Biomechanical parameter interactions during different flight segments in homing pigeons

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Summary

Multiple flight parameters of homing pigeons during different flight segments were investigated using GPS and accelerometer devices. Distinct patterns emerged: during climbing segments, birds showed an inverse relationship between speed and movement intensity; during level flight, they maintained moderate adjustments across all parameters; and during descent, speed showed a direct relationship with movement intensity and an inverse one with wingbeat frequency. In all flights wingbeats acceleration profile became more similar at higher speeds.

Introduction

Wingbeat characteristics have been investigated in relation to several conditions [1], studying the biomechanical cost of flying in flock relative to flying solo, highlighting the benefits of flying together in terms of energetically costly kinematics. Moreover, the variations of the wingbeat characteristics of homing pigeons were analysed as they learned the homing task, demonstrating that birds modulate these characteristics as a function of their navigational knowledge [2]. However, in all these studies the variations of these characteristics with different segments of continuous flight were not investigated. This study provides an insight on a selected set of biomechanical parameters extracted as homing pigeons returned to their loft. To better understand this point, a correlation analysis between selected biomechanical features was performed to highlight the presence of peculiar patterns between these variables as a function of their flight segments (rising, steady, descending).

Methods

Homing pigeons (*Columba Livia*) used for the experiment were part of a colony resident in a rural area and were released from an urban site located approximately 18 km from the loft. The dataset included 14 continuative flights of about 16 km.

The subjects were tracked using a commercial data logger (Axy-Trek, Technosmart Europe, Rome, Italy), including a tri-axial accelerometer (50 samples/s; range ± 4 g; axes aligned along medio-lateral, cranio-caudal and dorsal-ventral direction) and a GPS receiver (1 sample/s). Ground speed (GS, i.e. bird speed projected on the ground) and altitude (m above msl) were obtained from GPS data. The data logger was attached to the pigeon's back with Velcro strips and removable glue.

The analysis focused on steady flight segments, excluding zones within 500m of release and arrival points. Data were segmented in windows of 3 minutes, with 90% of overlap. In each window, dorsal acceleration was segmented into wingbeat cycles, and outliers were discarded through a temporal and morphologic check. Wingbeat frequency (WB) was obtained indirectly from the identification of maximum peaks of the dorsal acceleration signal; peak-to-peak (P2P) values were obtained from the dorsal-ventral and total acceleration, and coefficient of multiple correlation (CMC) was computed within all flight cycles included in the 3-min window. RMS values were obtained from total acceleration after removing the dorsal-ventral static component (gravity). Pearson's correlation coefficients were then estimated (α=0.05).

Results and Discussion

Flight segments	GS-WB	GS-H	GS-P2P	GS-RMS	P2P-WB	RMS-WB	H-WB	GS-CMC
Rising	**-0.79**	**0.70**	0.04	**-0.52**	0.02	**0.61**	**-0.81**	**0.52**
Steady	-0.40	0.28	**0.51**	0.41	0.00	**0.64**	-0.01	**0.56**
Descending	**-0.73**	0.36	**0.87**	0.15	**-0.69**	-0.13	0.01	**0.63**

Table 1: significant correlations (in bold) between variables in different flight phases.

During rising, GS increases for increasing heights and decreasing RMS accelerations and WB. WB increased with increasing RMS accelerations and decreased for increasing height. During steady flight, speed increases testified increased P2P activity and, similarly, WB increased for increased RMS. In the descending phase, ground speed decrease is handled with an increase in wingbeat frequency and a decrease in RMS. In this phase, WB and P2P intensity are inversely correlated. In all phases, waveform similarity of acceleration profiles increased with speed.

Conclusions

This research characterizes birds flight mechanics during different conditions laying the basis for the study of changes due to external factors and environmental conditions.

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References

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