

## Supplementary Materials for **Penetration mechanics of a beetle intromittent organ with bending stiffness gradient and a soft tip**

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## Supplementary Materials

Table S1. Flexural rigidity of the flagellum of *Cassida rubiginosa*. We measured the flexural rigidity of every second 300  $\mu\text{m}$  sections from the base (position 1) to the apex. Due to variations of the flagellum lengths among individuals treated in the experiment, the number of the measured positions varied among individuals. NA: data are not available.

individual	Measured position																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	NA	1.334×10 <sup>-13</sup>	7.259×10 <sup>-14</sup>	1.765×10 <sup>-13</sup>	3.737×10 <sup>-13</sup>	2.090×10 <sup>-13</sup>	4.850×10 <sup>-13</sup>	3.899×10 <sup>-13</sup>	3.915×10 <sup>-13</sup>	NA	9.655×10 <sup>-14</sup>	1.370×10 <sup>-13</sup>	1.046×10 <sup>-13</sup>	NA	1.220×10 <sup>-13</sup>		
2	1.679×10 <sup>-13</sup>	1.618×10 <sup>-13</sup>	2.282×10 <sup>-13</sup>	6.070×10 <sup>-13</sup>	3.241×10 <sup>-13</sup>	4.298×10 <sup>-13</sup>	5.640×10 <sup>-13</sup>	2.681×10 <sup>-13</sup>	3.194×10 <sup>-13</sup>	1.645×10 <sup>-13</sup>	1.031×10 <sup>-13</sup>	1.458×10 <sup>-13</sup>	1.993×10 <sup>-13</sup>	1.098×10 <sup>-13</sup>	1.805×10 <sup>-13</sup>		
3	NA	NA	NA	2.111×10 <sup>-13</sup>	3.576×10 <sup>-13</sup>	1.417×10 <sup>-13</sup>	2.649×10 <sup>-13</sup>	2.054×10 <sup>-13</sup>	2.646×10 <sup>-13</sup>	1.223×10 <sup>-13</sup>	5.639×10 <sup>-14</sup>	1.529×10 <sup>-13</sup>	9.871×10 <sup>-14</sup>	8.208×10 <sup>-14</sup>	8.350×10 <sup>-14</sup>		
4	NA	NA	6.990×10 <sup>-13</sup>	3.271×10 <sup>-13</sup>	2.576×10 <sup>-13</sup>	7.237×10 <sup>-13</sup>	2.086×10 <sup>-13</sup>	NA	2.079×10 <sup>-13</sup>	1.264×10 <sup>-13</sup>	1.337×10 <sup>-13</sup>	6.628×10 <sup>-14</sup>	7.527×10 <sup>-14</sup>				
5	4.06639E-13	3.924×10 <sup>-13</sup>	1.951×10 <sup>-13</sup>	2.599×10 <sup>-13</sup>	1.937×10 <sup>-13</sup>	4.498×10 <sup>-13</sup>	2.316×10 <sup>-13</sup>	3.621×10 <sup>-13</sup>	1.492×10 <sup>-13</sup>	1.650×10 <sup>-13</sup>	9.734×10 <sup>-14</sup>	2.625×10 <sup>-13</sup>	NA	1.162×10 <sup>-13</sup>	3.905×10 <sup>-14</sup>		
6	NA	2.611×10 <sup>-13</sup>	5.229×10 <sup>-13</sup>	3.082×10 <sup>-13</sup>	3.856×10 <sup>-13</sup>	4.305×10 <sup>-13</sup>	1.462×10 <sup>-13</sup>	1.432×10 <sup>-13</sup>	2.300×10 <sup>-13</sup>	2.320×10 <sup>-13</sup>	NA	1.203×10 <sup>-13</sup>	1.083×10 <sup>-13</sup>	1.195×10 <sup>-13</sup>	1.121×10 <sup>-13</sup>	8.378×10 <sup>-14</sup>	
7	NA	NA	1.658×10 <sup>-13</sup>	3.087×10 <sup>-13</sup>	NA	2.263×10 <sup>-13</sup>	NA	5.451×10 <sup>-13</sup>	3.949×10 <sup>-13</sup>	NA	NA	NA	1.915×10 <sup>-13</sup>	1.151×10 <sup>-13</sup>	1.249×10 <sup>-13</sup>		
8	NA	8.550×10 <sup>-14</sup>	NA	NA	1.778×10 <sup>-13</sup>	NA	2.621×10 <sup>-13</sup>	2.946×10 <sup>-13</sup>	4.032×10 <sup>-13</sup>	3.217×10 <sup>-13</sup>	1.937×10 <sup>-13</sup>	1.558×10 <sup>-13</sup>	NA	NA	1.290×10 <sup>-13</sup>	NA	1.595×10 <sup>-13</sup>
9	NA	1.493×10 <sup>-13</sup>	2.035×10 <sup>-13</sup>	NA	NA	4.342×10 <sup>-13</sup>	2.747×10 <sup>-13</sup>	1.821×10 <sup>-13</sup>	NA	1.349×10 <sup>-13</sup>	1.321×10 <sup>-13</sup>	7.180×10 <sup>-14</sup>	1.616×10 <sup>-13</sup>	1.066×10 <sup>-13</sup>	9.475×10 <sup>-14</sup>		
10	NA	NA	1.991×10 <sup>-13</sup>	3.025×10 <sup>-13</sup>	1.921×10 <sup>-13</sup>	2.162×10 <sup>-13</sup>	NA	2.765×10 <sup>-13</sup>	NA	NA	9.331×10 <sup>-14</sup>	NA	9.090×10 <sup>-14</sup>				

Table S2. Measurements of the flagellum wall thickness of *Cassida rubiginosa*, average  $\pm$  s.d. Unit:  $\mu\text{m}$ .

NA: data are not available. In parentheses, the number of measurements from each region is shown.

individual	Basal	Sub-basal	Middle	Sub-apical	Apical
1	NA	1.13 $\pm$ 0.20 (6)	1.19 $\pm$ 0.29 (5)	1.04 $\pm$ 0.12 (6)	0.84 $\pm$ 0.24 (8)
2	1.17 $\pm$ 0.11 (6)	1.05 $\pm$ 0.16 (11)	0.91 $\pm$ 0.26 (10)	1.05 $\pm$ 0.04 (3)	NA

Table S3. Measurements of the flagellum diameter of *Cassida rubiginosa*, average  $\pm$  s.d. Unit:  $\mu\text{m}$ . NA: data

are not available. In parentheses, the number of measurements from each region is shown.

Individual	Basal	Sub-basal	Middle	Sub-apical	Apical
1	NA	6.01 (1)	6.07 (1)	5.32 $\pm$ 1.18 (3)	4.88 $\pm$ 0.51 (4)
2	6.15 $\pm$ 1.03 (2)	6.03 $\pm$ 0.27 (2)	6.04 $\pm$ 1.24 (3)	5.27 $\pm$ 0.52 (2)	NA