

The Relationship Between Joint Stiffness and Leg Morphology in Spiders

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Introduction:

- Stiffness is a material or structure's resistance to deformation¹
- Leg segment size (cross sectional area, length) \propto muscle size²
- Increased leg segment size \propto increased muscle size³
- Joint stiffness is vital for a spider's locomotion and sense abilities

We hypothesize muscle linear stiffness is proportional joint rotational stiffness.

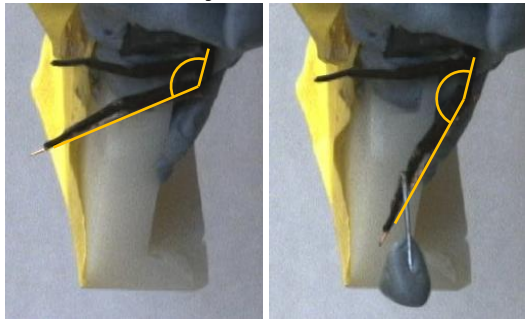
Objective: calculate joint stiffness of various types and sizes of spider species to help build morphological models used to predict spider biomechanics.

Methods:

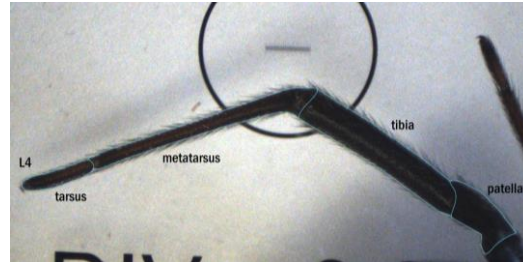
8 species were measured, with 2 joints/leg, and 3 trials/joint.

To calculate joint stiffness:

- The joint of interest was isolated.
- A mass was placed on a leg.
- The resulting joint extension was measured (seen below).
- Torque was calculated from these measurements, in addition to the leg length and position of the mass.
- Torque and the change in angle are used to find joint stiffness



Methods Continued:



- Cross-sectional area and length of the leg segments were measured using a microscope and 1mm scale

Species used: (approximate scales used)



Araneus diadematus



Dolomedes scriptus



Hapalopus colombia



Latrodectus hesperus



Leucauge venusta



Tiliotocatl albopilosus



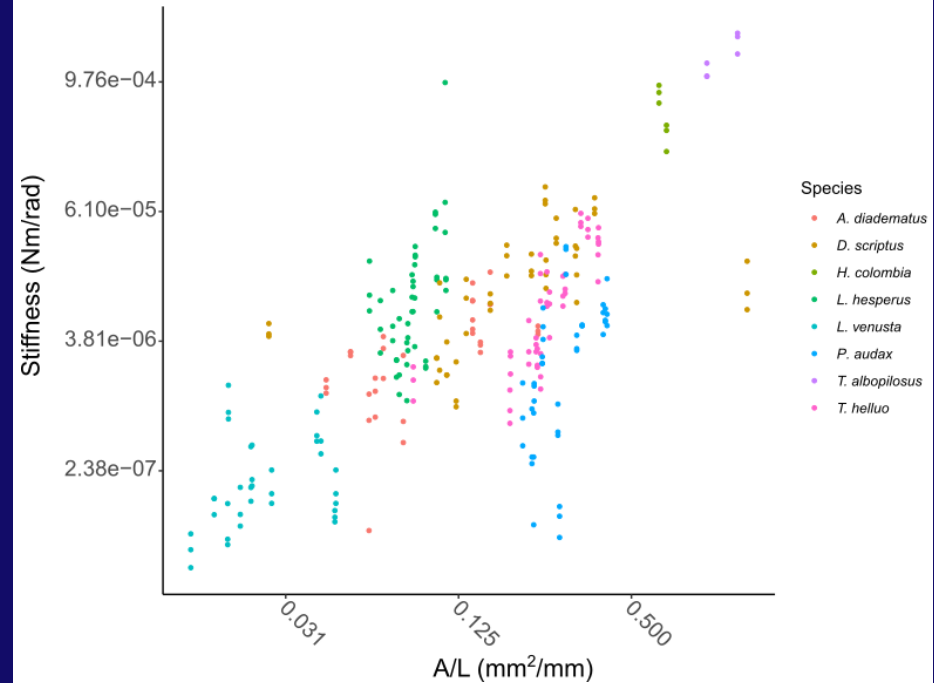
Tigrosa helluo



Phiddipus audax

Results:

Joint stiffness was plotted in relation to the leg cross-sectional area and length ratio (A/L) of the segment proximal to the joint. Both axes were log-scaled. Figure only shows the femur-patella joint of leg R1.



Conclusions:

- The relationship was initially predicted to be linear, and a biomechanical model to predict joint stiffness was created based on this.
- However, preliminary data suggests power law scaling.
- Therefore, one of the early assumptions may be incorrect, and joint stiffness may be influenced by more than just muscle size.
- Moving forward, a statistical model will be used.

References: (1) Ennos, R. (2012). Solid biomechanics. Princeton University Press, (2) Landkammer, S., Winter, F., Schneider, D. and Hornfeck, R. (2016). Biomimetic Spider Leg Joints: A Review from Biomechanical Research to Compliant Robotic Actuators. Robotics 5, 15, (3) Parry, D. A. (1957). Spider Leg-muscles and the Autotomy Mechanism. Journal of Cell Science s3-98, 331-340.