

Supplementary Materials for

Leg force interference in polypedal locomotion

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Published 5 September 2018, *Sci. Adv.* **4**, eaat3721 (2018)

DOI: 10.1126/sciadv.aat3721

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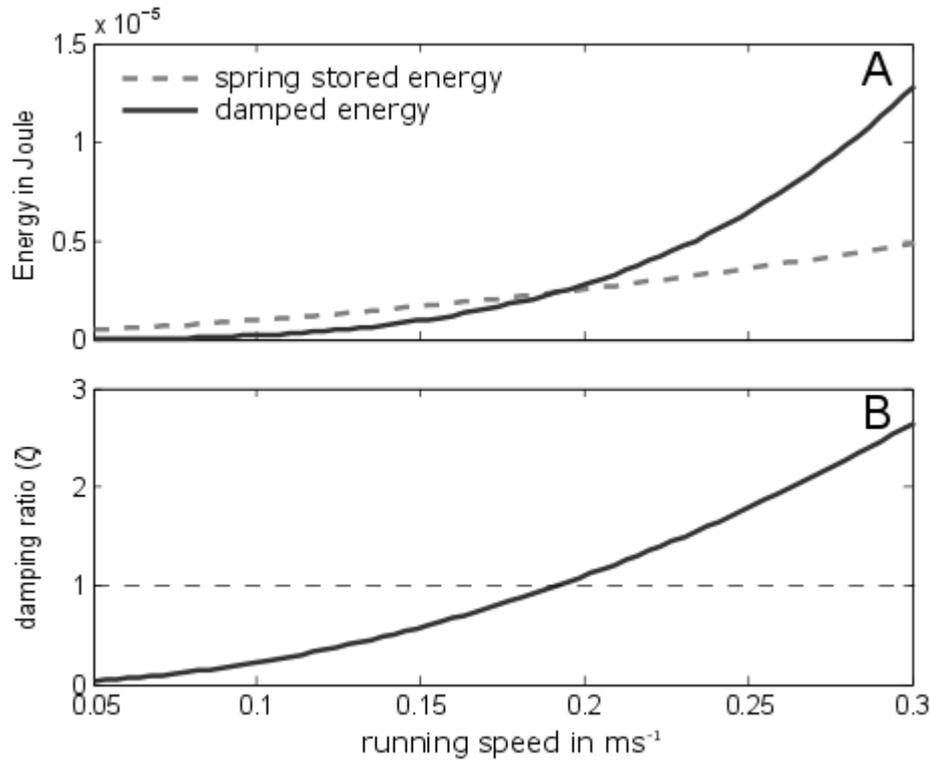


Fig. S1. Speed-dependent transformation of a locomotor system from an underdamped to an overdamped vertical oscillator. The calculations rely on data for the blaberid cockroach *Nauphoeta cinerea* (Weihmann *et al.* 2017).

A) Maximum values of potentially reusable energy E_{spring} , i.e. spring energy stored in elastic structures of the legs, and the energy dissipated during the stance phases E_{damp} . Spring energy was calculated as $E_{spring} = \frac{1}{2}kz^2$ and damping energy as $E_{damp} = \frac{1}{2}d\dot{z}^2$ with z being the vertical amplitude of the animals COM and \dot{z} being the mean vertical speed of the COM during stance. The mean vertical speed was calculated as $\dot{z} = \frac{z}{t_c}$ with t_c being derived from the linear speed dependency of its reciprocal value t_c^{-1} (cp. Weihmann *et al.* 2017; Fig. 5). Correspondingly, contact durations decreased hyperbolically from 0.2 s to 0.025 s in the speed range from 0.05 ms^{-1} to 0.3 ms^{-1} . Values for z are also based on measurements in *N. cinerea* (Weihmann *et al.* 2017). The spring constant k was estimated from the cockroaches' body weight (about 0.004 N) and the mean vertical amplitudes (about 0.001 m); it was set to 4. The damping coefficient was chosen such that the intersection point of the two energy forms fits to the transition speed from alternating tripodal to high speed metachronal gait as found for *N. cinerea*. The gait transition occurred at speeds somewhat above 0.15 ms^{-1} (Fig. 5 in Weihmann *et al.* 2017); accordingly, the damping coefficient was set to 0.006.

B) Damping ratio ζ over the speed range in accordance with the energies depicted in A. The damping ratio was calculated as the ratio between damping and spring energy ($\zeta = \frac{E_{damp}}{E_{spring}}$).

Damping ratios between 0 and 1 are referred to as underdamped and those above 1 are referred to as overdamped.

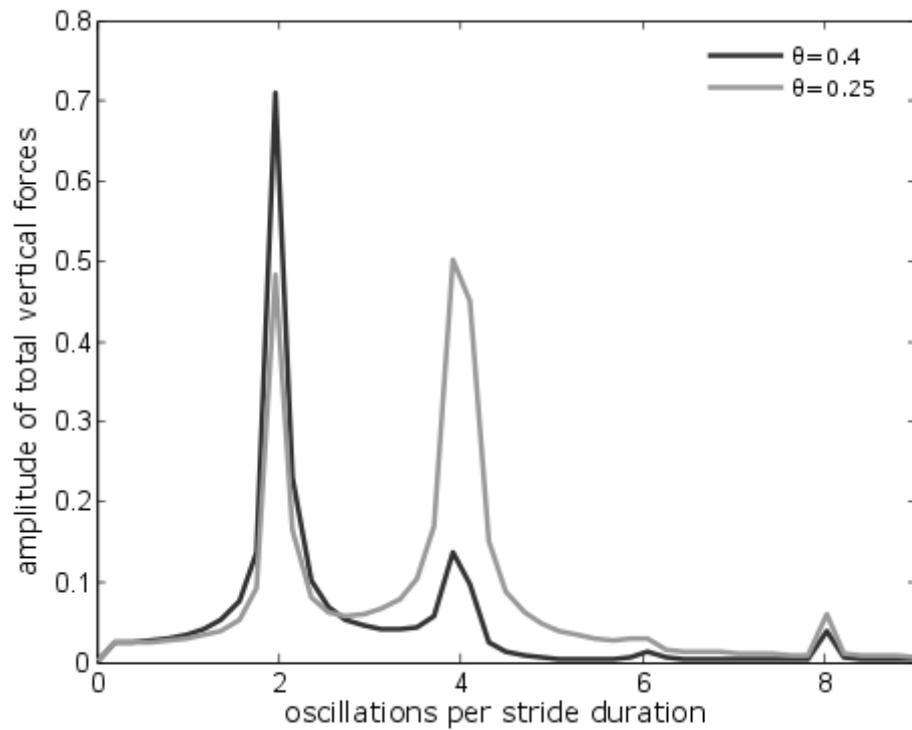


Fig. S2. Example force spectrums for locomotor apparatuses with three pairs of walking legs at a duty factor of 0.3. With an ipsilateral phase shift of 0.4, i.e. close to alternating tripodal leg coordination, the total vertical ground reaction forces are dominated by a frequency of two times stride frequency (black line). With larger deviations from the alternating gait pattern, other oscillations with higher frequencies might become dominant. Thus, in the second example (grey line), with an ipsilateral phase of 0.25, oscillations with four-times stride frequency have the highest amplitudes.