ELECTRONIC APPENDIX

This is the Electronic Appendix to the article

Resistance of flight feathers
to mechanical fatigue
covaries with moult
strategy in two warbler
species

by

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Electronic Appendix A

Supplementary Information to Material & Methods

(a) Mechanical fatigue apparatus

Figure 3 shows a detailed side view of the fatigue apparatus.

During the fatigue session one adjustment to the settings of the apparatus needed to be made depending on the orientation of the clamped feather. The rhachis of flight feather is slightly curved in the ventral direction. As the feather was turned once throughout each fatigue session it was thus necessary to make sure that the amplitude of the displacement remained approximately constant. Therefore the ramp was tilted 45 degress to the horizontal when the feather flection showed upwards and 30 degrees to the horizontal when the feather flection showed downwards.

(b) Bending stiffness test equipment

Figure 4 shows a schematic drawing of the clamping of the feather and the load cell arrangement in the MTS 810 testing machine.

In order to determine the applied load during testing, the strain of the thin steel plate fixed horizontally in the machine, was measured using four foil strain gauges – two on each side – connected in a Wheatstone bridge. This ensured that only forces from the pure bending of the plate are recorded. The deformations were applied by moving the lower cylinder of the testing machine.

Calibration of the load cell –The load cell was calibrated by turning the load cell upside down and by applying a range of known weights (figure 5). We assumed that the relationship between voltage and force was linear for the force range in the tests.

(c) Testing Procedure

Data correction and analysis - In order to measure the stiffness of the feather rhachis the thin steel plate of the load cell needs to bend. This produces a small error of the feather displacement measurement. This error was estimated by replacing the feather with a thick steel plate and by then measuring the force-displacement relationship (figure 6).

The stiffness of the test set-up measured under these circumstances was subsequently substracted from the force-displacement relationship measured from the flight feathers. Furthermore, the output data were forced through the origin. Bending stiffness was estimated as the slope of the least-square linear fit to the data

Feather clamping – The feathers were clamped in the testing machine so that the rhachis bent downwards. This ensured that the load device (see fig. 2) only touched the rhachis and not the vane.

[Figure captions for Supplementary Information]

Fig. 3: The large full circle reprents the circular aluminum disc attached to the axle of the engine. The four small full circles represent the plastic bars that bend the feathers while the disc is turning. The tilted, crossed square to the left represents the ramp to which the clamps for the feathers are attached. Measures are given in *mm*; ϕ represents diameter.

Fig 4: Schematic view of the apparatus used to measure bending stiffness. Measures are given in *mm*.

Fig. 5. Calibration of the load cell with known weights

Fig 6: Procedure to correct measurements for the displacement of the upper, thin steel plate during tests.

Fig. 1

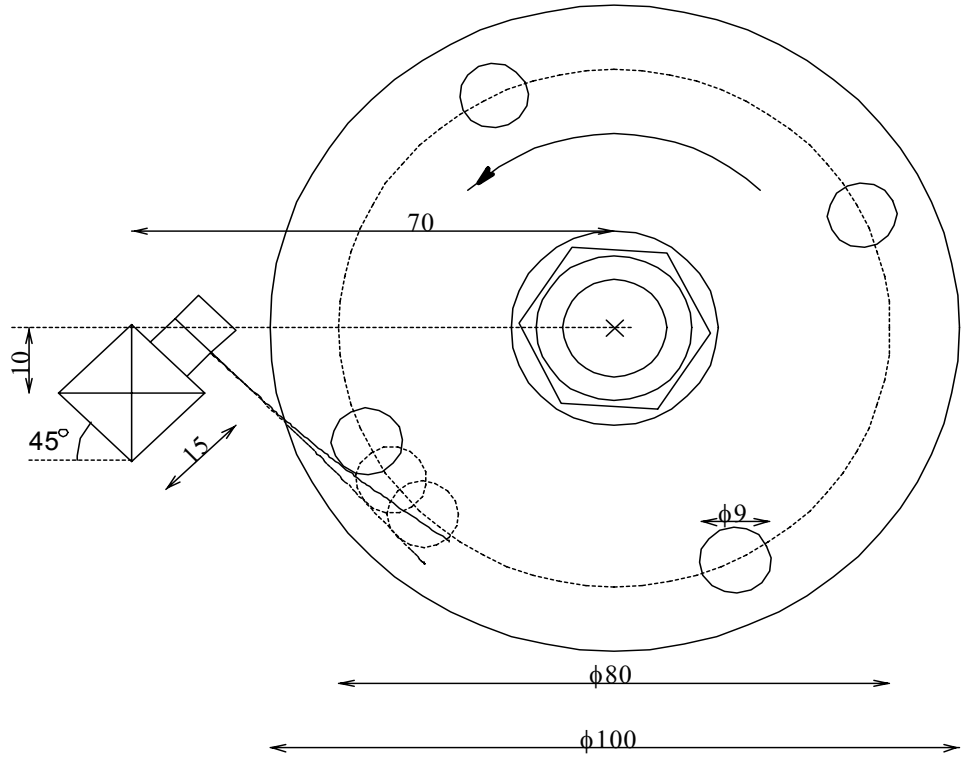
70
10
45°
15
ϕ9
ϕ80
ϕ100

Fig. 2

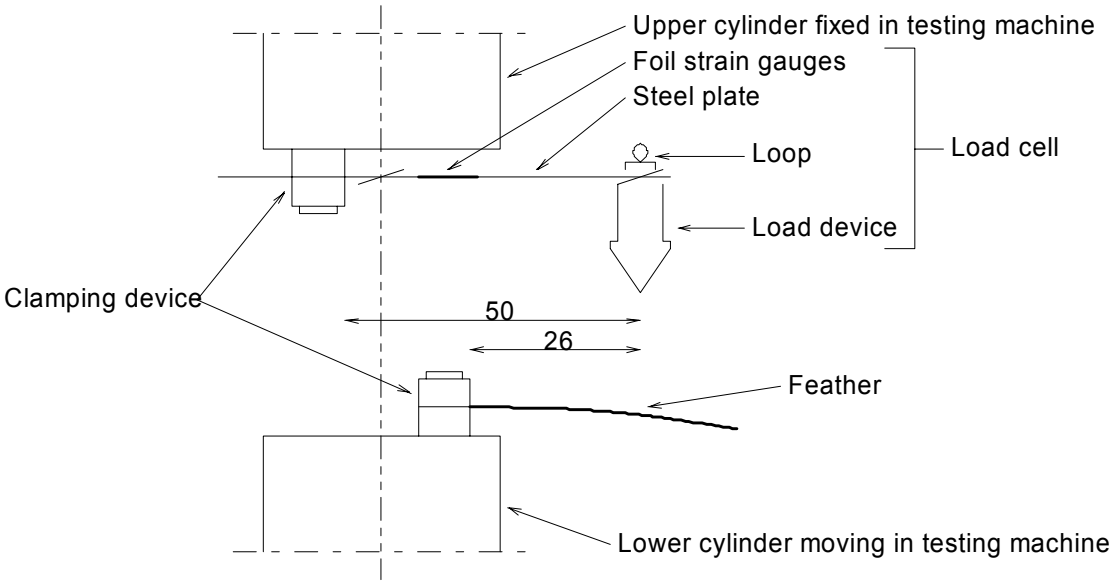
Upper cylinder fixed in testing machine
Foil strain gauges
Steel plate
Loop
Load cell
Load device
Clamping device
50
26
Feather
Lower cylinder moving in testing machine

Fig. 3

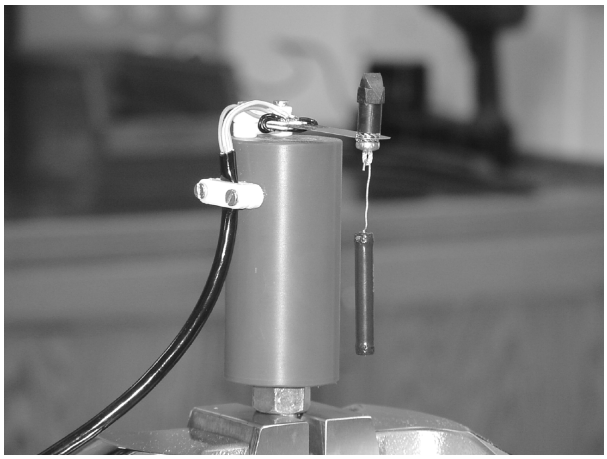

Fig. 4

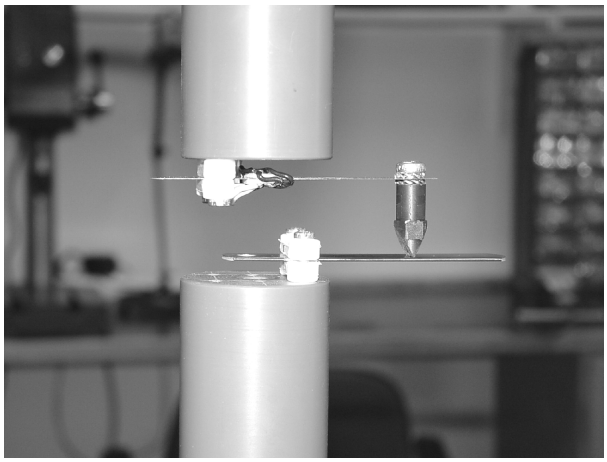

Fig. 5

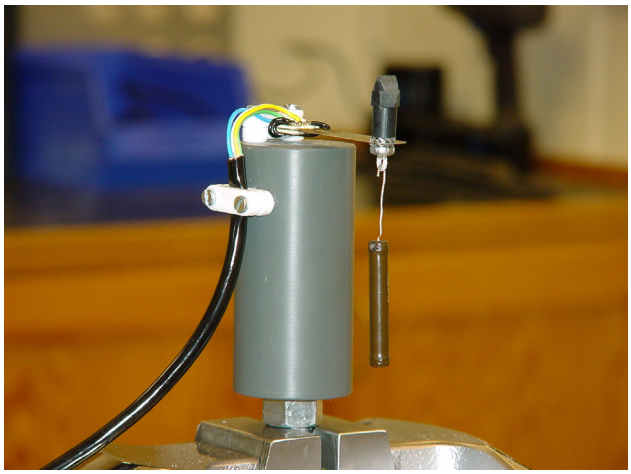

Fig. 6