

# Supplementary Material

## Diurnal dung beetles use the intensity gradient and the polarization pattern of the sky for orientation

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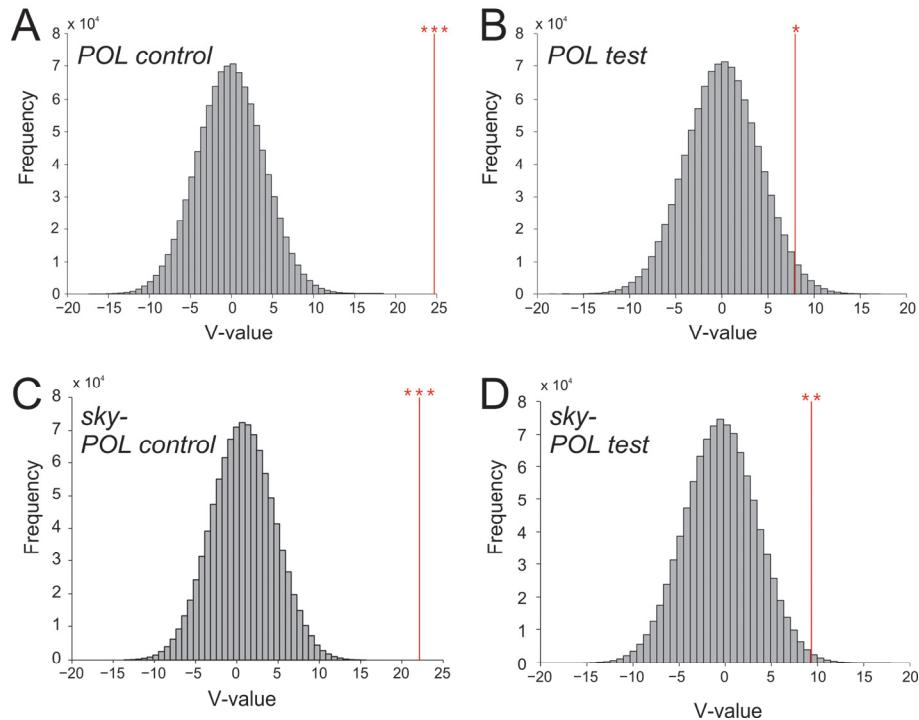


Fig. S1: Permutation tests of the polarized light experiments (see main article, Fig. 3). Measured bearings were randomly permuted across individuals and experimental conditions. The plots show the V-value obtained from 1,000,000 random permutations. Red lines indicate the unpermuted V-values. Probabilities were calculated as the proportion of permutations that resulted in a higher V-value than that obtained from the unpermuted data (equivalent to a one-sided test). \*\*\*  $p<0.001$ ; \*\*  $p<0.01$ ; \*  $p<0.05$ . (A) *POL control* experiment (Fig. 3C). (B) *POL test* experiment with a 90°-turn of the polarizer in between (Fig. 3D). (C) *sky-POL control* (Fig. 3E). (D) *sky-POL test* (Fig. 3F).

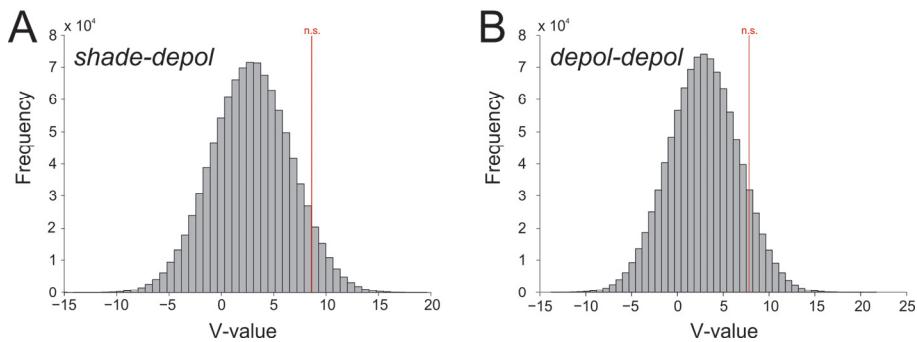


Fig. S2: Permutation tests of the *shade-depol* (A) and *depol-depol* (B) experiments. Measured bearings were randomly permuted 1,000,000 times across individuals and experimental conditions. Red lines indicate unpermuted *V*-values. n.s.= not significant.

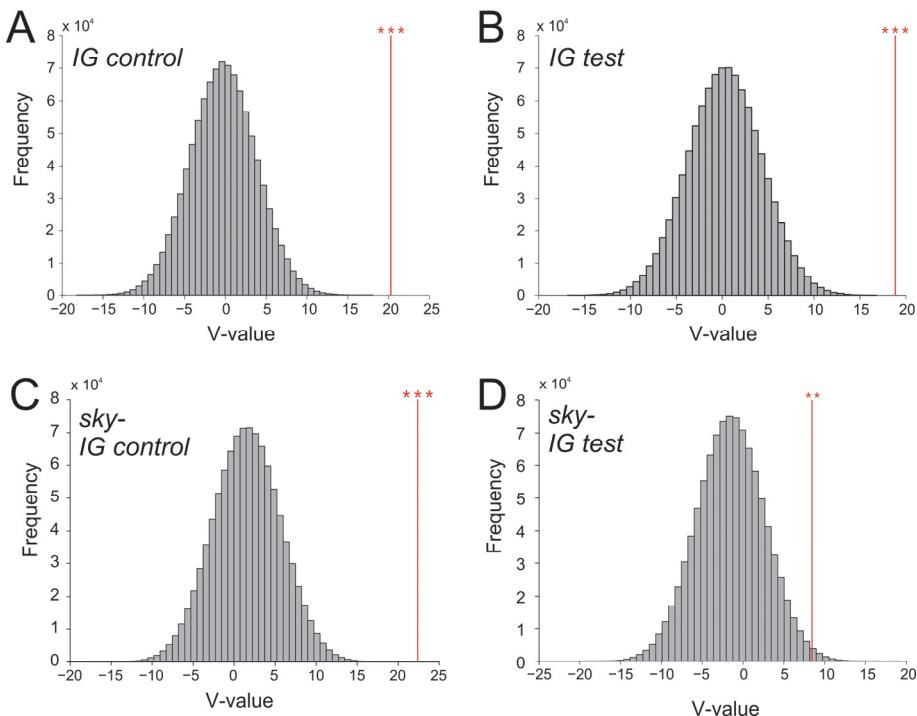


Fig. S3: Permutation tests of the intensity gradient filter experiments (see main article, Fig. 4). Measured bearings were randomly permuted 1,000,000 times across individuals and experimental conditions. Red lines indicate unpermuted *V*-values. \*\*\*  $p<0.001$ ; \*\* $p<0.01$ . (A) *IG control* experiment, where beetles rolled twice without filter turn (Fig. 4C). (B) *IG test* experiment with a  $180^\circ$ -turn of the intensity gradient filter in between (Fig. 4D). (C) *sky-IG control* (Fig. 4E). (D) *sky-IG test* (Fig 4F).

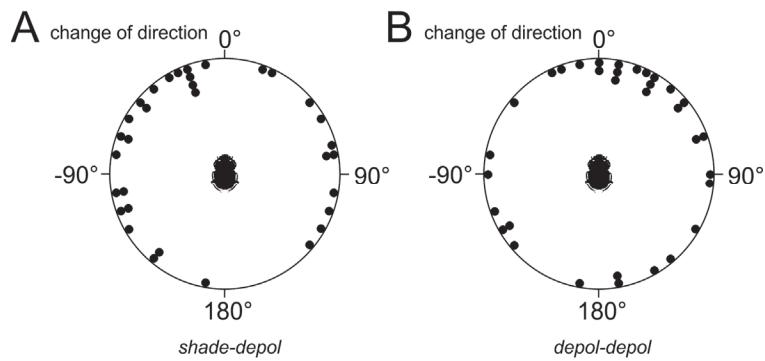


Fig. S4: The effect of a depolarized sky on the orientation behavior of beetles. Change of rolling direction of two consecutive rolls when the beetles rolled once in the shade and once under the depolarizer (A,  $p=0.027$ ) or twice under the depolarizer (B,  $p=0.017$ ).