1. Introduction

Touching different sites on the body of a locust elicits scratching movements of one or more legs that are directed towards the stimulus. We are seeking to understand how spatial information signalled to the target location is used together with limb proprioceptive information to generate these targeted movements. We have analysed the kinematics of scratching in Schistocerca gregaria under a variety of limb loading conditions to address the question: ‘can locusts compensate for altered loading on a limb to maintain precise targeting?’ We show that a load of 12% of the leg mass has little effect on the accuracy of targeting, indicating that limb proprioceptive signals play a vital role in modifying the motor output that drives these movements.

2. Somatotopy of movements

When touched at different places on a wing (triangle symbols below) locusts made appropriately directed movements of the ipsilateral hind leg. Plotting all of the positions reached by the tarsus in 610 responses of 8 animals revealed the workspace used for combinations of 2 start positions and 5 target positions in the absence of any load. The ‘scratch areas’ are color-coded by stimulus site. There were systematic differences between the areas scratched, which reflect leg targeting, although there was considerable overlap between adjacent areas. To reveal the relative frequency with which the tarsus reached targets in different locations within the workspace we calculated density maps in which more intense colour levels indicate increased frequencies. In the example below the tarsus most often passed across a region slightly posterior and ventral to the target.

3. Effect of load on workspace

Loading the proximal or distal end of the femur, or the distal end of the tibia had little effect on tarsal workspace for posterior targets, but caused a posterior shift of the distribution for anterior targets (N = 221 loaded responses of 3 animals).

4. Quantifying the shift

A transect that passed through the peaks of unloaded distributions for a range of target sites (inset) was used to cut through the loaded distributions shown on the previous panel, yielding the graphs shown below.

5. Efficacy of targeting

Loading the femur or tibia had no significant effect on the efficacy of posterior scratching movements as assessed by measuring the point of closest approach of the tarsus to the target site (P > 0.05, 3 df, ANOVA). Loading the proximal femur had a small but significant effect on anterior scratches (P < 0.05, asterisk below).

6. Summary

Locusts make targeted scratching movements of a hind leg in response to stimuli on a wing. Quantitative analyses of the kinematics of these movements reveal somatotopically organised but overlapping patterns of response. Loading the leg with a substantial weight that more than doubles leg mass has only minor effects on limb targeting.

Even when the leg is loaded, the tarsus passes close to the stimulus site so the effectiveness of scratching is probably maintained.

7. Conclusions

Tarsal position appears to be controlled in locust scratching movements. We are presently analysing this dataset to determine if velocity is also controlled.

To achieve this control exteroceptive sensory information from the wings that signals target site must be integrated with leg proprioceptive information signaling either joint angles or joint loading. Candidate interneurones which may be involved in these computations have recently been identified (T. Matheson, submitted).

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