



FLIGHT OF ODONATA: MECHANICAL STUDY OF THE WINGS

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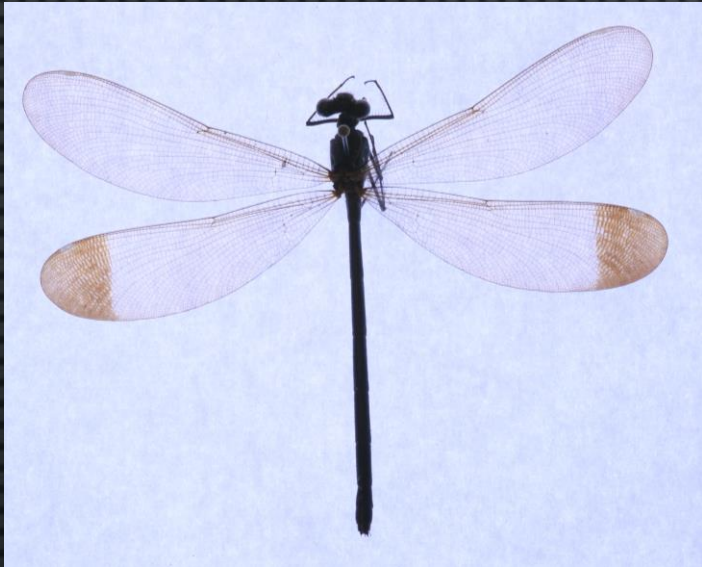


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The Secret World of Dragonflies, Andy Holt

WHY STUDY ODONATA?



Calopteryx (Odonata :
Calopterygidae)



Aeshna sp. (Odonata : Aeshnidae) - BBC Earth Unplugged
Dragonfly acrobatics in slow motion



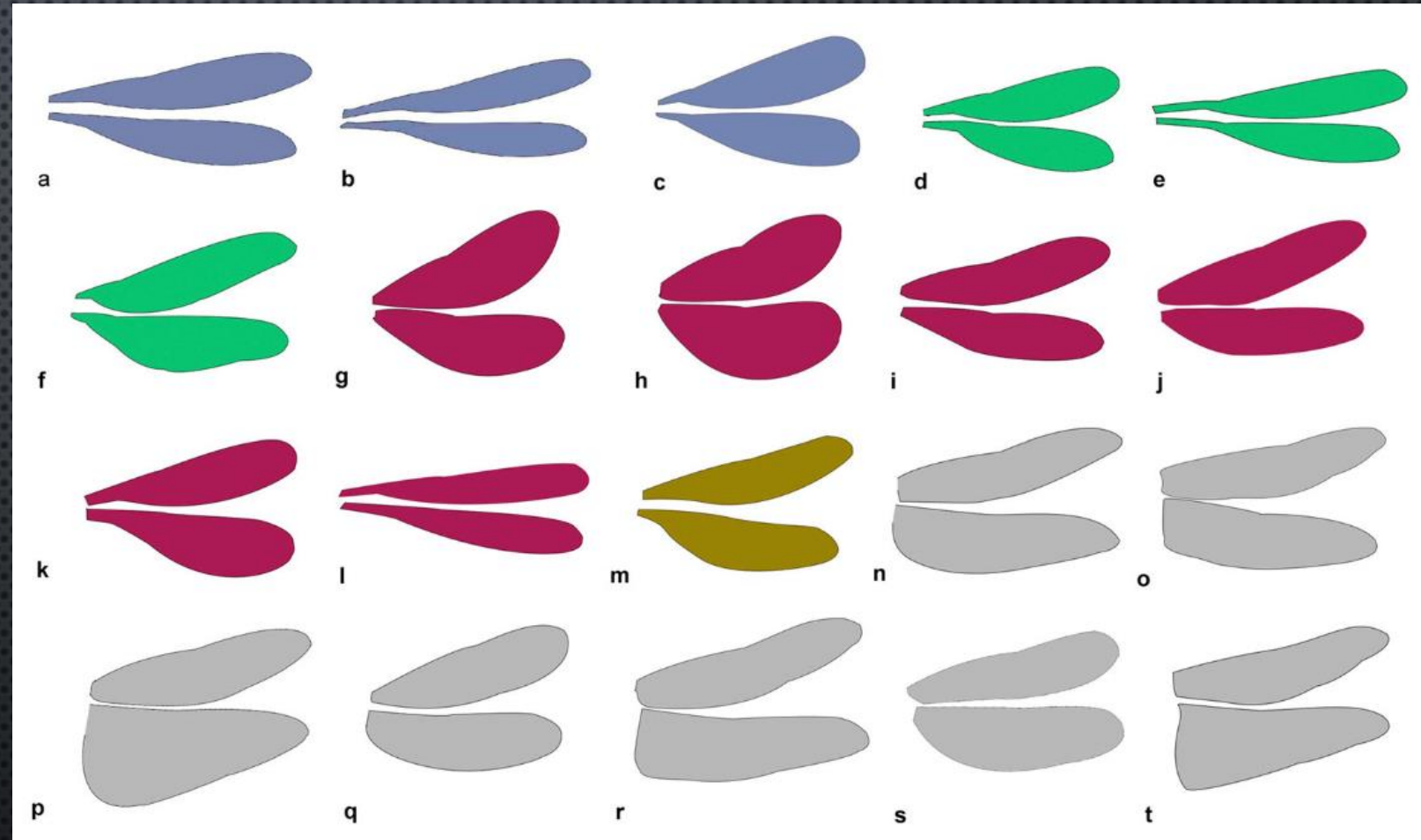
Anax (Odonata : Aeshnidae)

WHICH PARAMETERS TO STUDY AND HOW?



Boyeria Irene sp. (Odonata :
Aeshnidae)

- Wing shape
 - Aspect ratio
 - With or without petiole



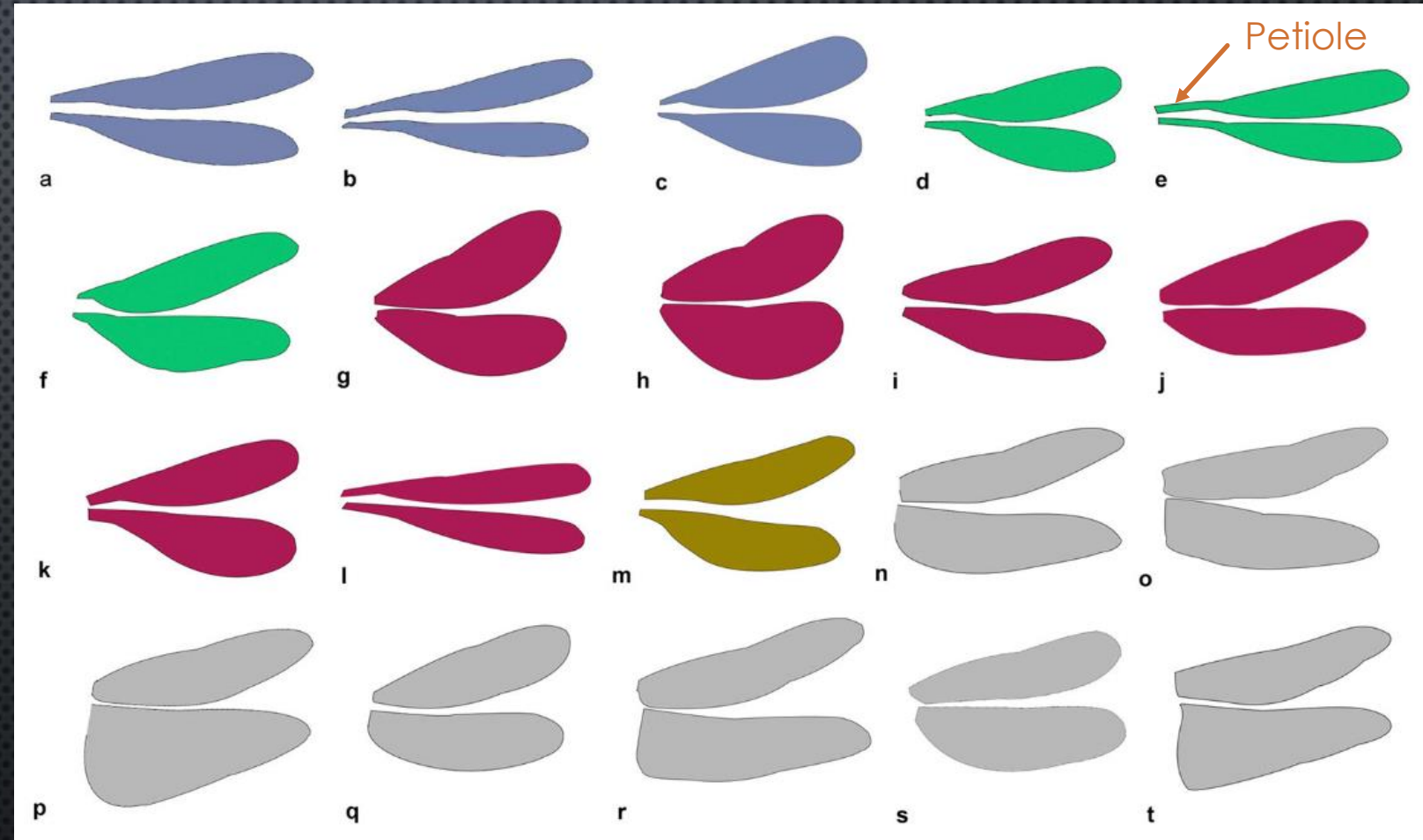
Diversity of shape of dragonfly wings. Wootton (2020)

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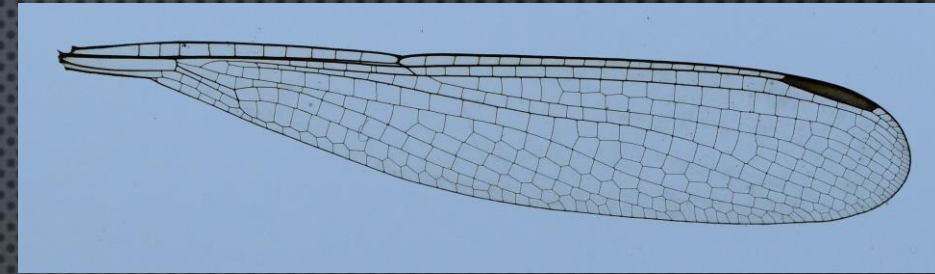


Diversity of shape of dragonfly wings. Wootton (2020)

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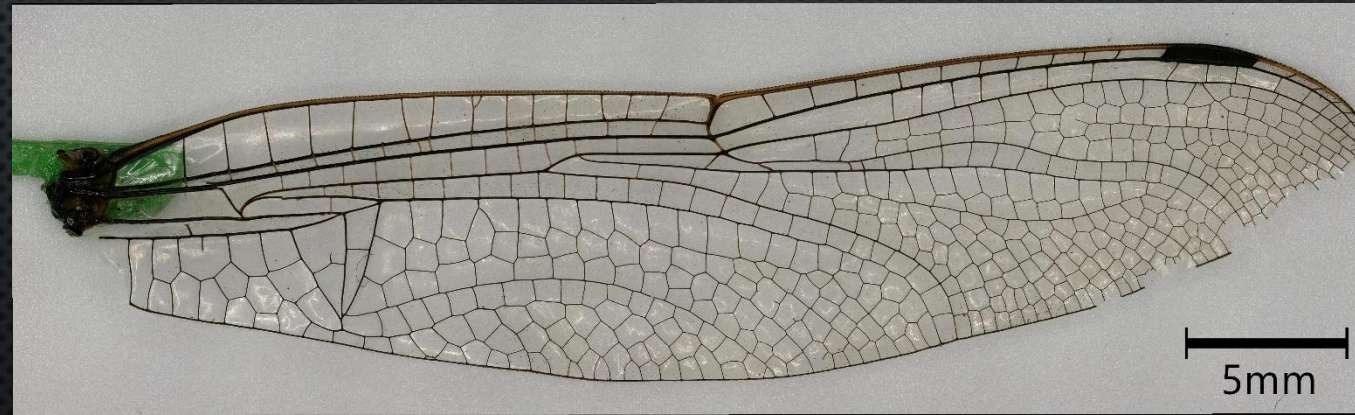


- Wing shape
 - Aspect ratio
 - With or without petiole
- Distribution of structures
 - Venation & corrugation
 - Nodus
 - Pterostigma



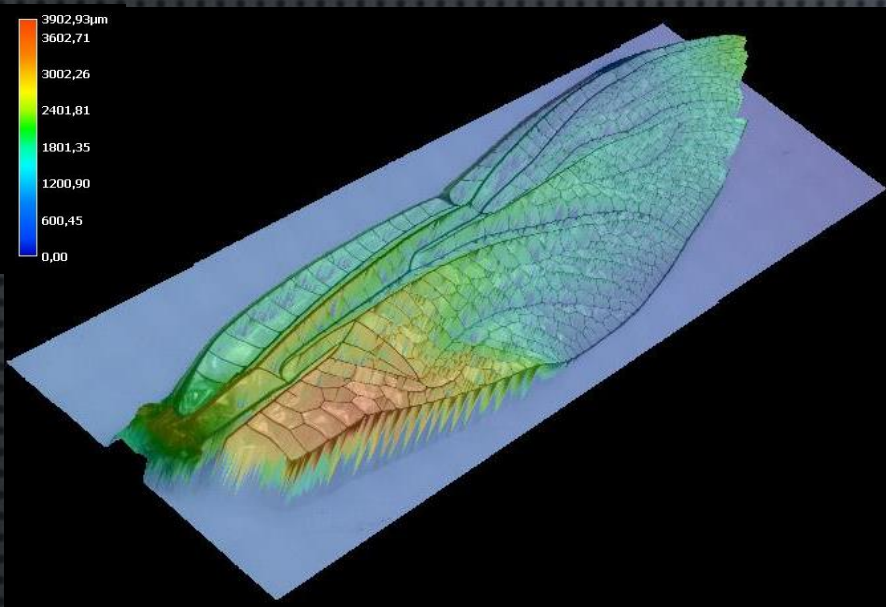
Chlorocypha cyanifrons .sp
(Odonata : Chlorocyphidae)

Boyeria Irene sp. (Odonata :
Aeshnidae)



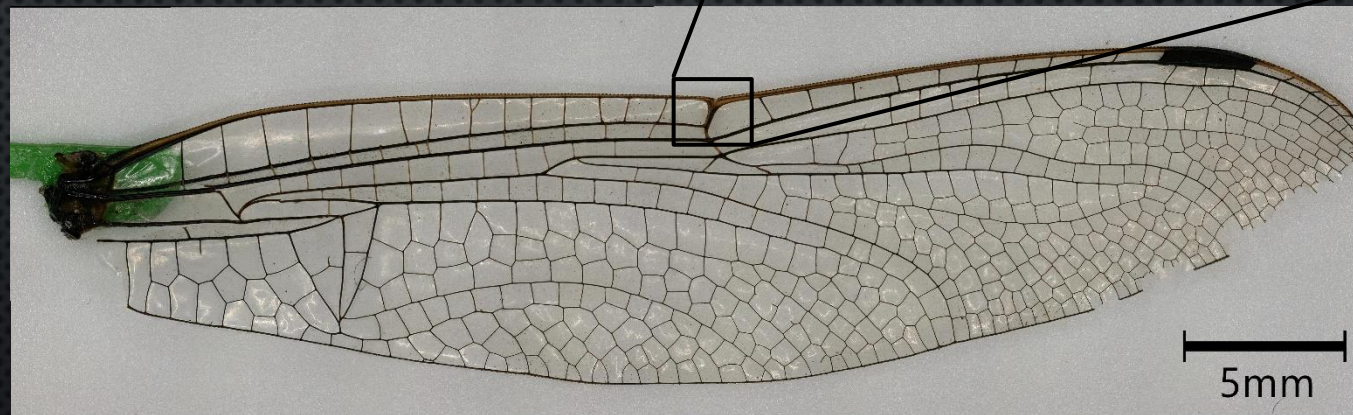
Orthetrum (Odonata : Libellulidae)

WHICH PARAMETERS TO STUDY AND HOW?



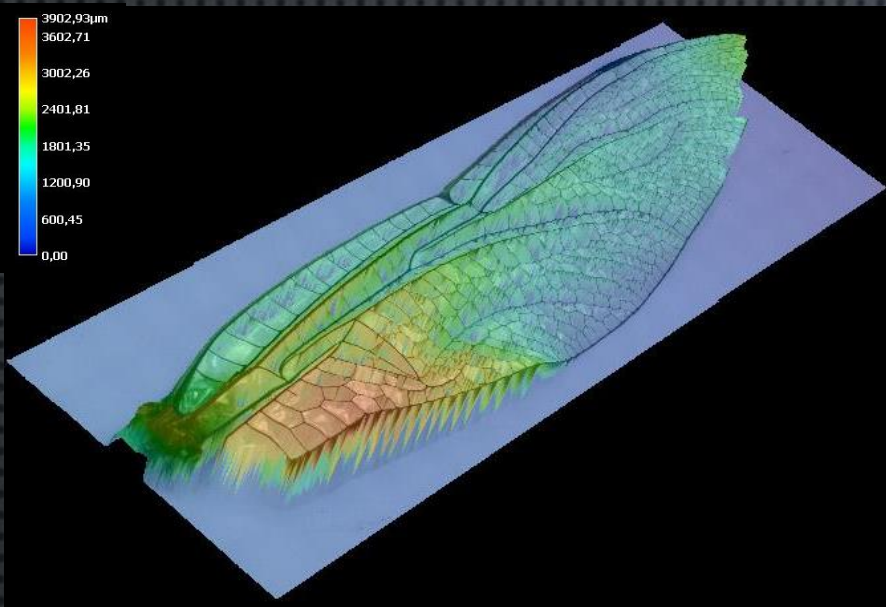
Boyeria Irene sp. (Odonata :
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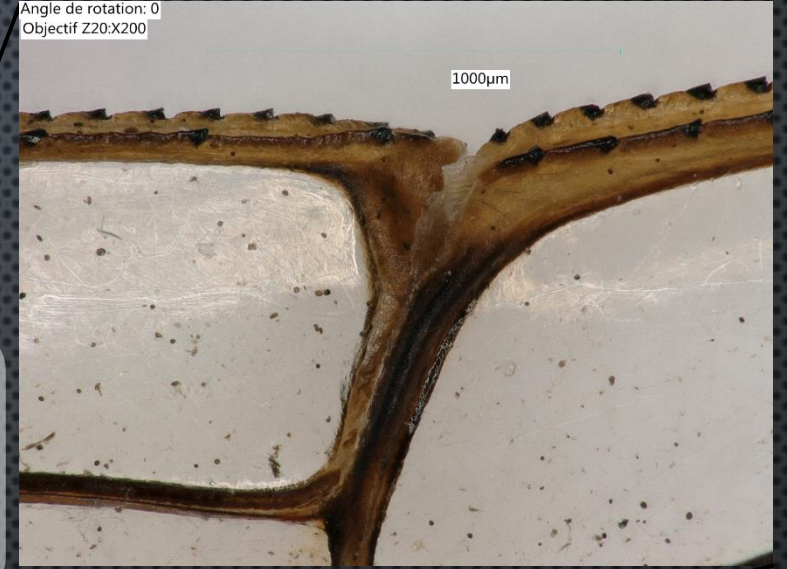
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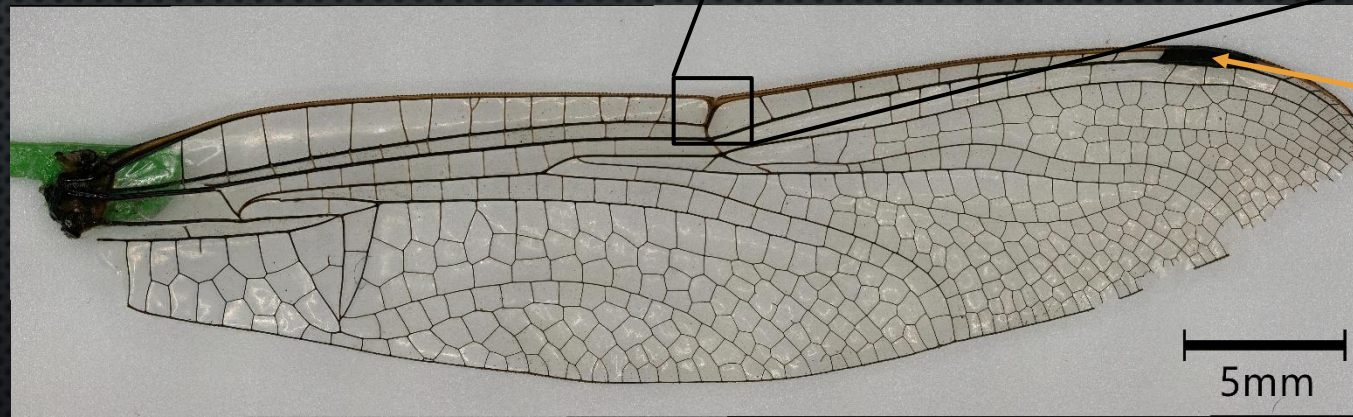


Boyeria Irene .sp (Odonata :
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Nodus

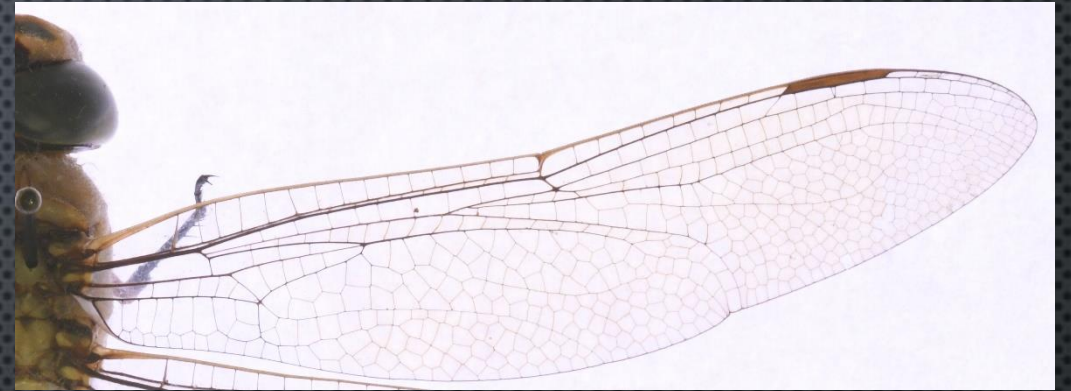


Pterostigma

Orthetrum (Odonata : Libellulidae)

MECHANICAL CHARACTERIZATION

- VIBRATION TEST
 - OBTAIN INFORMATION OF WING BEHAVIOR FOR VARIOUS FREQUENCIES
 - RESONANT FREQUENCY
 - AN INDIRECT MEASUREMENT OF THE STIFFNESS ($=EI$)
- GIVE COMPARISON POINT FOR AERODYNAMIC STUDY



Right forewing specimen 1.14
Anax parthenope sp. (Odonata : Aeshnidae)

MECHANICAL CHARACTERIZATION

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- CAN THE MECHANICAL CHARACTERISTICS BE CORRELATED TO VARIOUS BEHAVIOURS?
 - HAWKER
 - PERCHER



AESHNA SP. (ODONATA : AESHNIDAE) - BBC EARTH UNPLUGGED
DRAGONFLY ACROBATICS IN SLOW MOTION



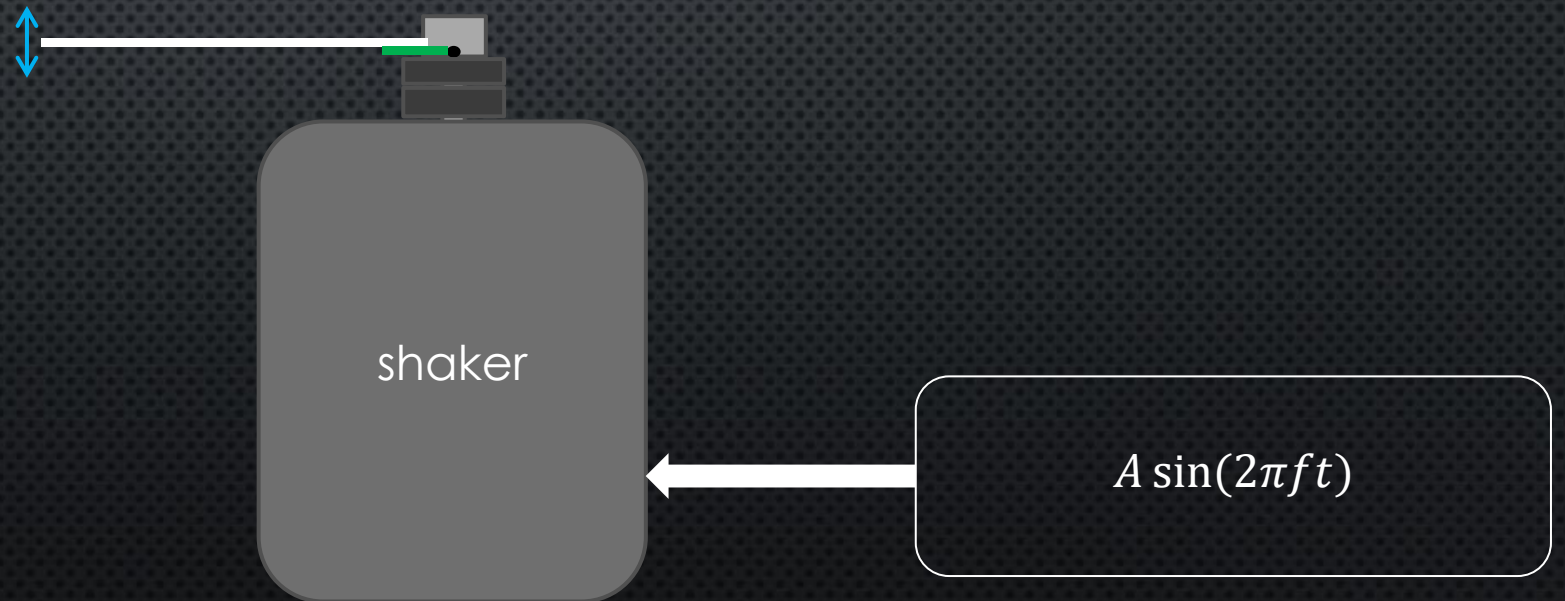
DAMSELFLY - PERCHER, HOMEMADE WANDERLUST

MECHANICAL CHARACTERISATION

INPUT PARAMETERS :

$$f \in [10-250] \text{ Hz}$$

$$A = 0,25\text{mm}$$

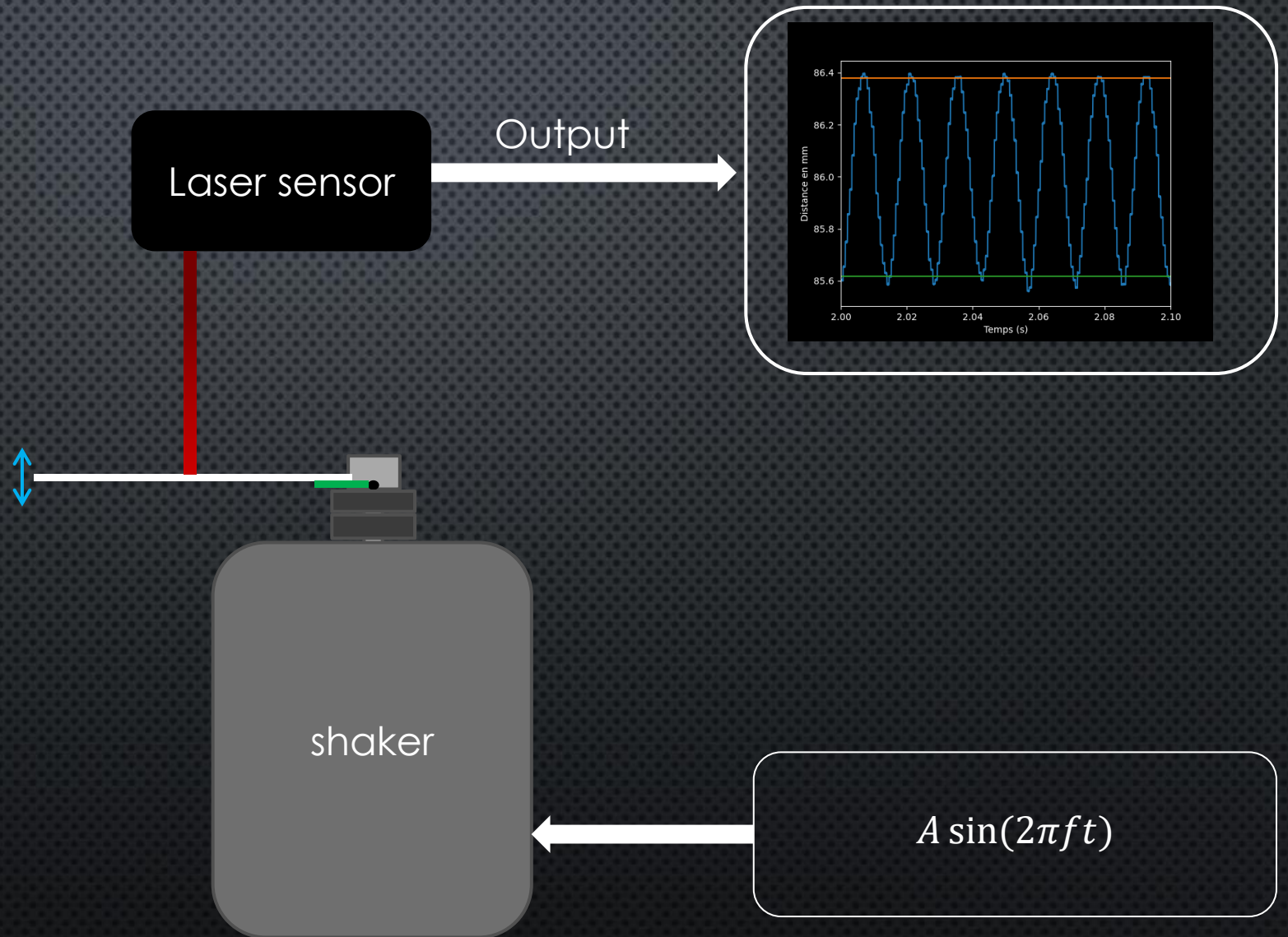


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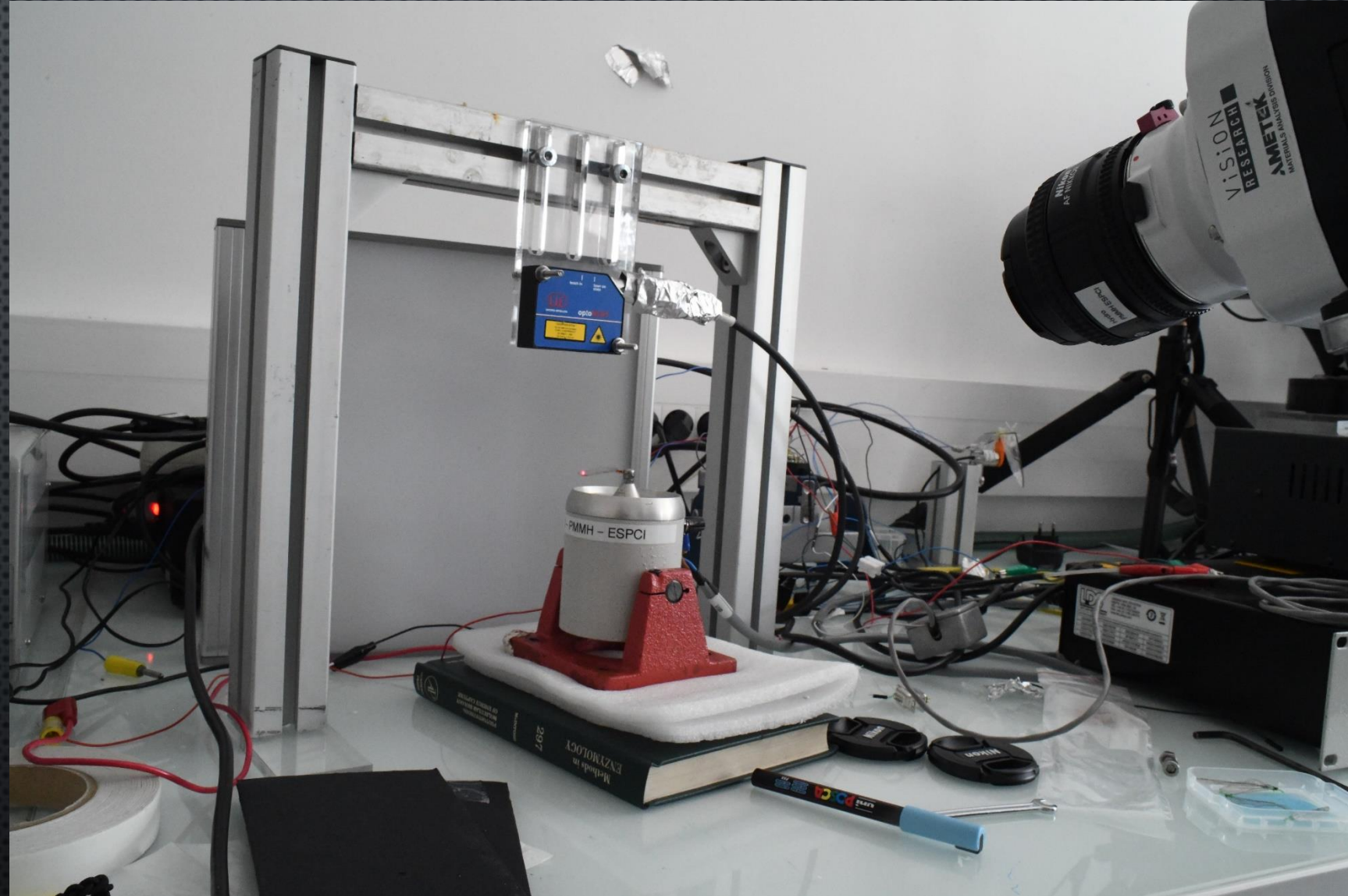


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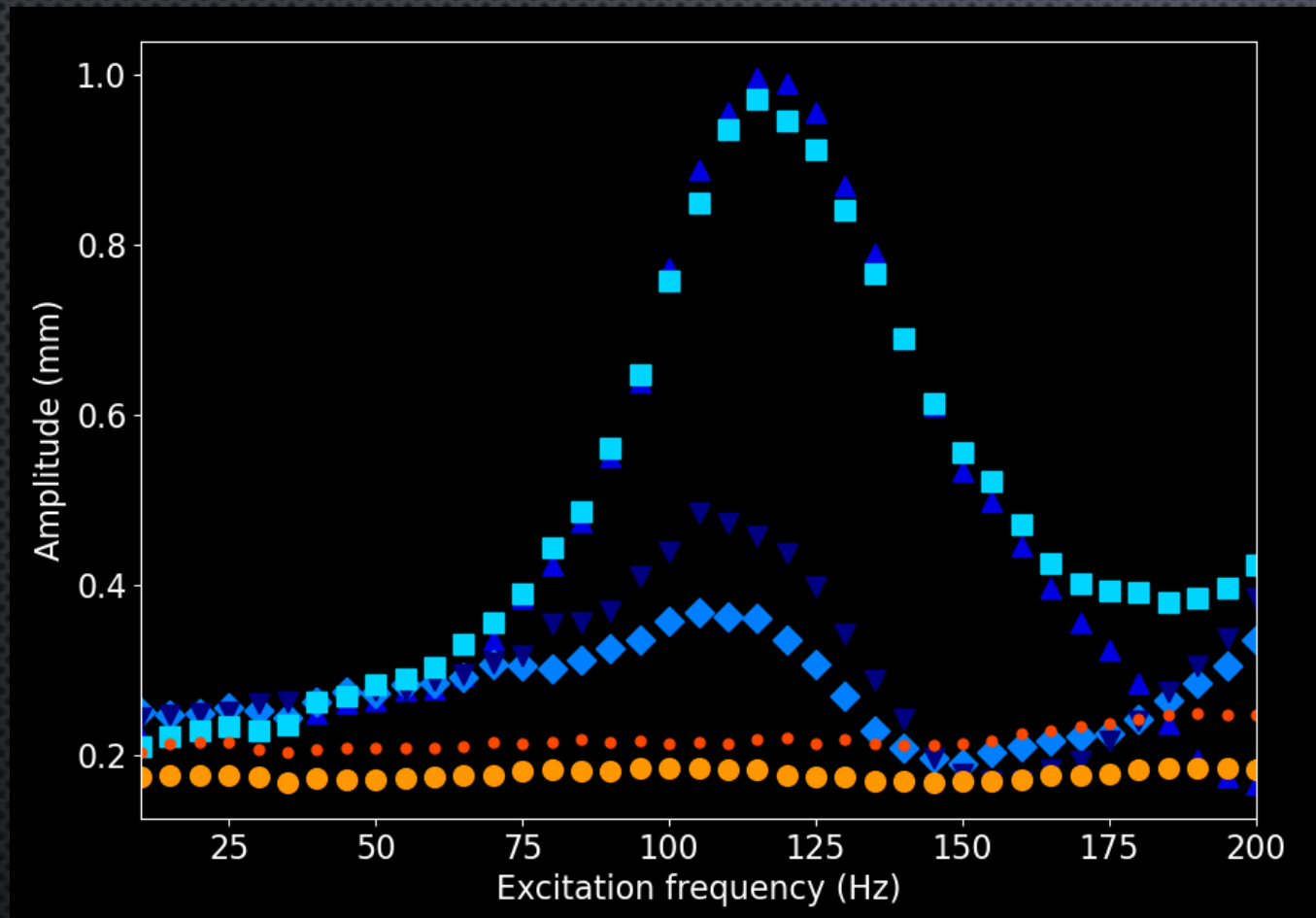
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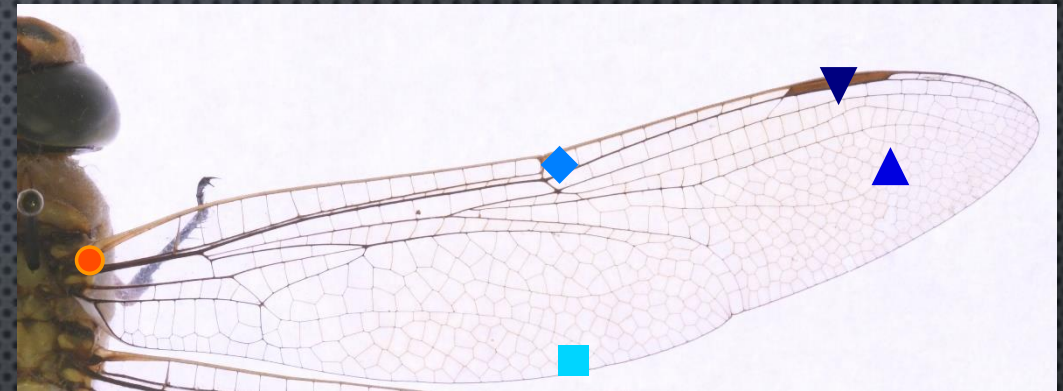


Right forewing specimen 1.14
Anax parthenope sp. (Odonata : Aeshnidae) - 115Hz
x0,0029

A SINGLE WING, VARIOUS POINTS OF MEASUREMENT



Right forewing specimen 1.14 dry



Right forewing specimen 1.14
Anax parthenope sp. (Odonata : Aeshnidae)

Wings flapping *Anax parthenope julius*
(Odonata : Aeshnidae) $\in [28.31, 35.8]$ Hz

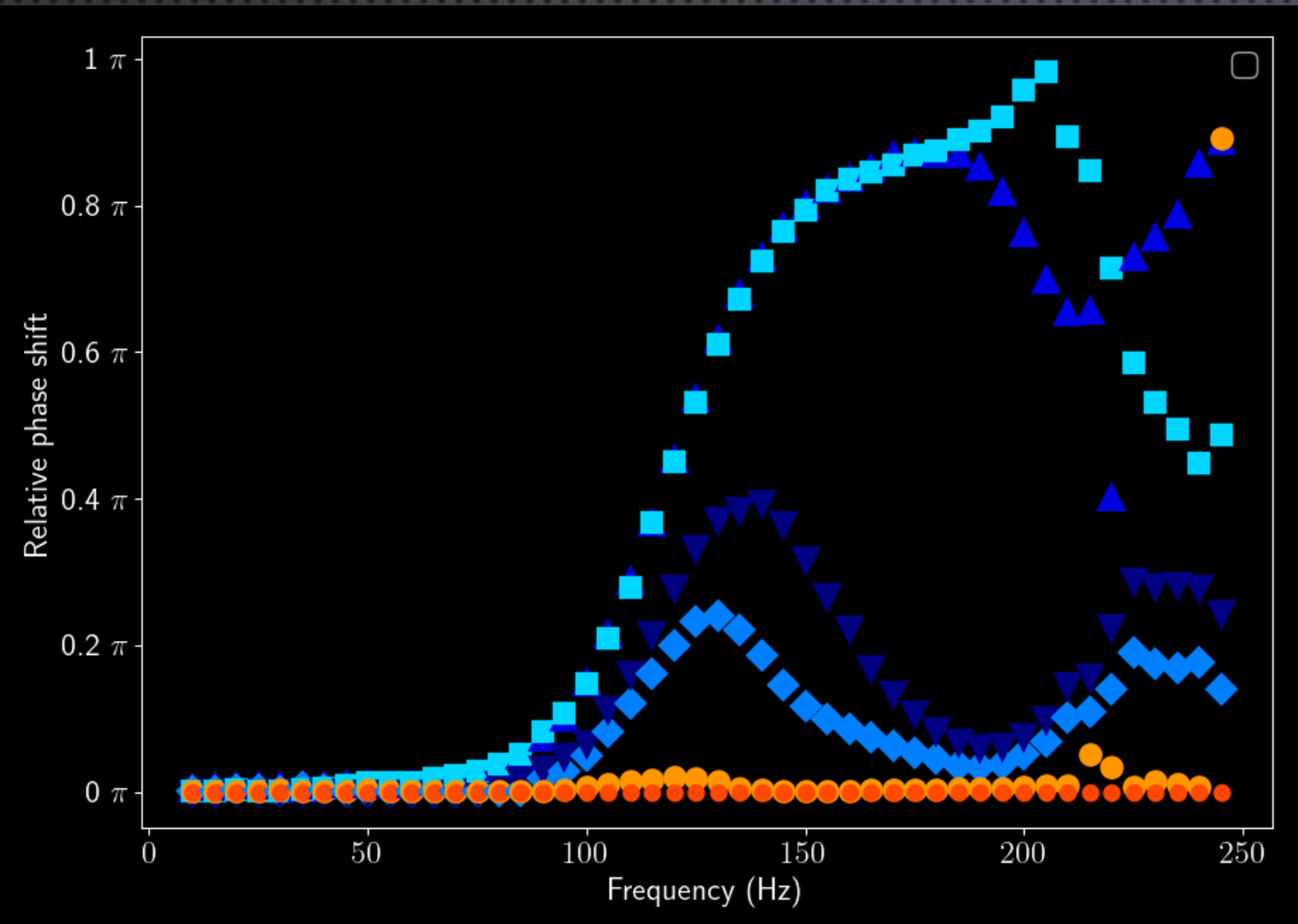
Yu, W., Zhang, H., Xu, R., Sun, Y., & Wu, K. (2022). Characterization of Wingbeat Frequency of Different Taxa of Migratory Insects in Northeast Asia. *Insects*, 13(6), 520.

RELATIVE PHASE SHIFT

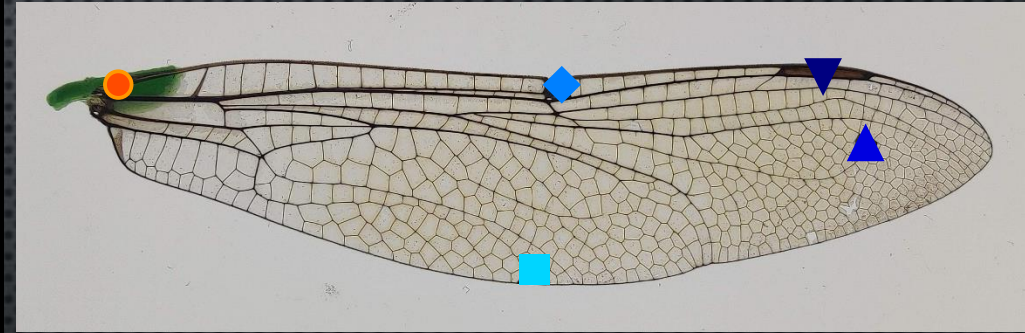


Right forewing specimen 1.14
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x0,0029

RELATIVE PHASE SHIFT



Right forewing specimen 1.14 absolute relative phase shift



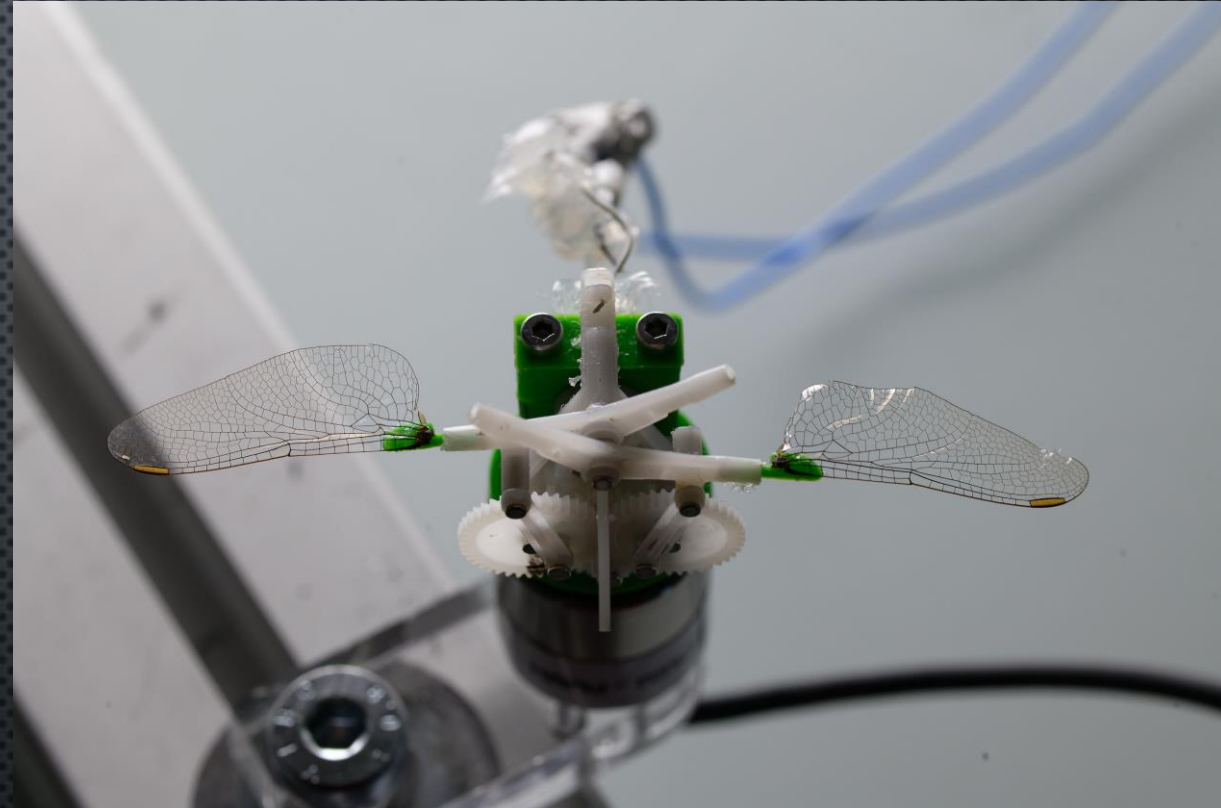
Right forewing specimen 1.14
Anax parthenope sp. (Odonata : Aeshnidae)

CONCLUSION

- FLIGHT PERFORMANCE OF ODONATA IS LINKED TO MECHANICAL PROPERTIES OF THEIR WINGS
- WE CAN COLLECT INFORMATION ABOUT MECHANICAL BEHAVIOR
 - FREQUENCY RESPONSE OF THE WING
 - RESONANT FREQUENCY – MUCH HIGHER THAN THE FLAPPING FREQUENCY
 - RELATIVE PHASE SHIFTS

PERSPECTIVES

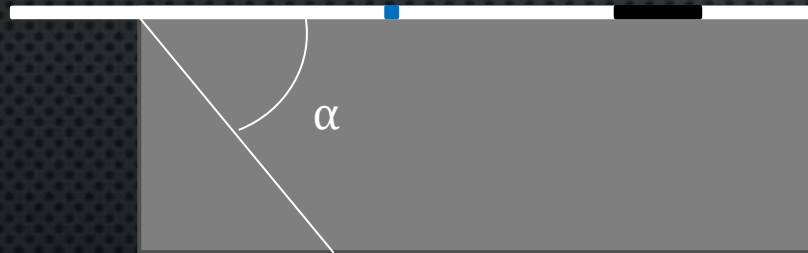
- LINKS AERODYNAMICS AND MECHANICS
- AERODYNAMIC STUDY OF REAL AND ARTIFICIAL WINGS
- CORRELATION WITH BEHAVIOR OF ACTUAL ODONATA ?
- MORE INFORMATION ABOUT ODONATOPTERA



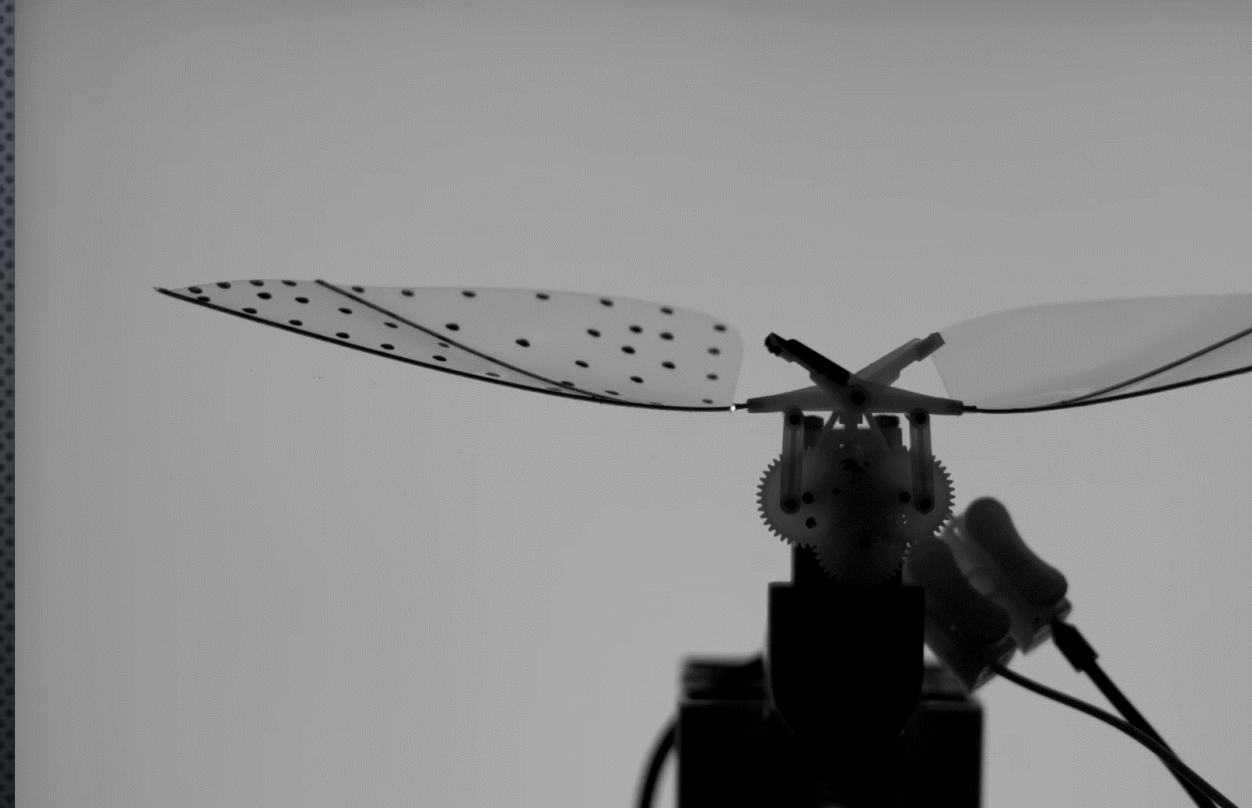
Aerodynamic study – simplified flapping flight

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Artificial wing



Artificial wing x 0,04

PERSPECTIVES

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EARTH
UNPLUGGED

Hawker

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Percher

DAMSELFLY - PERCHER, HOMEMADE WANDERLUST

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Tupus gallicus Nel *et al.*, 2009 (Meganeuridae), Permien (Lodève, France).

THANKS FOR YOUR ATTENTION.

170Hz AG 4,3 Coenagrion (Odonata : Coenagridae)

BIBLIOGRAPHY

Wootton, R. (2020). Dragonfly flight: morphology, performance and behaviour. *International Journal of Odonatology*, 23(1), 31-39.

Salami, E., Ward, T. A., Montazer, E., & Ghazali, N. N. N. (2019). A review of aerodynamic studies on dragonfly flight. *Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science*, 233(18), 6519-6537.

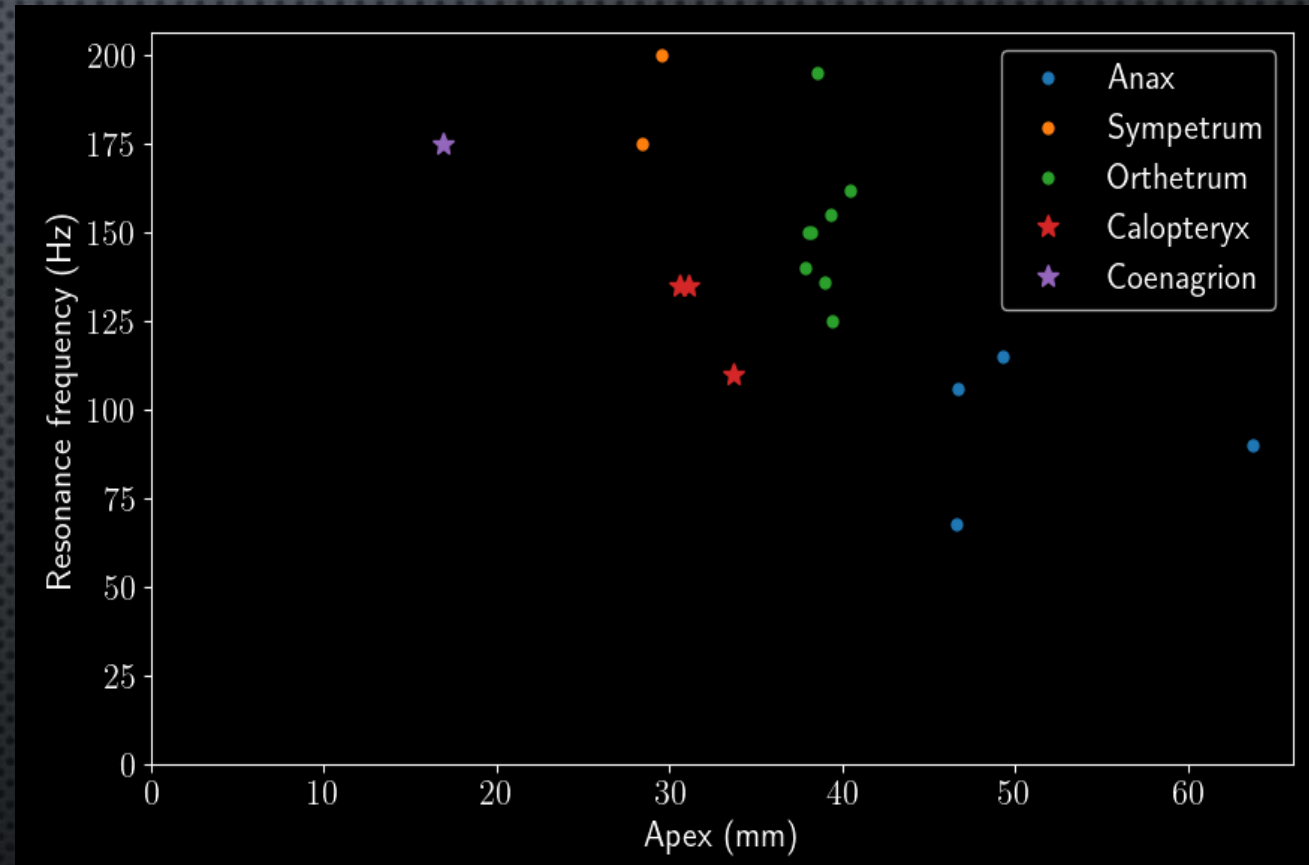
Nel, A., Fleck, G., Garrouste, R., Gand, G., Lapeyrie, J., Bybee, S. M., & Prokop, J. (2009). Revision of Permo-Carboniferous griffenflies (Insecta: Odonatoptera: Meganisoptera) based upon new species and redescription of selected poorly known taxa from Eurasia. *Palaeontographica Abteilung A*, 89-121.

San Ha, N., Truong, Q. T., Goo, N. S., & Park, H. C. (2013). Relationship between wingbeat frequency and resonant frequency of the wing in insects. *Bioinspiration & biomimetics*, 8(4), 046008.

Ramananarivo, S., Godoy-Diana, R., & Thiria, B. (2011). Rather than resonance, flapping wing flyers may play on aerodynamics to improve performance. *Proceedings of the National Academy of Sciences*, 108(15), 5964-5969.

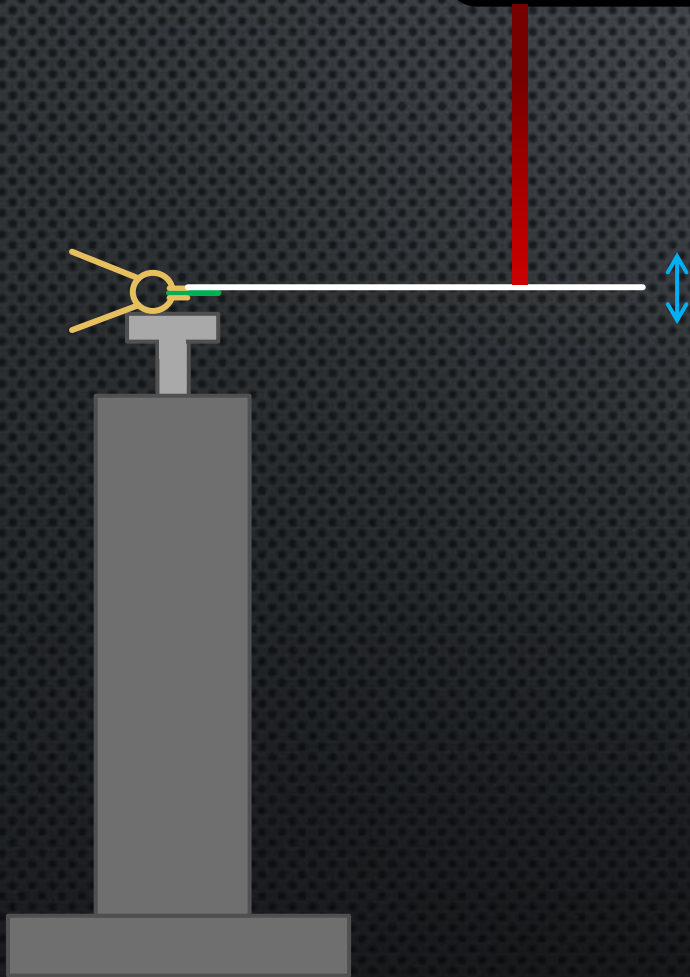
MECHANICAL CHARACTERISATION - CONCLUSION

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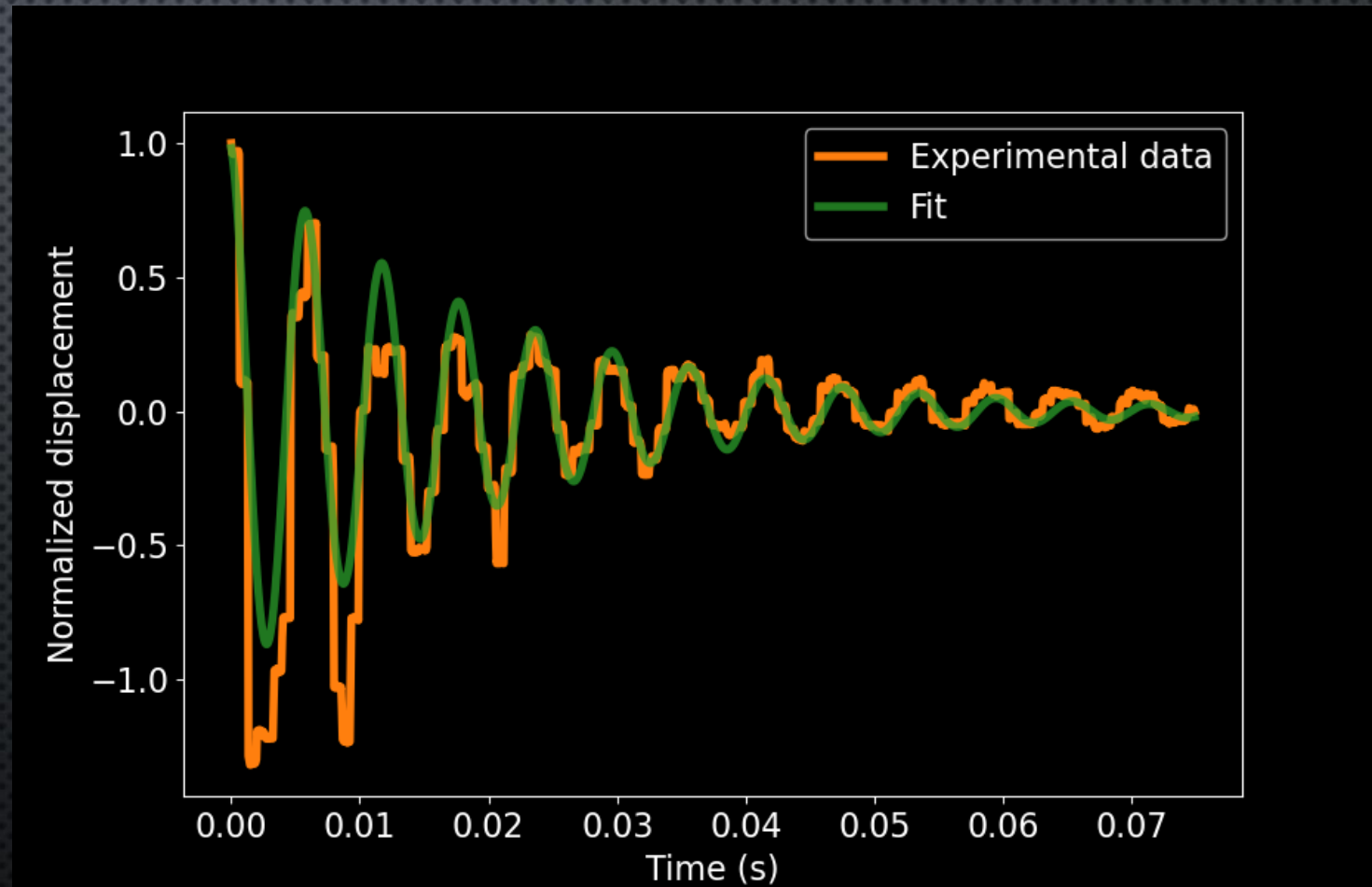


MECHANICAL CHARACTERISATION - A OTHER EXPERIMENT

Laser sensor



Imposes a displacement u_0 and observe the relaxation answer



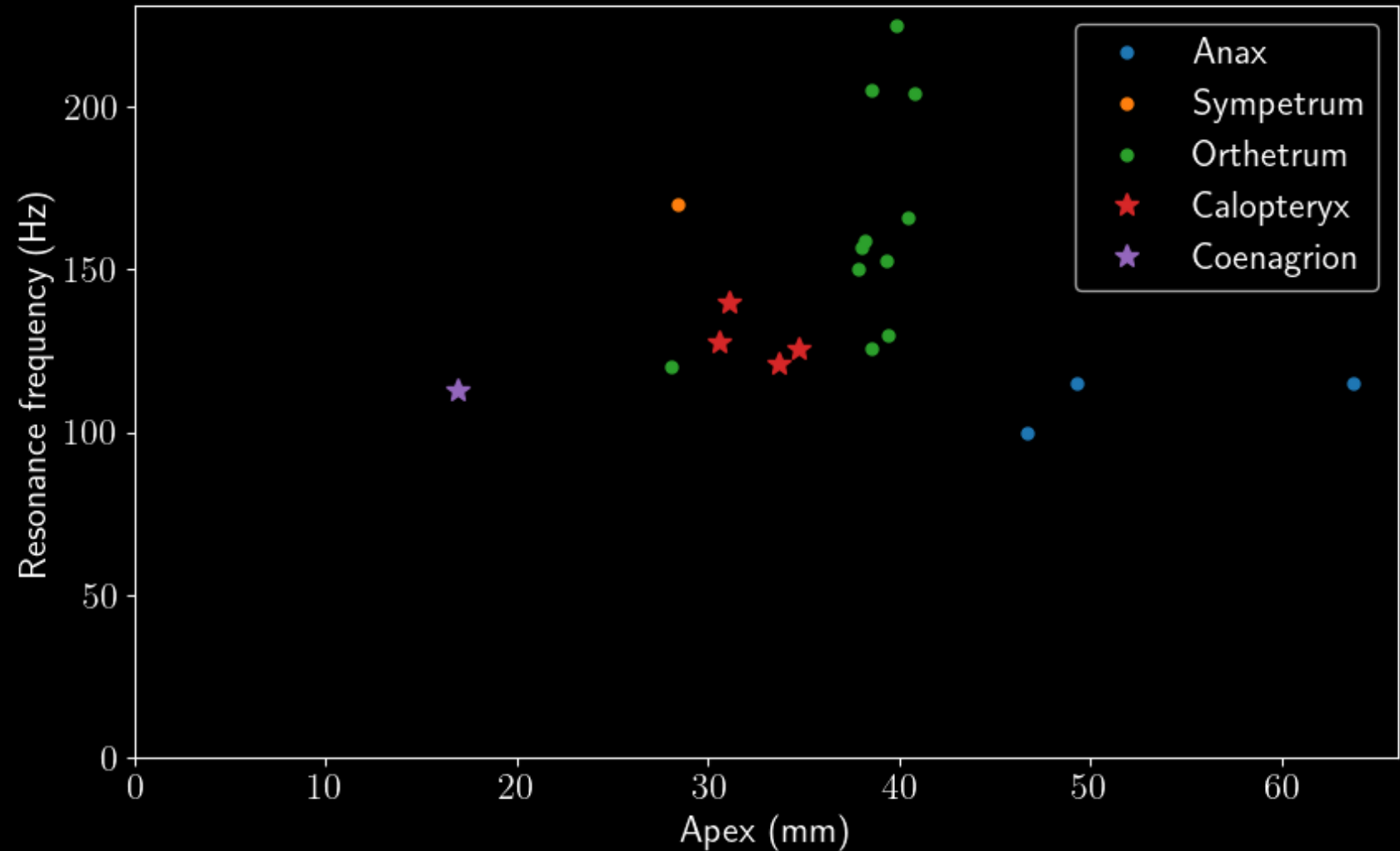
SAMPLE – REAL WINGS

Anisoptera :

- Aeshnidae Anax
 - Anax congoliath
 - Anax parthenope
- Libellulidae
 - Orthetrum
 - Sympetrum

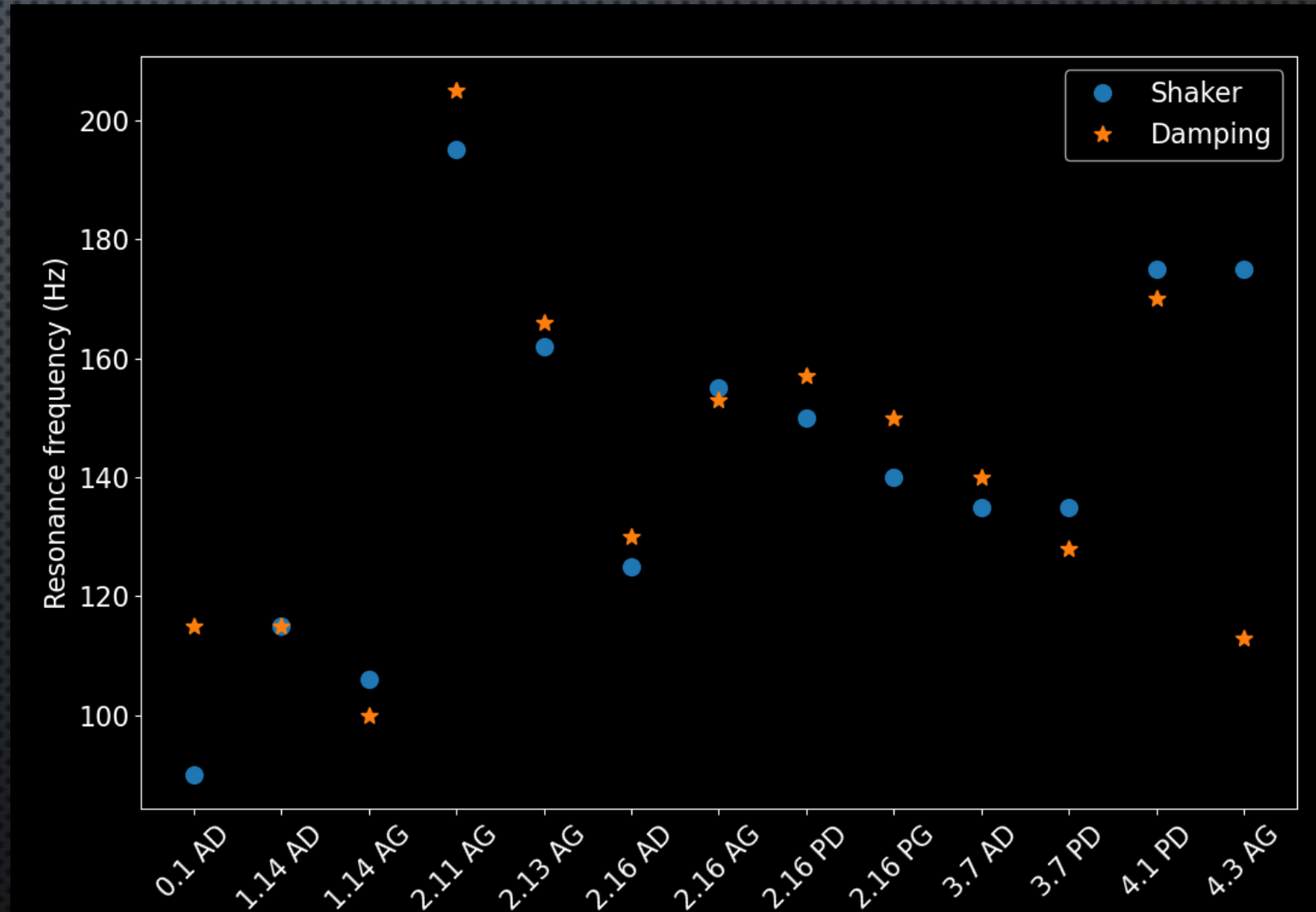
Zygoptera :

- Coenagrionidae
 - Calopteryx
 - Coenagrion

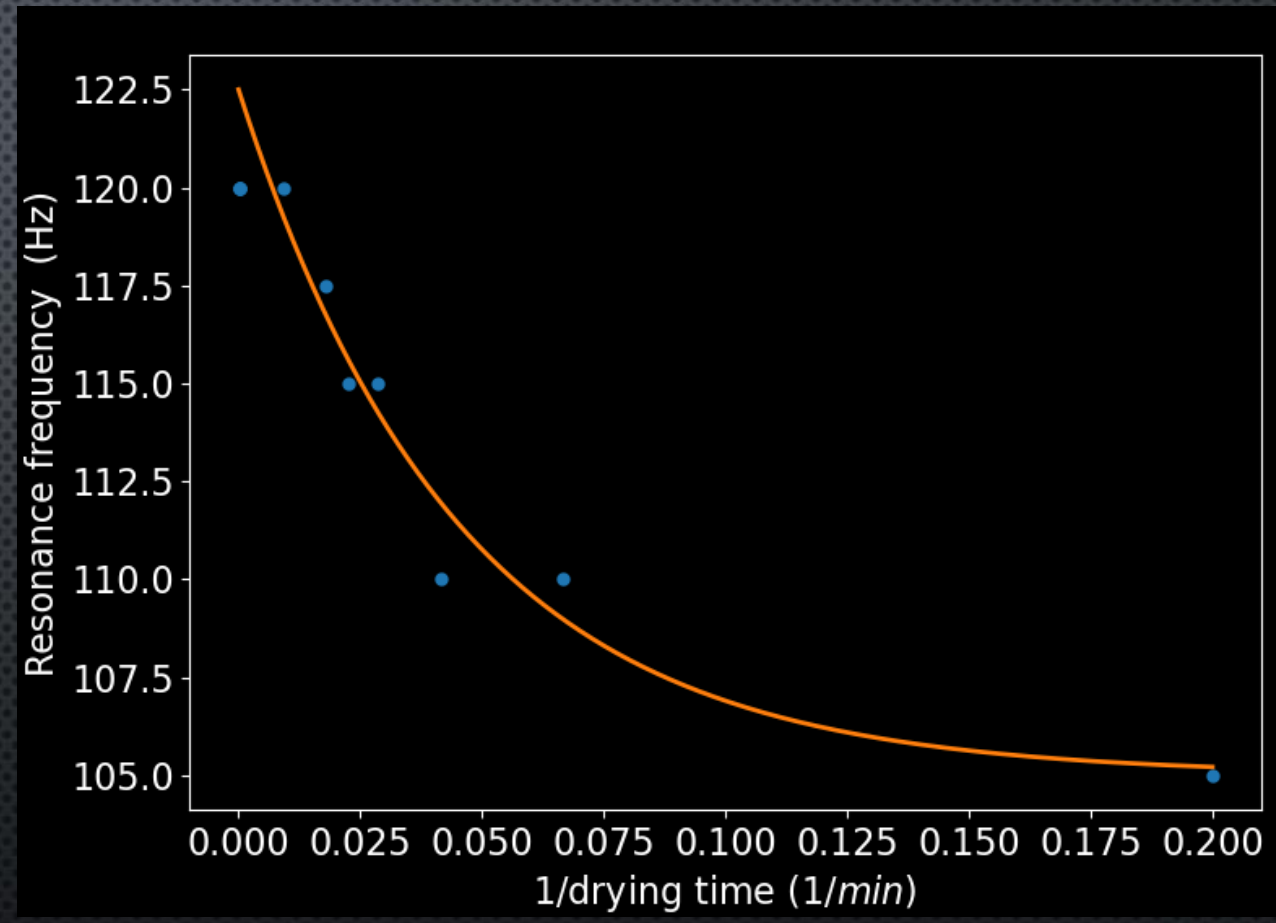
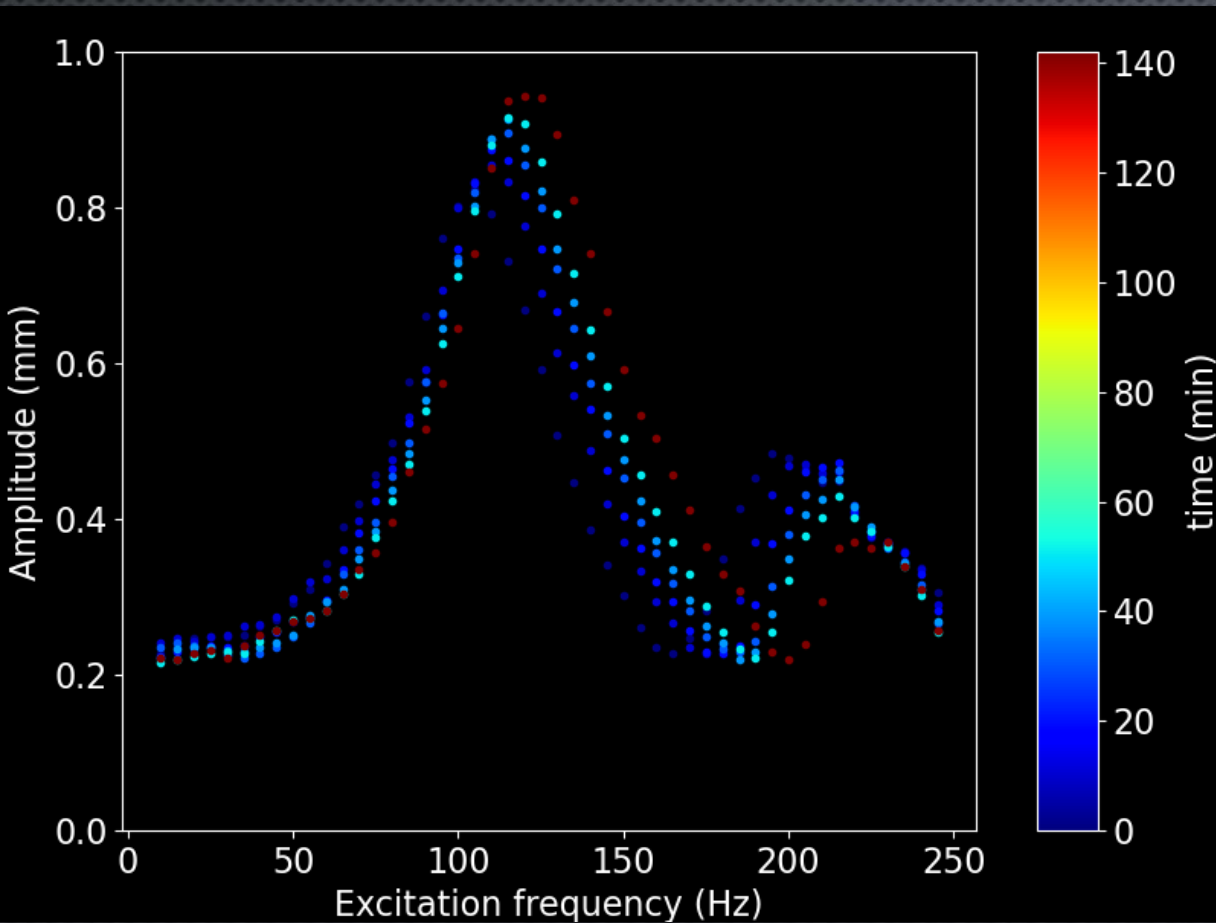


CONCLUSION – PERSPECTIVE

- CURRENTLY, THERE IS NO IDENTIFY TREND
- DOUBLE CHECK EXPERIMENTAL RESULTS
- PERFORM COMPARATIVE STUDY ON MORE SPECIMENS
- VISUALIZE THE DEFORMATION MODE ?
- ON ARTIFICIAL WINGS SEE THE INFLUENCE OF VARIOUS PARAMETERS

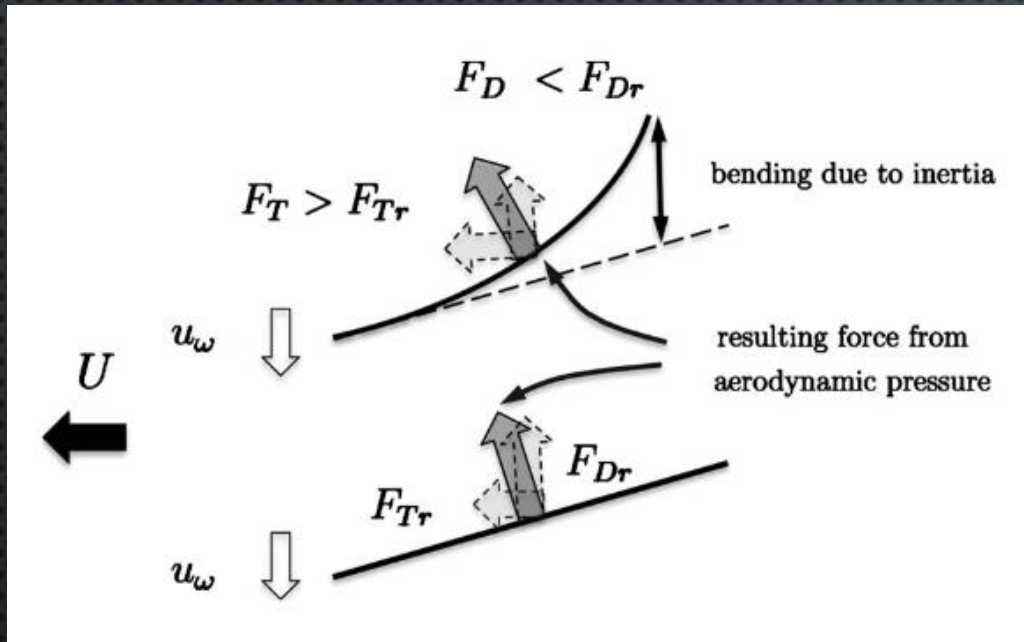


INFLUENCE OF DRYING TIME



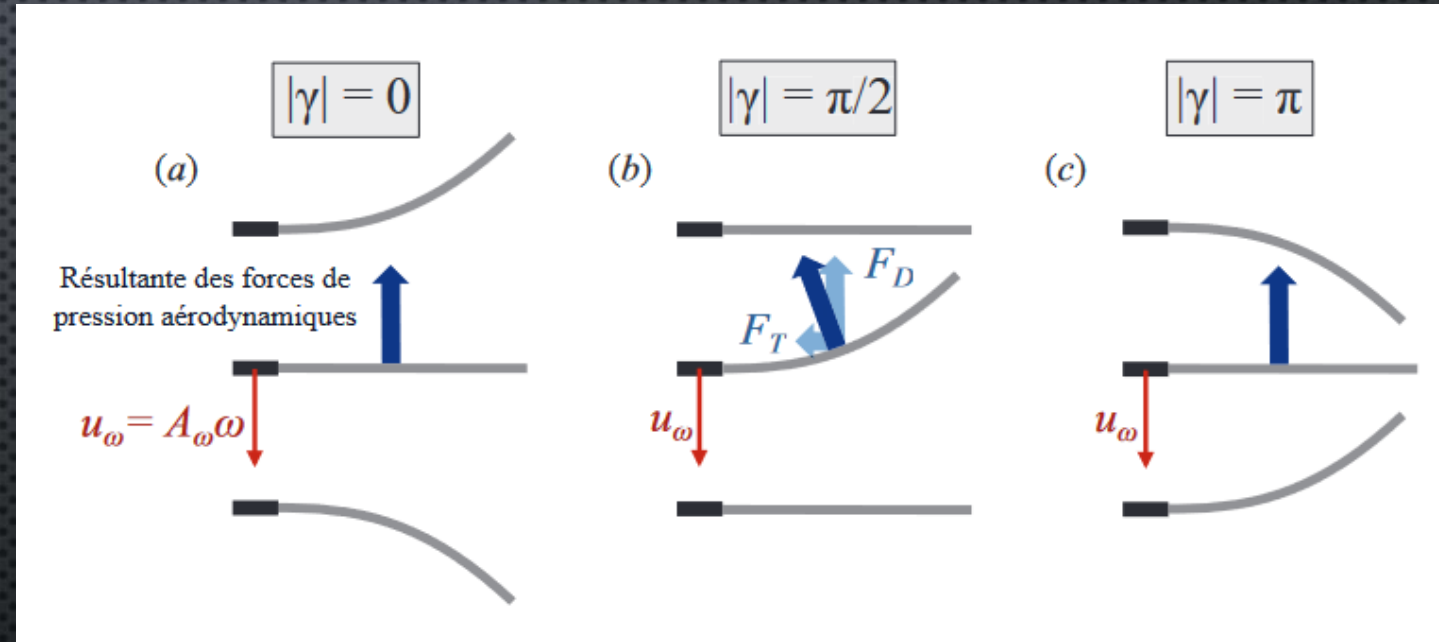
$$\tau = 22 \pm 7 \text{ min}$$

RELATIVE PHASE SHIFT – SHAPE – AERODYNAMIC EFFECT



Schematic diagram of the redistribution of aerodynamic forces.

Thiria, B., & Godoy-Diana, R. (2010). How wing compliance drives the efficiency of self-propelled flapping flyers. *Physical Review E*, 82(1), 015303.



Schematic shape of a beam during a cycle for various relative phase shift

RAMANANARIVO, Sophie. Propulsion biomimétique de structures élastiques. 2014. Thèse de doctorat. Université Paris-Diderot-Paris VII.