Species and population-level differences in submersion tolerance among riparian and non-riparian spiders

Phidippus purpuratus

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Pardosa lapidicina

ABSTRACT

Spiders that inhabit dynamic boundaries between terrestrial and lotic systems are under constant risk of flooding. Many species may have evolved adaptations to respond to rising water either through avoidance or submersion tolerance. Mechanisms for coping with periodic flooding have important implications for predicting species composition, recolonization, and resilience against flood-related disturbance for riparian arthropod communities. We examined submersion tolerance of spiders by taxon and microhabitat, comparing web-building and cursorial, riparian and non-riparian, and ground-dwelling versus arboreal species. We submerged individual spiders for three hours in distilled water and recorded survival, activity level immediately after removal, and activity level eight hours after removal (N = 1,154). During trials we noted that most but not all spiders formed plastrons (breathing bubbles) during submersion. We found large differences in submergence tolerance by guild and habitat but not sex of the spider. Web-building spiders and vegetation-dwelling cursorial spiders showed poor survival post-submersion, even those that live on overhanging vegetation along rivers and streams. Most ground-dwelling cursorial spiders including wolf spiders and fishing spiders showed no negative effects of submersion and most were active the entire time of submergence. We also found significant differences in submersion tolerance between populations of wolf spiders of the same species within the riparian zone compared to populations from other habitats, indicating population-level local adaptation to flooding. Population-level differences in submersion tolerance indicate that riparian ground spiders likely persist during flood events rather than being recolonized by new spider populations.

INTRODUCTION

Riparian zones are dynamic ecotones that are prone to episodic flooding. Terrestrial arthropods that inhabit these areas may exhibit behavioral, morphological, or physiological adaptations to survive inundation by showing high levels of submersion tolerance. These tolerances may vary substantially with the integument, respiratory systems, microhabitat preferences, feeding ecologies, life history patterns or sex of the spider. Previous studies of the wolf spider *Pardosa lapidicina* suggest high submersion tolerance (Keiser and Pruitt, 2014) but it remains unknown if such tolerance is site or taxon specific. Stratton et al. (2003) found that the exoskeleton cuticles of wolf spiders (Lycosidae) and fishing spiders (Pisauridae) have a high degree of hydrophobicity, suggesting faster recovery times from submersion than other spider families. Both pisaurids and lycosids are cursorial ground spiders that do not build webs. We predicted that these, and other cursorial ground spiders such as gnaphosids and corrinids may be particularly resilient and adapted to inundation. In contrast, vegetation-dwelling cursorial spiders (e.g. salticids and oxyopids) should exhibit lower tolerance since they may be more likely to avoid flooding by moving up through vegetation. We also predicted that web-building spiders that utilize vegetation for support may also show lower levels of submersion tolerance and that riparian species should have higher submergence tolerance overall compared to non-riparian species. Riparian and non-riparian populations within a species were also compared. Decleer (2003) observed that spider populations in marshland have increased survival rates during inundation trials when compared to populations outside of marshlands. We similarly hypothesized that populations in riparian habitats will exhibit greater submersion tolerance than their non-riparian counterparts of the same species due to periodic flooding in these areas. Finally, we predicted, due to sexual dimorphism among many spider species, significant sex differences in submergence tolerance.

QUESTIONS

- **Are there differences in submersion tolerance among spider families and genera?**
- **Do differences in submersion tolerance reflect ecological differences among spider taxa?**
- **Are populations of different lycosid species locally adapted to flooding?**
- **Do males and females show different submergence tolerance?**

Castianeira occidens

Gnaphosa sericata

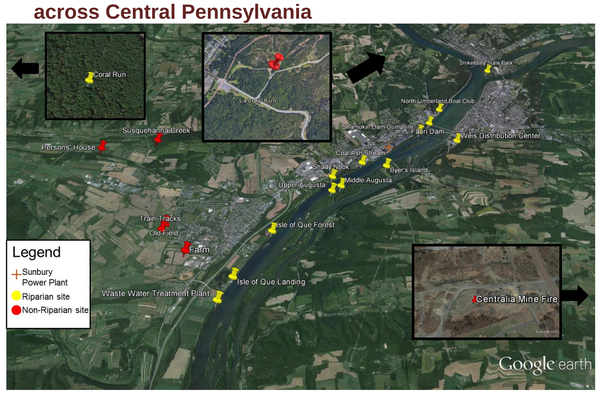
Pirata piraticus

Sampling Methods

Agelenopsis pennsylvanica

Dolomedes scriptus

- **Collected spiders across 9 families and 21 genera (N=1,154) from riparian and non-riparian locations across Central Pennsylvania**

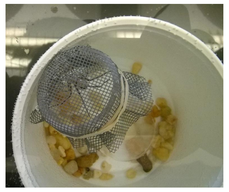


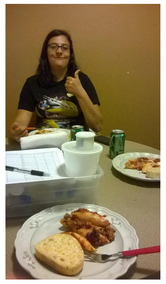
Tetragnatha elongata

Oxyopes salticus

Submersion Testing

Spiders were placed into vials with mesh tops and submerged in distilled water for 3 hours





- **The spiders that were not immediately responsive were monitored for 8 hours post-submersion (even during dinner).**
- **Full recovery time was defined as the time until a spider was standing upright after removal from the water (Figures 1-4).**

RESULTS

Are there differences in submersion tolerance among families and genera?

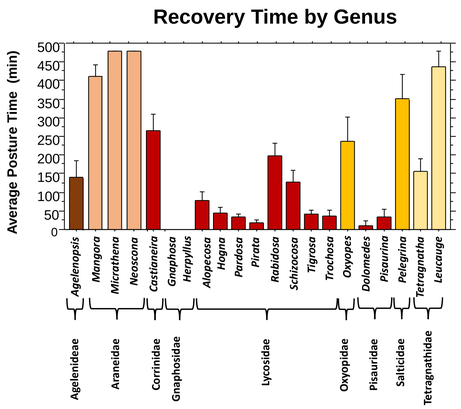


Figure 1: Recovery Time by Genus One-way ANOVA, Genus Effect: F =32.1; P=<0.0001, N=1,154.

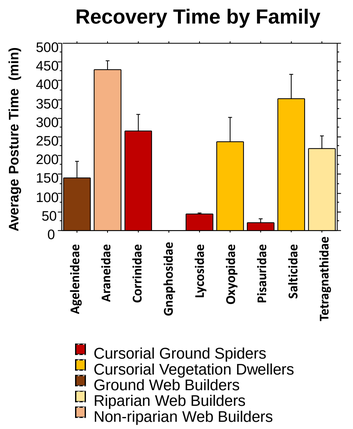


Figure 2: Recovery Time by Family One-way ANOVA, Family Effect: F =60.2; P=<0.0001, N=1,154

Are populations of different lycosid species locally adapted to flooding?

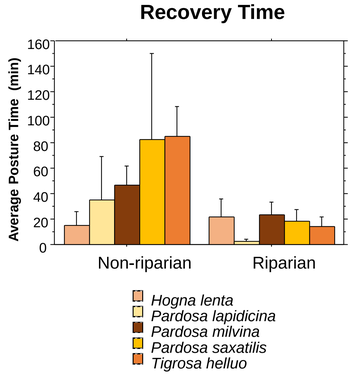


Figure 3: Recovery Time by Species Two-way ANOVA: Riparian/Not Riparian effect: F=8.42, P=0.0039; Species: F=1.27, P=0.2803, Riparian/Not Riparian*Species interaction: F=1.578, P=0.1790. N=492.

Are there sex-based differences in recovery time across families?

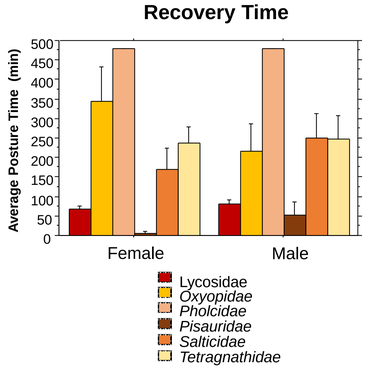


Figure 4: Recovery time by Family and Sex Two-way ANOVA: Female/Male effect: F = 0.023; P=0.8806; Family effect: F=29.569, P=<0.0001, Female/Male*Family interaction: F=0.915 P=0.4707. N = 916

SUMMARY AND CONCLUSIONS

- **Submersion tolerance varied among genera and family**
- Guild differences appeared with decreasing survival rates as follows: cursorial ground spiders, cursorial vegetation dwellers, ground web builders, riparian web builders, non-riparian web builders.
- Different guilds have different exposure and risk to flooding and therefore have evolved different methods of coping with it, including avoidance and tolerance.
- We found no significant sex differences in submergence tolerance across any of the six spider families tested.
- **Riparian wolf spiders are significantly more submersion tolerant than non-riparian wolf spiders of the same species, but we found no difference in tolerance across lycosid species.**
- Differences in recovery time across populations suggest that there is local adaptation to flooding. If so, then riparian populations are persistent, surviving periodic flooding rather than being recolonized by new migrants after every flooding event. This also suggests that any recolonization that may be occurring is insufficient to eliminate these adaptive differences.

References

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- Keiser, C., and Pruitt, J. 2014. Submersion tolerance in a lakeshore population of *Pardosa lapidicina*. Journal of Arachnology 42:192-194
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Susquehanna UNIVERSITY

Micrathena gracilis