# Flight muscle coordination of collision avoidance behaviour in flying locusts

UNIVERSITY OF SASKATCHEWAN

GRAY LAB – NEUROETHOLOGY OF INSECT FLIGHT

NSERC CRSNG

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ICN 2014 Student Poster Award Eligible

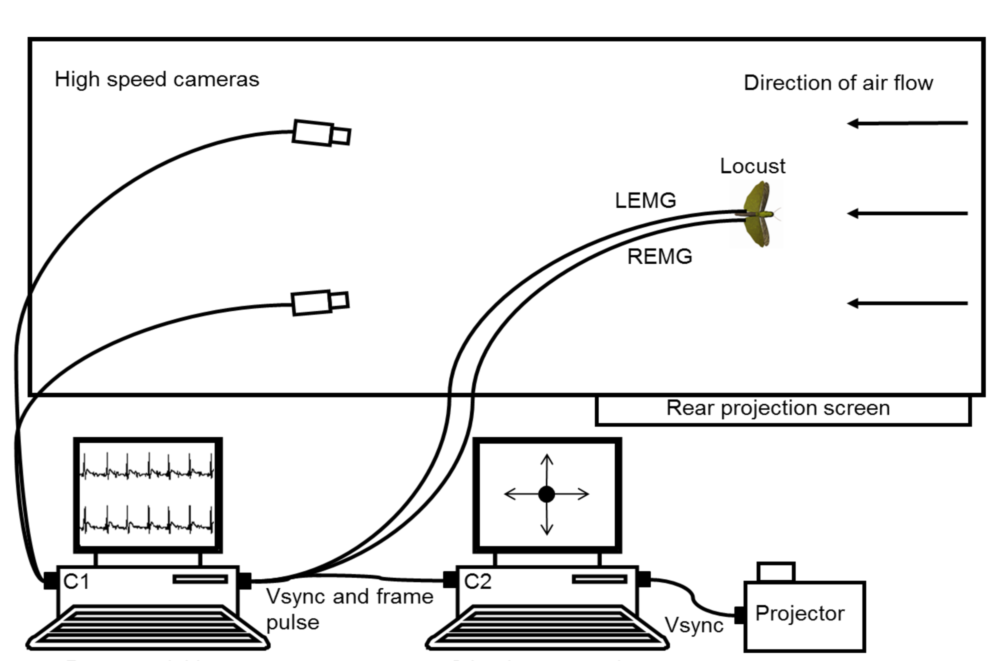
## INTRODUCTION

Animals display a variety of adaptive behaviours to avoid predators and collisions with conspecifics. Complex neural control mechanisms underly these behaviours, which are controlled by specialized neural circuits. *Locusta migratoria* is a model organism for examining flight muscle coordination of collision avoidance behaviour. Loose tether experiments have shown that locusts free to maneuver in 3-dimensional space will adjust wing beat frequency, coordinate timing of a single bilateral pair of flight muscles, and coordinate forewing asymmetry during the downstroke (McMillan et al., 2013). Experiments were designed to test two hypotheses: 1) Synchrony between 3 bilateral pairs of flight steering muscles increases prior to initiation of intentional flight steering behaviour. We analyzed electromyograms (EMG) recordings from 3 bilaterally paired forewing (m97[1st basalar], m99[subalar], and hindwing (m127[1st basalar]) steering muscles. 2) Timing and synchrony of multiple flight muscle activity correlate with whole body motion within 6 degrees of freedom during intentional flight steering. Concurrent EMG and high speed video allowed for measurements of muscle activity and body orientation.

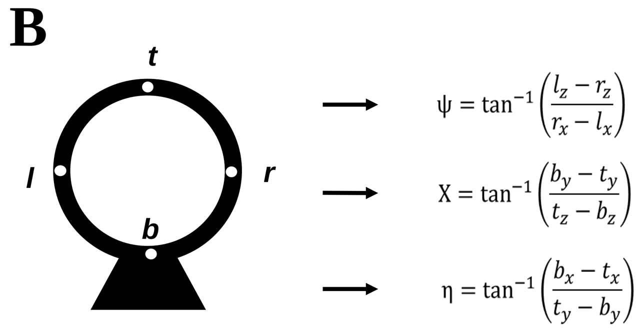
## EXPERIMENTAL SETUP

**Fig. 1** :Locusts (n=18 ) were tethered within a wind tunnel (A) and presented with a looming stimulus (14cm disk, 3m/s). A four point marker allowed for calculation of roll, pitch and yaw (B,C). EMG's were inserted in flight muscles m97, m99 and m127 (D,E).

A

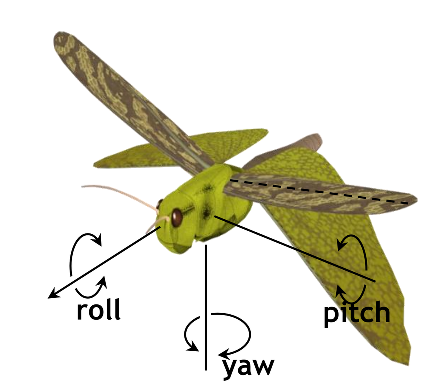



B

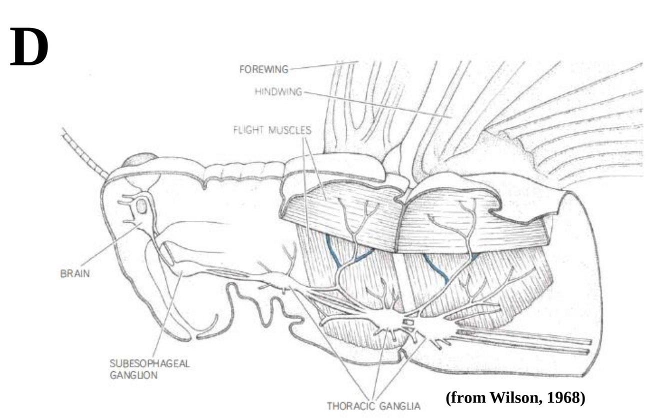



$$\psi = \tan^{-1}\left(\frac{l_z - r_z}{r_x - l_x}\right)$$
$$X = \tan^{-1}\left(\frac{b_y - t_y}{t_z - b_z}\right)$$
$$\eta = \tan^{-1}\left(\frac{b_x - t_x}{t_y - b_y}\right)$$

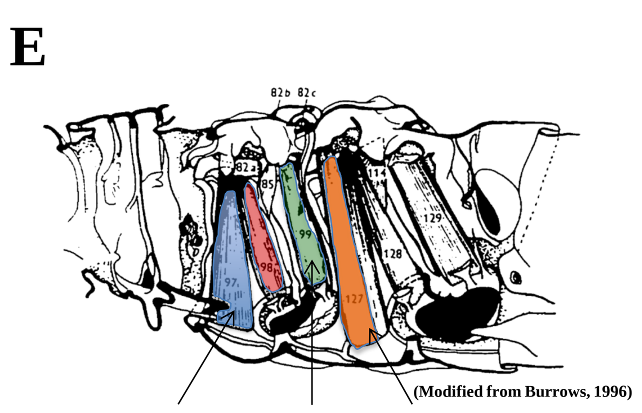
C




D




E




## METHODS

A

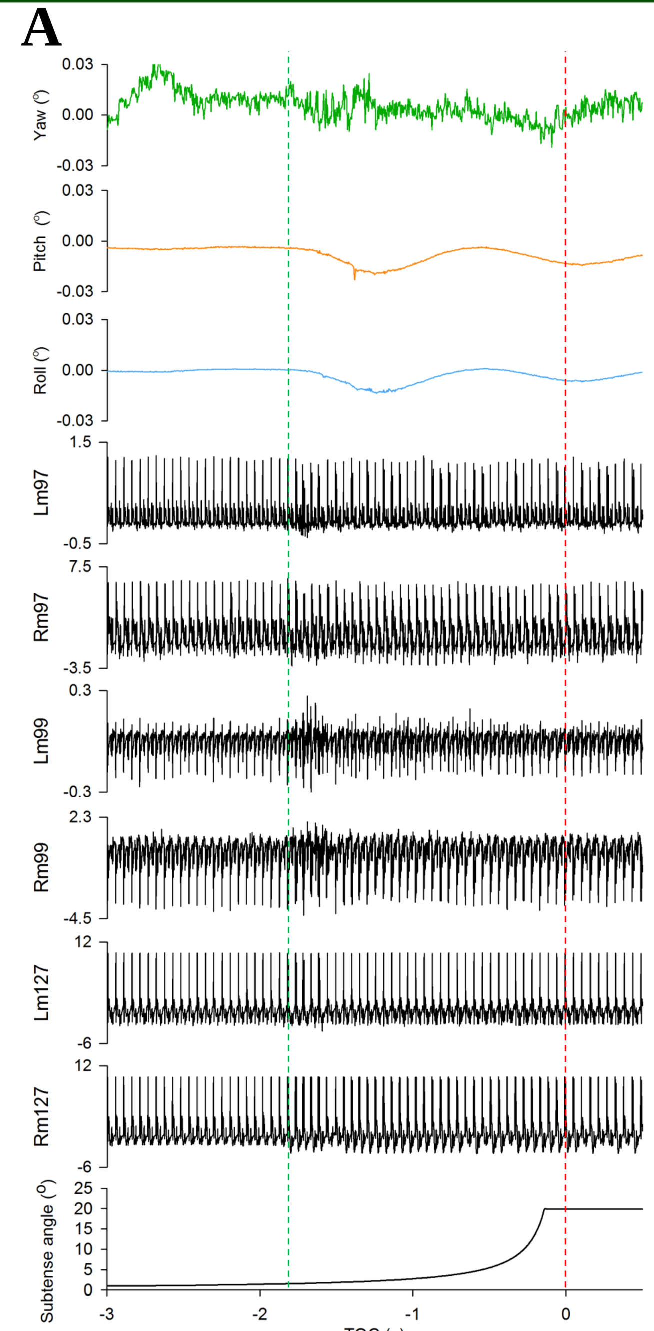
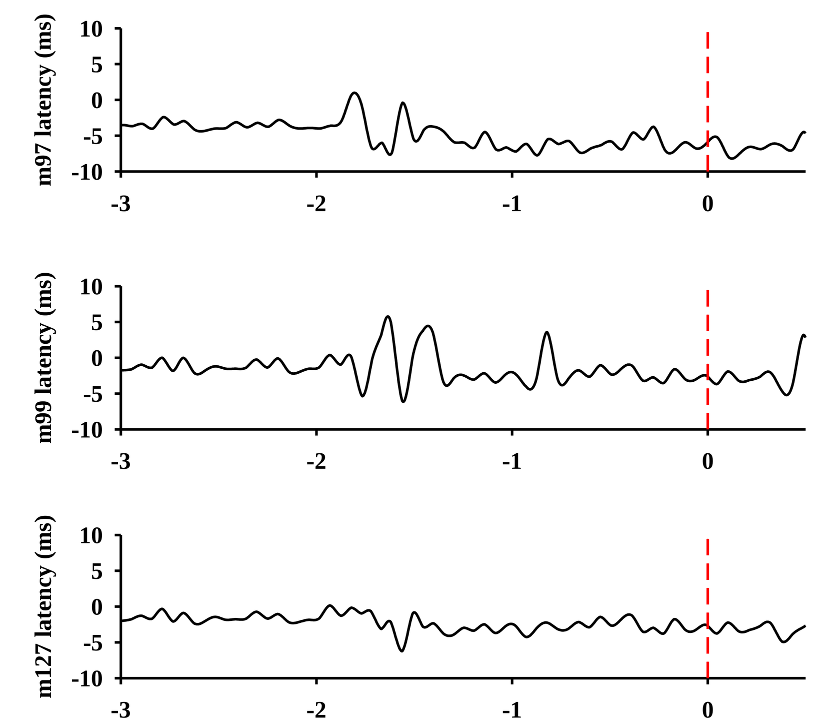



Fig.2: A) Raw data from one locust showing left turn kinematics, EMGs, and subtense angle aligned to time of collision (TOC) and time of EMG synchrony (TOS). B) Left-Right latency of m97,m99 and m127.

B

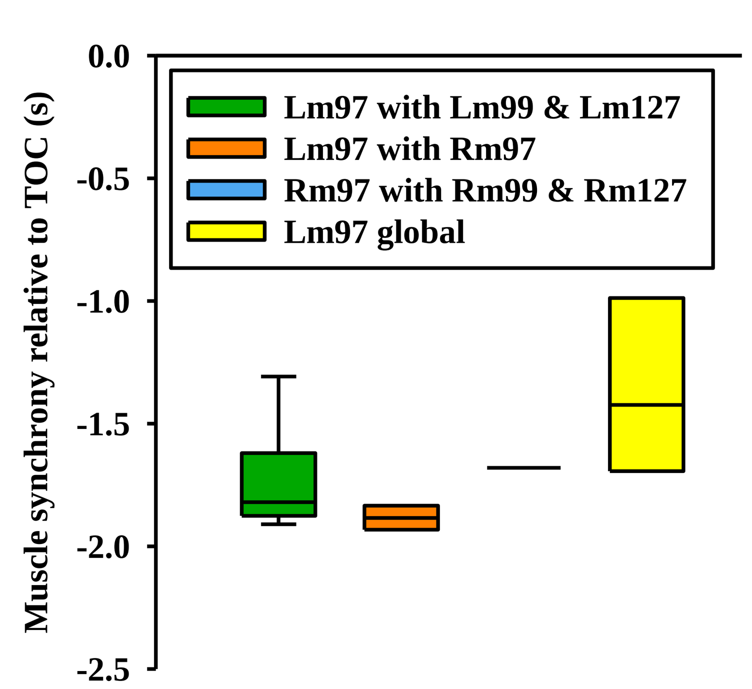



## RESULTS

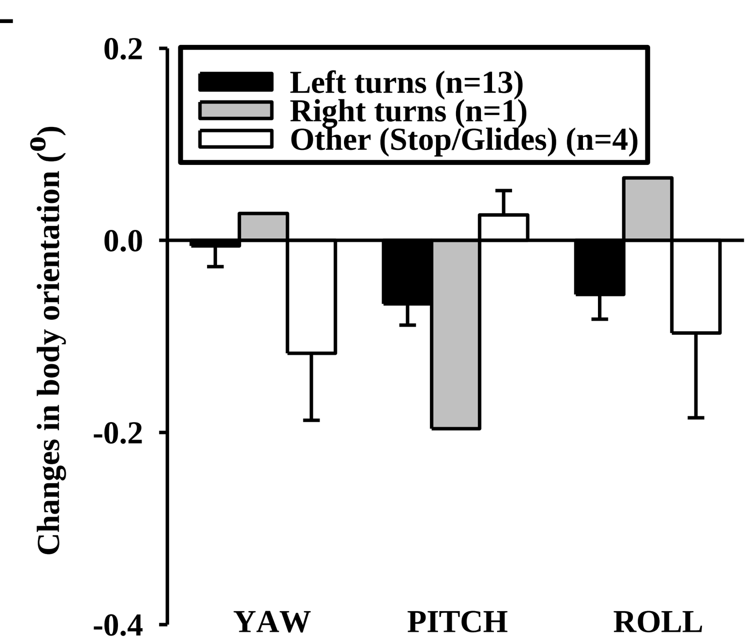
### Muscle synchrony and steering directionality

Fig. 3: A) Muscle synchrony relative to time of collision occurred earlier for directed responses or a single glide (green, orange, blue) whereas global synchrony, present during stops and glides, occurred later. B) Directionality (mean ± sem) of yaw, pitch and roll behaviours. During left turns, yaw and roll were to the left (negative) and pitch was down (negative). For right turns yaw and roll were to the right (positive) whereas pitch was down. Stops and glides included left yaw and roll and upward pitch.

A



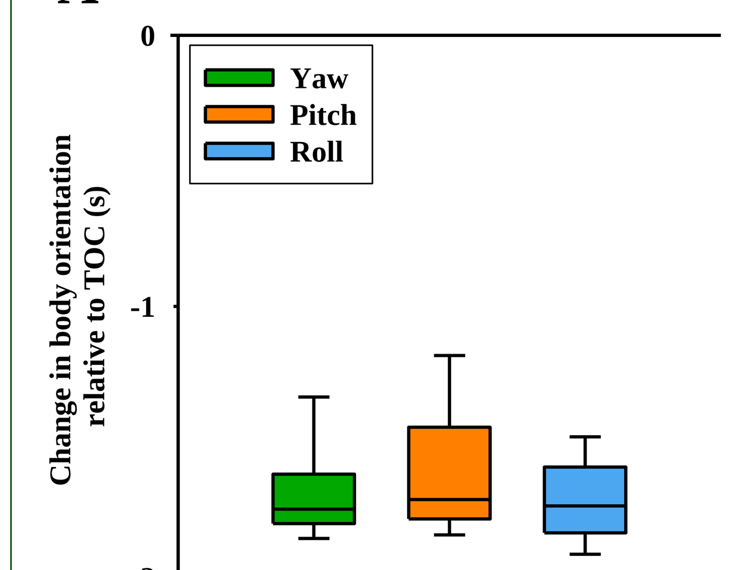

B



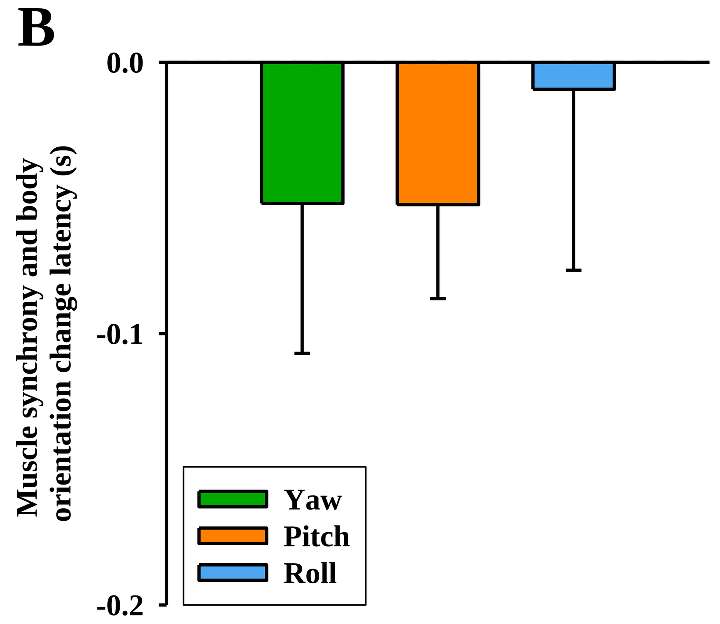

## Muscle Synchrony and Kinematic Change

Fig. 4: A) Initiation of Yaw, Pitch and Roll relative to TOC. Roll occurred first, followed closely by pitch, then yaw. B) Latency (mean ± sem) from muscle synchrony (Lm97 with Lm99 and Lm127) to time of kinematic change. Mean changes in orientation occurred after changes in muscle synchrony.

A




B




## SUMMARY

- 3 pairs of bilateral flight muscles synchronize approximately 1.72 s before collision, regardless of behaviour type.
- Body orientation changes approximately 1.66 s before collision.
- Different collision avoidance behaviours display a unique combination of body orientations.
- Mean muscle synchrony times precede changes in body orientation.

## References

Burrows, M. 1996 The Neurobiology of an Insect Brain.
McMillan, G.A, Loessin V, Gray J.R. 2013. *J. Exp. Biol.*, 216, 3369-3380.
Wilson, D.M. 1968. Sci. Amer. 218:83-90.

## Acknowledgements

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