

General Articles

The design and use of a device to detect deer pedicle growth

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Abstract

The design, construction and use of a device to detect changes in deer pedicle volume are described. The device is highly sensitive for detecting the initiation of pedicle growth. Between-sample differences of 170 mm³ in the pedicle volume of live deer were detected (triplicate measurements) using the detector; these correspond to a change in height of the pedicle of at most 0.67 mm. The within sample coefficient of variation was 1.4%. The pedicle growth detector enables more precise measurements to be obtained for identifying the onset of pedicle development to the nearest week than is currently possible with palpation.

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Introduction

In the study of deer antler development, it is often necessary to know the precise time a pedicle (the permanent bony protuberance from which an antler will grow and cast) begins to grow from the frontal lateral crest. Whether or not a pedicle has begun to grow has previously been judged by palpation or observation of development⁽¹⁾⁽²⁾⁽³⁾⁽⁴⁾⁽⁵⁾. Regardless of the experience of the operator, it is very difficult to judge by palpation or observation whether, in the very early stages of growth, a pedicle has begun growing, because the size of the lateral crest of deer calves varies, and because touch is not sufficiently sensitive to detect a change in height of a millimetre. It is our experience that when the height of the crest or pedicle is less than 5 mm there is virtually no way to tell if pedicle development has begun, but most pedicles higher than 5 mm are thought to have been developing for a minimum of 2 months (unpublished observations). In order to solve this problem, we have designed a pedicle growth detector.

Basic Principle of the Design

The detector is required to have two main functions: to set baseline parameters for each individual's lateral crest prior to pedicle growth; and to detect crest height changes at the initiation of pedicle growth of at least 1 millimetre.

We observed that the cranial surface area of each crest is reasonably large; hence a small change in the height of a slow-growing pedicle will be magnified in its change in volume. If we can transduce this change in shape (large area and short height) to a measurable

form (small area and large height), we will be able to detect small changes in height of the crest very precisely. For this purpose we chose water as a medium to measure the shape of the crest or newly formed tissue. The advantages of using water are that it is a liquid which changes shape easily, its volume is not sensitive to temperature in operational conditions of 10-30 °C and it has a low viscosity. If the change in volume between consecutive measurements is statistically significant we will infer that the pedicle being measured has begun to develop.

Materials

The following materials are required to build each component of one pedicle growth detector suitable for red deer (*Cervus elaphus*).

1. To construct the fluid reservoir container: A stainless steel tube of i.d., 30 mm; o.d., 32 mm; length, 48 mm. A stainless steel cap with two holes: centre hole tapped $\frac{1}{8}$ " B.S.P.; peripheral hole, 7 mm in diameter. A brass tube: i.d., 6 mm; o.d., 8 mm; length, 10 mm. Three 13 mm long brass leg holders: a large one, i.d., 10 mm; o.d., 16 mm; two small ones, i.d., 3.5 mm, o.d., 10 mm. Each leg holder has a threaded hole. A long machine screw: 40 mm in length and 3 mm in diameter required to hold the balance weight (Figure 1).
2. To construct the legs: A dial indicator, for ensuring the pressure placed on each leg is constant at each measurement (Mitutoyo, Series 2 inch, graduation = 0.001", 1 revolution = 0.1", total travel = 0.4", P/No. 2412-08). Two stainless steel rods: 3.2 mm in diameter, 38 mm in length. Each of them must be threaded at the upper end to permit the attachment of a hexagonal stainless steel nut and at the lower end to permit twice the thickness of a nut to be attached to allow the ball end to project from the leg. Two knurled lock screws: 10 mm in length; 3 mm in diameter. One machine screw: 10 mm in length, 3 mm in diameter. Three light springs (Figure 1).

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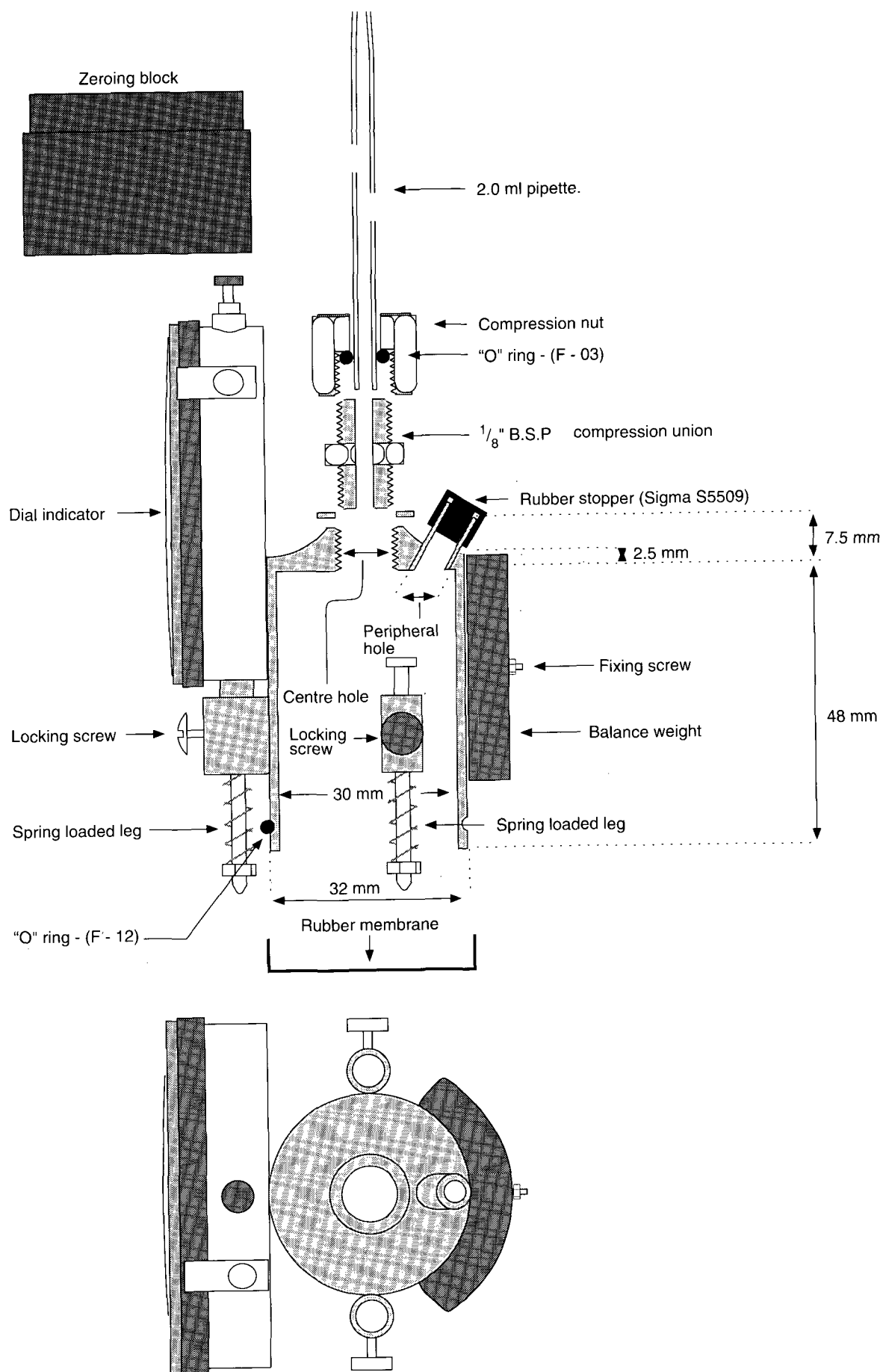


Figure 1. Diagrams of the zeroing block, a vertical section of the components for the detector, and a plan view from above the detector.

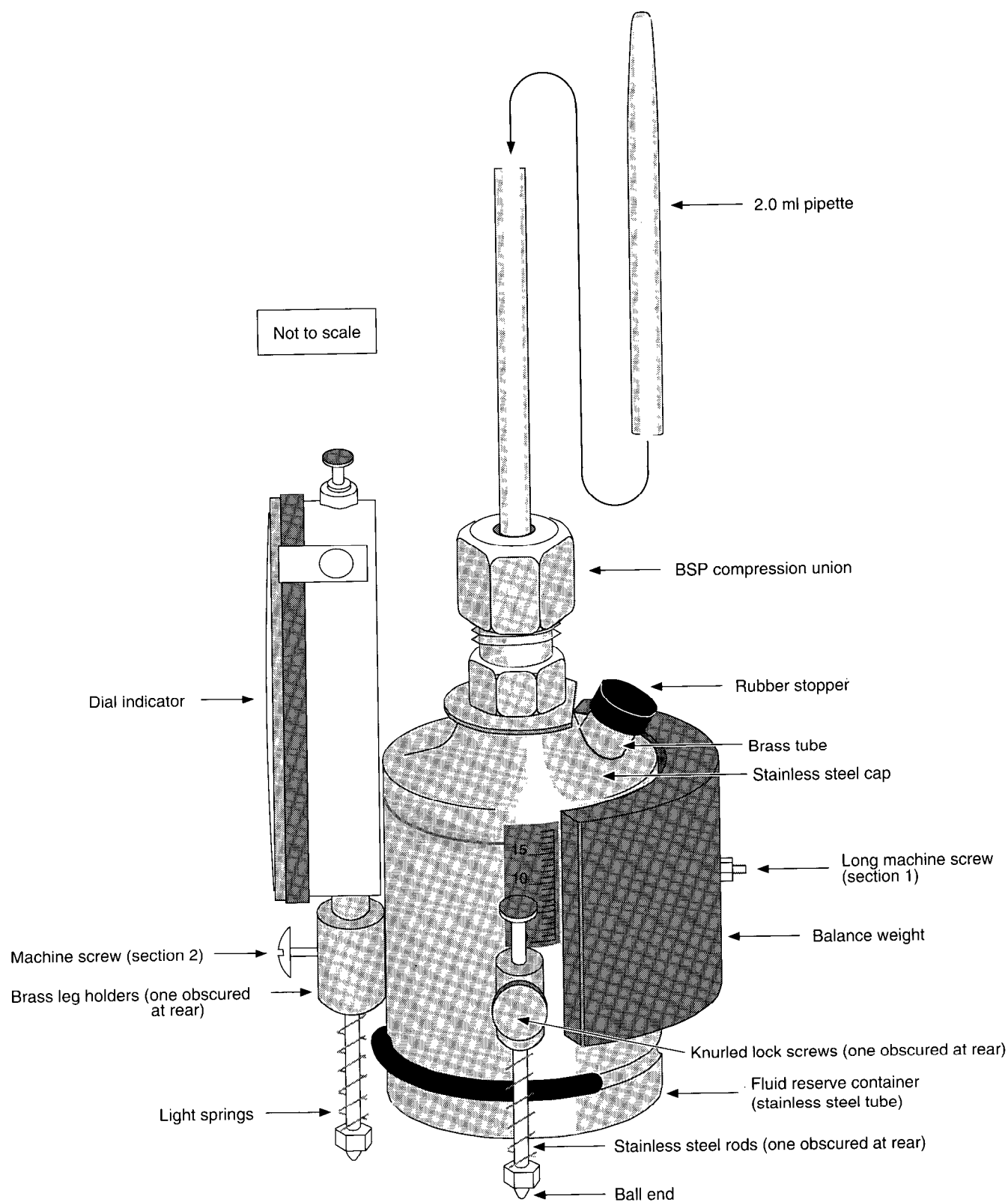


Figure 2. Drawing of the detector.

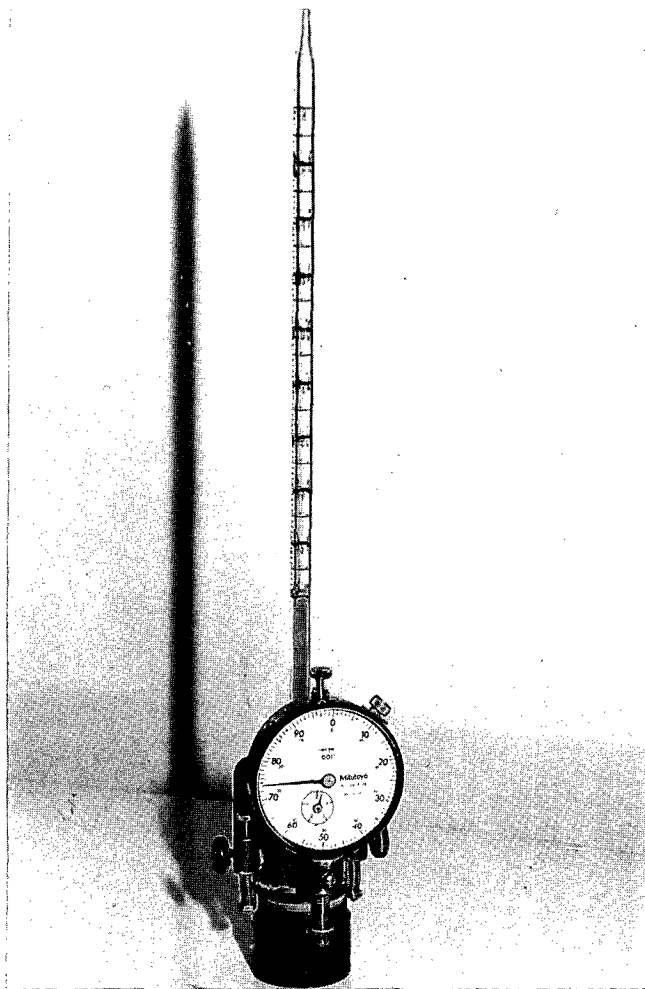


Figure 3. The detector on the zeroing block.

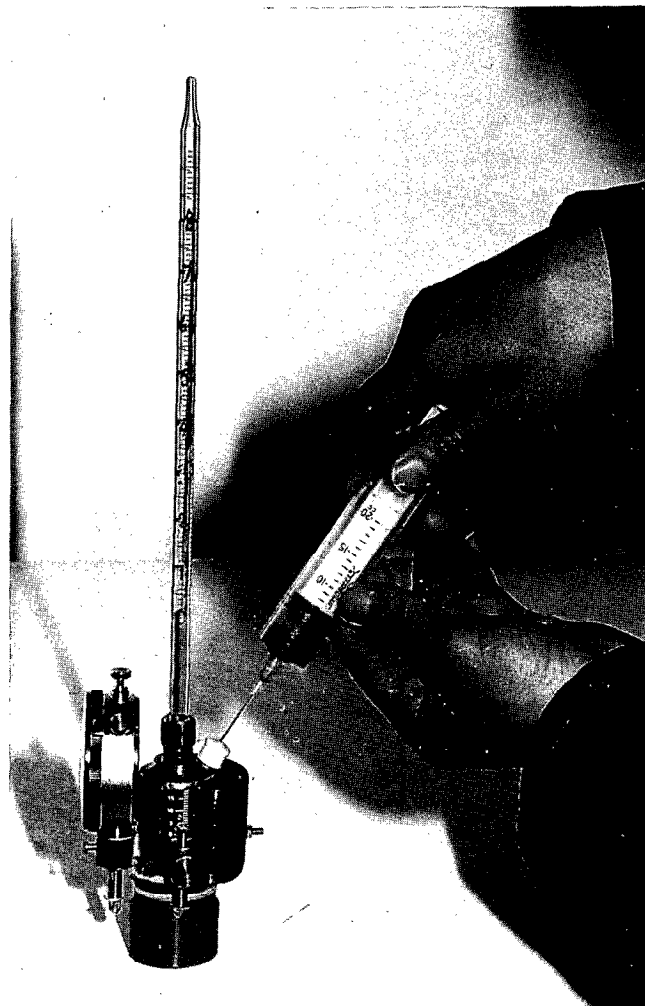


Figure 4. Adjustment of the water level in the pipette.

3. To hold the pipette: A $\frac{1}{8}$ " B.S.P. compression union and a compression nut (Paykel Engineering). A 2 ml pipette, graduated in 0.1 ml increments which each correspond to a linear measure of 1.0 cm (Silberbrand, W-Germany). A small "O" ring (F-03): i.d., $\frac{1}{4}$ "; o.d., $\frac{3}{8}$ "; section, $\frac{1}{8}$ ".
4. To seal the lower surface of the container: A piece of rubber membrane taken from surgical gloves (Ansell Gammex): 50 mm in diameter; 0.25 mm in thickness. An "O" ring (F-12): i.d., $1\frac{1}{16}$ "; o.d., $1\frac{3}{16}$ "; section, $\frac{3}{8}$ " (Paykel Engineering) or a rubber band.
5. To block the hole in the brass tube: A rubber stopper, Size 6 mm (Sigma S5509).
6. To zero the detector: A plastic (PVC) block, 35 mm in diameter; 27 mm in height.
7. To balance the detector: A 170 g lead balance weight encased in a cover made from a segment of mild steel tube (52 mm in diameter), capped on each end to contain the sheet lead weight. A hole was drilled through the weight at a height to match the size of the container and was attached to the container.
8. The water was coloured with 0.005% methylene blue to ease observation.

Note: All parts mentioned above can be replaced with other more readily available materials and the sizes can be changed according to the deer species studied.

Construction

1. Weld the cap to the upper side of the stainless steel tube (or alternatively tap the tube and cap). Weld the brass tube to the rim of the peripheral hole of the cap. Weld the three brass leg holders and the long machine screw to the outer surface of the stainless steel tube to make a container. Mark calibrations on the container over the two small brass leg holders respectively as shown in Figure 1.
2. Make a groove in the lower side of the container (Figure 1).
3. Screw the compression union into the centre hole of the cap (use thread tape and a copper washer to seal).
4. Insert the lower tip of the pipette into the compression union. Place the small "O" ring on to the lower tip of the pipette. Screw the compression nut tightly on the union.
5. Assemble the three light springs on the three legs of the indicator and the two stainless steel rods. Put the three legs into the three leg holders separately. Put the machine screw and the two knurled lock nuts on to the three holders (Figure 1).
6. Mark the numbers on the three legs: Mark the indicator leg as No. 2, the leg to the left of the indicator leg as No. 1 and the other as No. 3.



Figure 5. Three points on a young red deer stag's head on which the three legs of the detector stand. The markers a, b and c, are for legs 1, 2 and 3 of the detector respectively.

7. Fix the rubber membrane on to the bottom of the container with the big "O" ring or the rubber band (Figure 1).
8. Insert the stopper into the brass tube.
9. Use a syringe and needle to fill the container with blue water through the rubber stopper.
10. Place the detector on the plastic zeroing block and adjust the water level inside the pipette to the zero position with the syringe.
11. Attach the balance weight on to the container through the long machine screw and fasten the hexagonal nut on the screw to hold the weight (Figure 1). The completed detector is illustrated in Figure 2.

Detection Procedure

1. Place the detector on the zeroing block (Figure 3). Use a syringe through the rubber stopper to adjust the blue water level in the pipette to the zero point (Figure 4).
2. Restrain the deer, preferably in a crush.
3. Completely shave the antlerogenic region around the frontal lateral crest in a 30 mm radius (Figure 5).
4. Stand on the right side of the deer to measure the left frontal crest/pedicle (Figures 6-8) and the left to measure the right side.
5. Locate the depression on the midline between the orbit and the apex of the crest, and place leg 1 of the detector in the depression (Figure 6).
6. Align leg 3 with the external auditory meatus of the opposite ear and rest it on the scalp, overlying the hard frontal bone (Figure 7).
7. Tighten the two knurled screws of legs 1 and 3 with leg 2 just touching the scalp (the heights of legs 1 and 3 must remain secure for subsequent readings, as these heights will be suitable for all deer whose crest/pedicle heights are lower than 5 mm).
8. Using legs 1 and 3 as a fulcrum, rotate the detector forward until it is about perpendicular to the head (Figure 8). Record the measurement on the dial indicator so that the same pressure will be applied

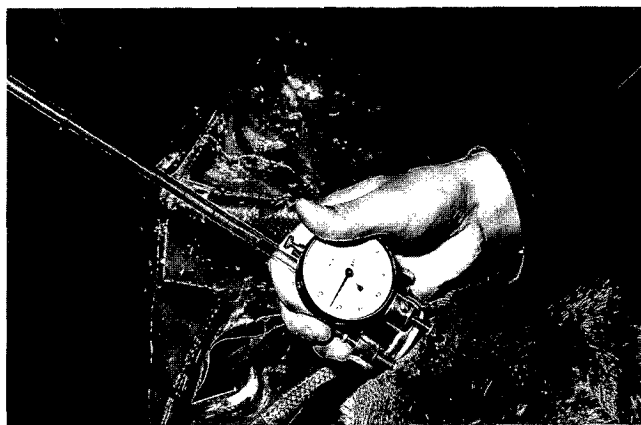


Figure 6. Leg 1 of the detector is placed on the depression on the midline between the orbit and apex of the crest.

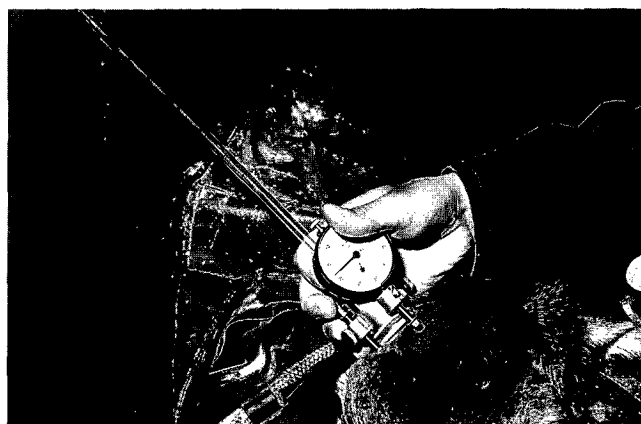


Figure 7. Legs 1 and 3 of the detector rest on the deer scalp with the container of the detector over the crest.



Figure 8. Recording the measurement on the dial indicator and the water level position in the pipette with a pen.

- on the three legs of the detector in subsequent measurements. A second person must record the water level in the pipette (pedicle size is indicated by the water level in the pipette).
9. Mark the point on which each leg stands with a permanent pen or tattoo ink (Figure 5).
 10. Place the detector on the block again to confirm that

the water level in the pipette is still at the zero position.

11. Repeat the procedure with the detector placed in the same level position as previously. Repeat the detection 3-5 times. Record the water level in the pipette each time.

Experimental Testing

The detector was used to detect the start of pedicle growth in nine live male red deer calves from 6½ to 7½ months of age with triplicate measurements at weekly intervals.

A laboratory simulation test using the detector was conducted on the left frontal lateral crest of a frozen 4-month-old male red deer head. Seven plasticine disks of varying volumes over the required range, with no plasticine as a control, were moulded to the site and located in a marked position to simulate a growing pedicle. The eight treatments were applied in a randomised block experiment, with four replicates and two subsamples for each treatment within each replicate. The plasticine was relocated for each sample (between replicates), but not for subsamples; the detector was rested on the zeroing block between subsamples. Measured volumes were related to actual volumes, obtained from weight and density calculations, by linear regression.

Results

The volumes of the lateral crests and pedicles of both sides of live red deer calves measured by the detector followed a pattern. Firstly there were low amplitude fluctuations of $\pm 120 \text{ mm}^3$ about a stable level (which varied among pedicles from 460 to 1610 mm^3) followed by a sharp increase in volume of at least 190 mm^3 (median = 406) and finally there was a period of continued growth over several weeks. This increase in volume corresponded to the early growth of the pedicle which rapidly exceeded the scale of the detector. Each measurement thus could be assessed as either pre- or post-pedicle initiation.

Treatment means for the plasticine pieces simulation experiment ranged from 250 (SEM = 3) mm^3 for the control to 1210 mm^3 for the largest simulated pedicle; this range covered most of the volumes of the frontal lateral crest over the period of pedicle initiation. The regression relationship between volumes obtained from the detector (y) and actual volumes (x) was given by

$$y = 295 + 1.51 x$$

(SEM 25) (SEM 0.076)

where SEM is the standard error of the mean

with $R^2 = 98.3\%$ and there was no pattern to the residuals. Thus detector volumes were about half as large again as actual volumes. This may in part be due to the detector measuring the space around the plasticine. It does not compromise the functioning of the detector in any way, since the bias is independent of the magnitude of the volume, so that both changes in volume and their standard errors will be subject to the same scale factor. The scale factor for live deer will be between 1.0 and

Table I. Sample components of variance (S^2), coefficient of variation (CV%), range of observed values (mm^3) and minimum detectable volume change (mdv, mm^3) for detector samples from the simulation and live deer experiments

	S^2	CV%	Range	mdv
Simulation measurements				
Between sample	100	1.0	–	16
Within sample	83	1.5	220-1220	–
Live deer measurements				
Between days within antler ^a	5200	6.7	–	169
Within sample	235	1.4	360-1980	24

^a Pre-pedicle "detection".

1.5 (from the simulation experiment), since the crest has smoother contours than the plasticine on the crest, so the detector cannot be used as a volume meter, but works well to measure changes in volume.

Various components within and between both live and simulated samples, and stratum coefficients of variation are given in Table I. They show a high level of consistency in sample values and a close correspondence between the simulation experiment and the within-sample live data. Within- and between-sample variances were similar in the simulation experiment but different for the live data, suggesting that there are sources of variation in using the detector from week to week on live deer before pedicle initiation which were not modelled in the simulation experiment. A suitable test of pedicle initiation is then to evaluate the mean difference between weeks for each case and if this is greater than the 95 percentile of the t -distribution, based on the between-sample pre-pedicle variance for live deer, to assess that pedicle growth has started. For triplicate subsampling the least detectable difference is then 170 mm^3 . Such a test may be sharpened or confirmed by using information from previous or subsequent weeks, respectively. Given the pattern of initial pedicle growth described above, this suggests that the detector can be used to determine the time at which pedicle development starts to the nearest week, with a 5% chance of wrongly detecting pedicle initiation and a negligible chance of not detecting true pedicle initiation.

Discussion

In recent years, one of the most active areas of antler development research has been the study of the mechanism of pedicle formation, the pedicle being a prerequisite for antler growth. In studies of pedicle formation, an important aspect is to determine the timing of pedicle initiation very precisely. However, palpation is not sufficiently precise and sensitive. Therefore the use of the pedicle growth detector will make possible experiments which cannot be done at present by palpation. The mean area of a red deer pedicle at the time when the pedicle bud first appears is 254 mm^2 ($n=8$; unpublished data) and the minimum volume change which can be detected by the 2 ml pipette detector is at most 170 mm^3 . Therefore the detector can detect a change in pedicle height of 0.67 mm. Currently,

changes in the crest/pedicle height of less than 5 mm at a very early stage of growth cannot be measured by palpation, so the sensitivity of the detector for detecting pedicle development is at least 7.5 times better than for palpation.

Because the detector is so sensitive to volume change, the detection precision will be seriously affected by inaccurate use of the detector. To avoid this, an operator should carefully follow the above procedure, and also know what kind of factors can affect the precision. The precision is mainly affected by the following factors: the three points on which the detector's three legs stand must be marked accurately and each time the three legs must be put on the three points precisely. The hair over the antlerogenic area on which the rubber membrane of the detector rests must be shaved each time the detector is used.

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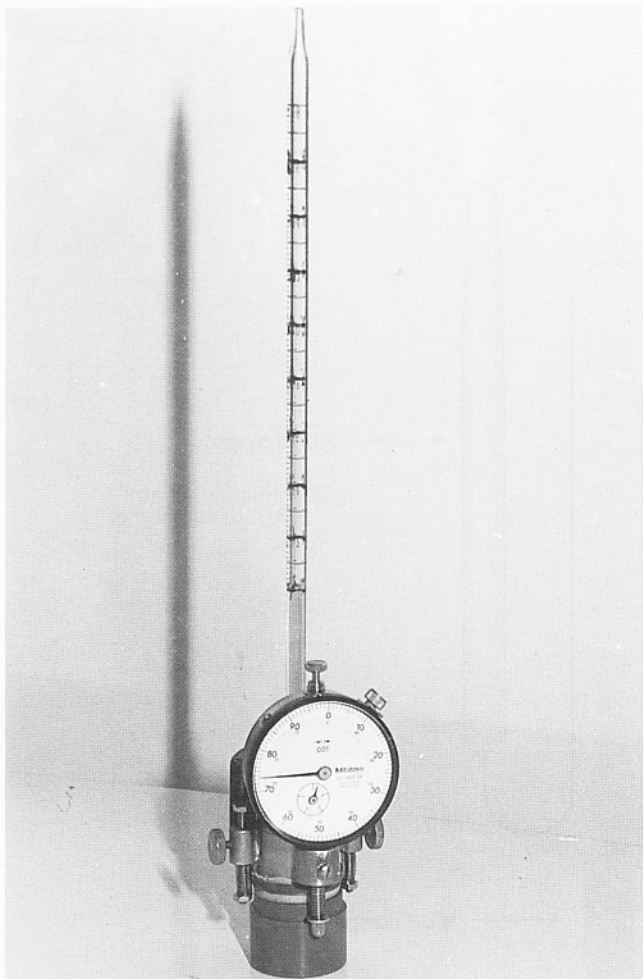


Figure 3. The detector on the zeroing block.

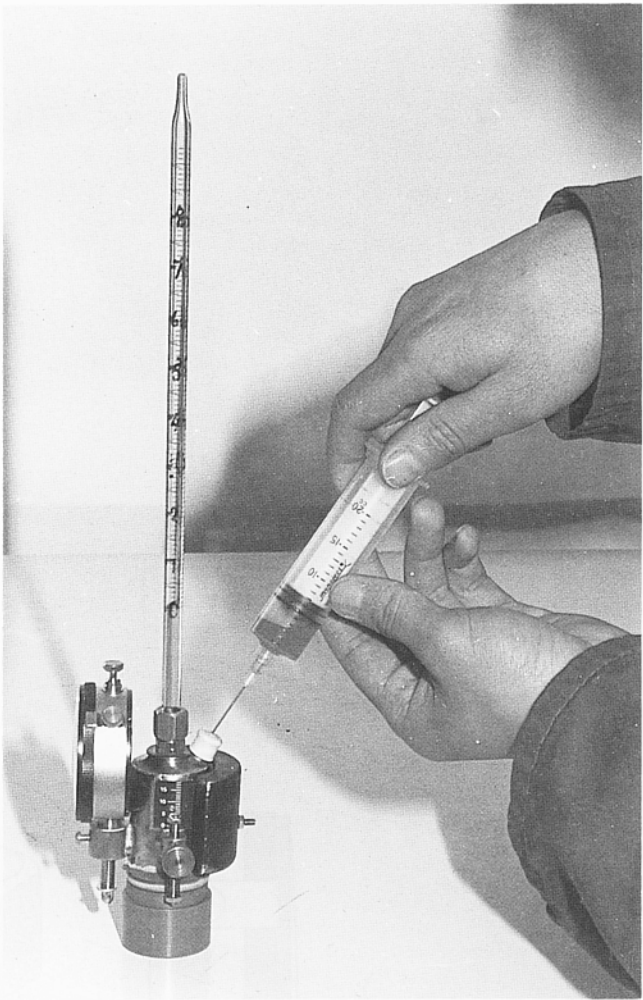


Figure 4. Adjustment of the water level in the pipette.

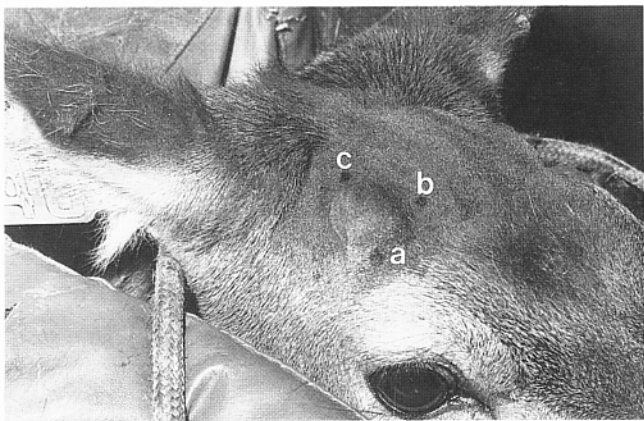


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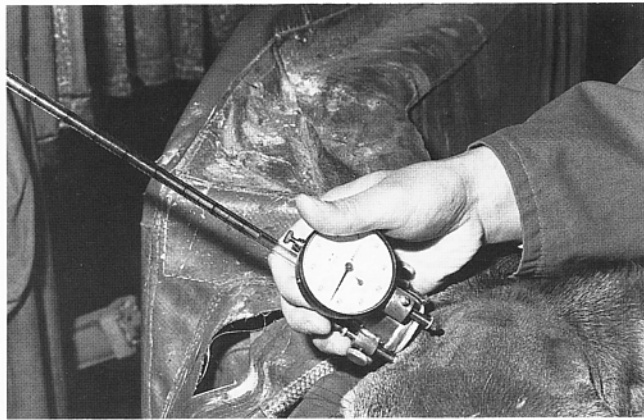


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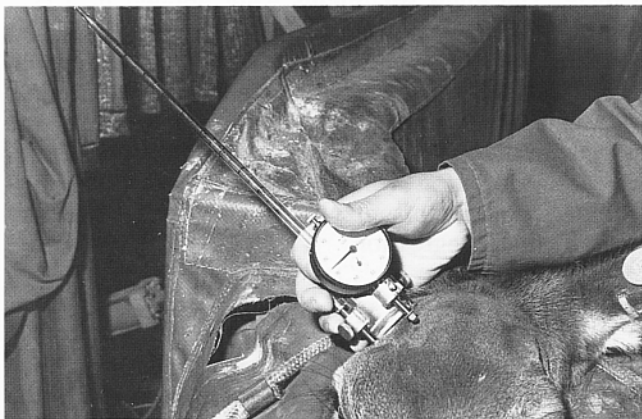


Figure 7. Legs 1 and 3 of the detector rest on the deer scalp with the container of the detector over the crest.

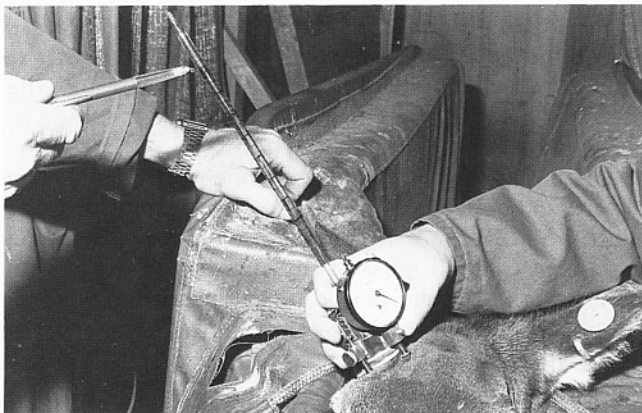


Figure 8. Recording the measurement on the dial indicator and the water level position in the pipette with a pen.