent year post-capture, the antlers would be shed and regrown, leaving us empty-handed unless we once again captured the deer. We quickly understood that we had to be more imaginative to get our measurements.

(It is possible to measure shed antlers each year, but finding and then linking them to an individual deer is problematic, to say the least. This is true even in a park such as ours, where collecting antlers is a competition between park staff and thousands of locals and their curious dogs! As well, there can be many weeks between the first and last shed. The other advantage of photogrammetry is that photos can be taken before the rut, when antlers may be damaged.)

Developing a method

We learned of research that used cameras with laser pointers to essentially put a scale on the horns of Alpine ibex. Two lasers attached to a camera projected two points of light onto the horns, which then appeared in photographs. Knowing the distance between the laser dots—in this case, five centimetres, 1.97 inches—made it possible to “interpret” the size of the horns. Measuring real-life objects in photographs this way is known as photogrammetry, and lasers are just one approach.

The laser-scale method and others have been sparsely applied in wildlife research to measure the body sizes of dolphins and seals, elephants and gorillas. Deer have been a focal point for research in animal behavior and ecology, and they are also a key group for management of hunting in certain areas. Interestingly, we found no application of photogrammetry for measuring free-ranging deer antlers or body sizes.

From this basis, we developed our own photogrammetry method. The size of an object in a digital photograph in pixels can be converted to centimetres. Since this changes over distance, we used a handheld laser rangefinder to determine the exact distance from the camera to the subject. Pixel size in a digital image can also be measured easily on a computer with software like Adobe Photoshop.

Now we could a) photograph a subject of known size; b) measure the distance to it with our rangefinder; c) count pixels in the image on the computer; and then d) combine these findings to calibrate the equipment. To do so exactly, we took a photograph of our known subject every five metres (16.4 feet) out to 200 metres. Then we could determine how many pixels correspond to a centimetre of object dimension at any distance.

But it’s not that easy

Simultaneously, we discovered some methodological considerations before we could apply photogrammetry to fallow deer antlers. First, the photo subject has to be perpendicular to the camera so that no variation is introduced by tilting the subject toward or away from the camera. Happily, deer, like many herbivores, often stand laterally to observe objects of interest, which gives us a clear, perpendicular photograph of the antlers. The bigger problem is that deer antlers are not straight, even when viewed perpendicularly. Thus photo measurements of antler length and width move in and out in three dimensions as they follow the morphology of the antler.

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With an antler in hand, this curvature is no problem—a flexible tape measure follows the curves nicely. However, an antler in a photograph is flattened to two dimensions, which biases the 3-D measurement. This prevents direct comparisons of hand to photogrammetric measurements. A photo cannot provide the true dimensions of an antler; it always under-measures because it cannot follow the curvature of the bone.

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A “fallow buck” posing for the camera. Note the significant three-dimensional curvature of the antlers, which has to be corrected for in photogrammetry. Author’s photo

In order to bridge the gap, we analyzed the differences between hand and camera measurements. Instead of capturing and “invasively” measuring a number of fallow bucks, we gathered and hand-measured an abundance of deer skulls. Then we mounted each one onto a tripod, which became our “free-ranging” deer. Next, we photographed the antlers at random distances, as in real field scenarios. Finally, with both sets of dimensions in hand, we could calculate the differences between them. With a little bit of statistical coercion, these calculations allowed us to correct for the underestimation bias introduced in a two-dimensional photograph. This resulted in average errors of less than 5%. In real terms, this is less than three centimetres on an antler of 60 centimetres (23.6 inches), even when photographed from more than one hundred metres (109 yards) distance.

Since we had skulls from dozens of roe deer too, we also applied the method to those antlers. Due to their relatively simple shape compared to fallow deer antlers, the results were even more accurate, often varying only by millimetres.

Application

With the methodological experiment concluded, we began field application in the Phoenix Park. We photo-measured hundreds of antlers on individual deer, collecting accurate and valuable data for our behavioral work without disturbing the animals, at a fractional cost and over a small number of days.

Now, with measurements from three seasons of antler growth, our dataset is growing and has the potential to fill knowledge gaps and answer new questions in behavioral ecology. Even without attributing measurements to specific animals, it’s possible to estimate the average size of traits in a population by sampling enough individuals.

Our other goal to bring this photogrammetry technique forward and put it in the hands of other researchers and wildlife managers for accurate, non-invasive and collaborative research in deer and other species.

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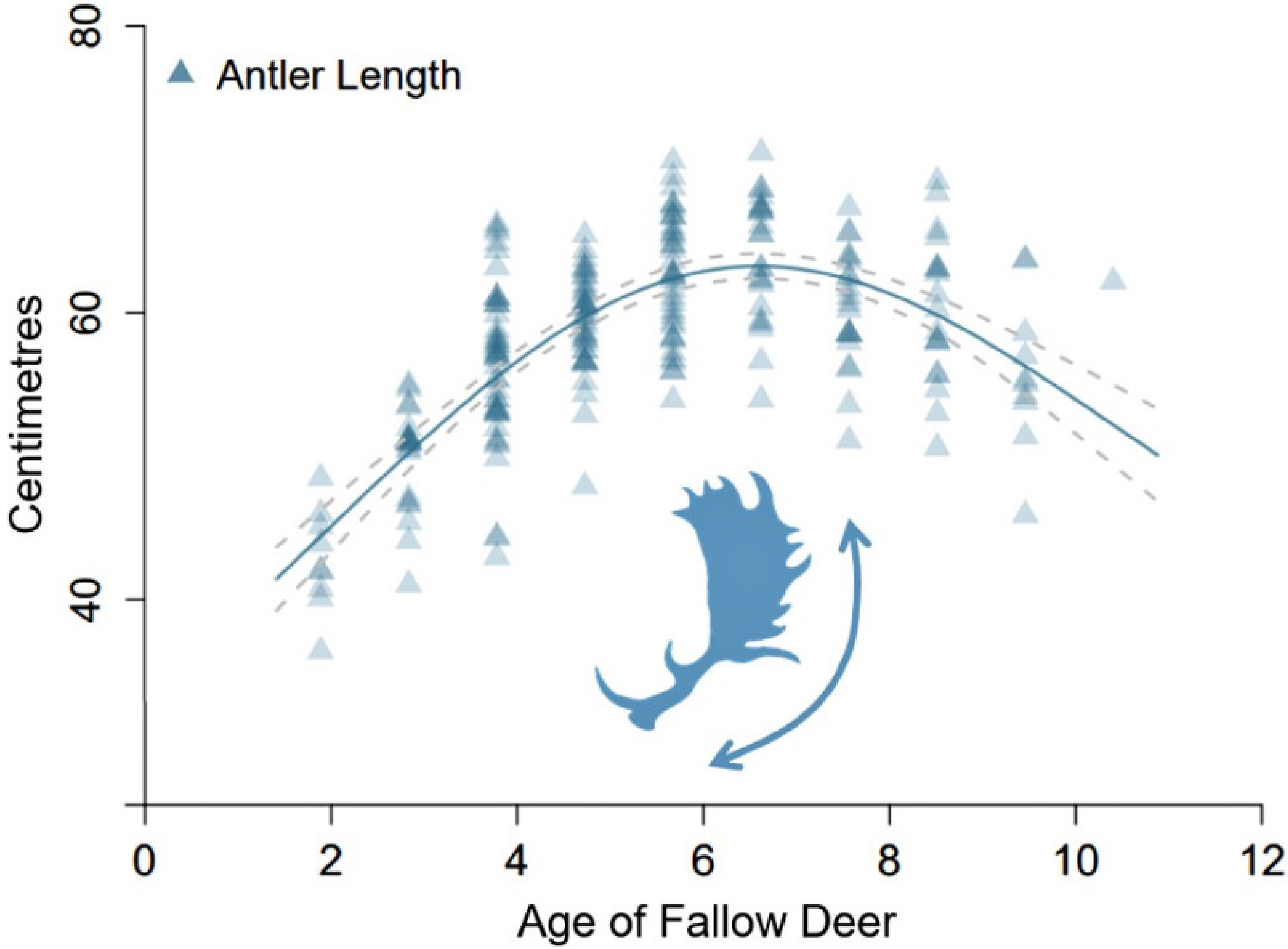

It is important to stress that the technique is not limited to antlers. Photogrammetry can be adapted to other key traits, such as shoulder height and neck and body width, which may tell us even more about animal condition. We plan to establish a system for non-invasive collection of such measurements of the Phoenix Park fallow deer to give us new insights into how behaviors are linked to body size. This is important because antlers are not the only thing contributing to males securing females during the mating season.

Our new system will also showcase the adaptability and applicability of photogrammetry as a way to fit more pieces into the puzzle of wildlife ecology and behavior in our modern human-dominated landscapes, which interests everyone who studies or manages free-living animals.

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Basic photogrammetry for practitioners and scientists

Photogrammetry is applicable by anyone with minimal equipment. Here are a few pieces and steps to the basic process.

Equipment

- *Digital camera with a 200/300/400mm lens*
- *Laser rangefinder*
- *Camera tripod*
- *30-centimetre ruler*
- *Computer with image manipulation software (e.g., ImageJ, GIMP, Photoshop)*

Calibration

- *Lock the camera lens at your chosen focal length. (Focal length determines how big an object appears in photos; for accurate results, it must be kept constant.)*

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- *Find a large flat, open space such as a sports field.*
- *Mount the ruler vertically—we attached it to a utility pole, as above—in such a way that the camera can see it. Set the midpoint of the ruler at the same height above the ground as the camera.*
- *Starting at 20 metres or more, depending on the focal length of the lens, and with the camera on the tripod, photograph the ruler at 5-metre intervals, measured by the laser rangefinder, out to the maximum distance at which you expect to be working in the field. (We moved the camera, not the utility pole.)*
- *Open the photographs on the computer in the image manipulation software.*
- *With the tool in the app (refer to the user manual if need be), measure the size of the ruler in pixels.*
- *Divide the ruler length by the pixel size at each photo's distance; this gives centimetres per pixel at the given distance. This relationship can be shown graphically in Excel or other spreadsheet software.*
- *Repeat photographs and measurements and average the results to sharpen your calculations.*
- *It is now possible to measure straight objects photographically when the distance to the object is known.*

For further application to curved objects or for queries or help, refer to our paper or contact @AdamFSmith / @UCD_Wildlife / adam.smith@fzs.org

Adam F. Smith is a PhD student with the Frankfurt Zoological Society; he conducted this work as part of his Master's thesis at University College Dublin.

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Banner image: A free-ranging Phoenix Park fallow buck and a tripod-mounted skull. Author's photo

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