Seasonal variation in soil moisture and temperature, and its impacts on earthworm communities

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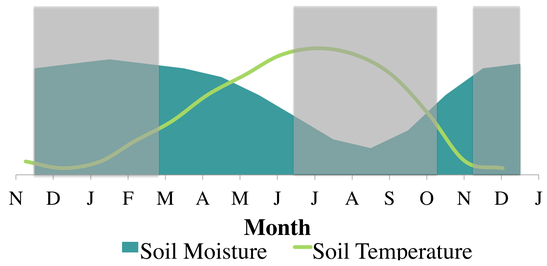
Introduction

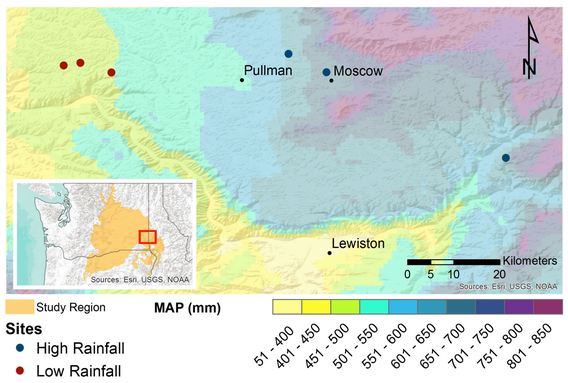
Earthworms are recognized biological indicators of soil health and are credited with increasing crop yields by an average of 25-35%. In the dryland wheat producing region of the Inland Pacific Northwest (IPNW) hot dry summers and cold wet winters may limit earthworm activity and its potential benefits to soil health and crop growth. This study seeks to determine the effect of seasonal soil moisture and temperature fluctuations on earthworm populations and active periods.



Generalized patterns in soil moisture and temperature. Months with earthworm activity expected to be limited by soil moisture or soil temperature in grey.

Materials and Methods

Six sites were selected within in two rainfall zones of the Palouse region, high (550-650 mm) and low (450-500 mm). Soil moisture and temperature probes were installed at 20 cm to allow continuous monitoring. Earthworms were sampled every 2 weeks from April-July. Earthworm sampling was carried out using a combined sifting/hand-sorting technique from 3 pits randomly located within a 10 m x 10 m area. Earthworms were weighed to determine fresh weight and adults were identified to species. Earthworms were considered to be aestivating if found curled up in a spherical chamber or desiccated and inactive. Soil moisture was also measured in individual pits at each sampling date at 20 cm. This work represents the preliminary results from the first sampling season.

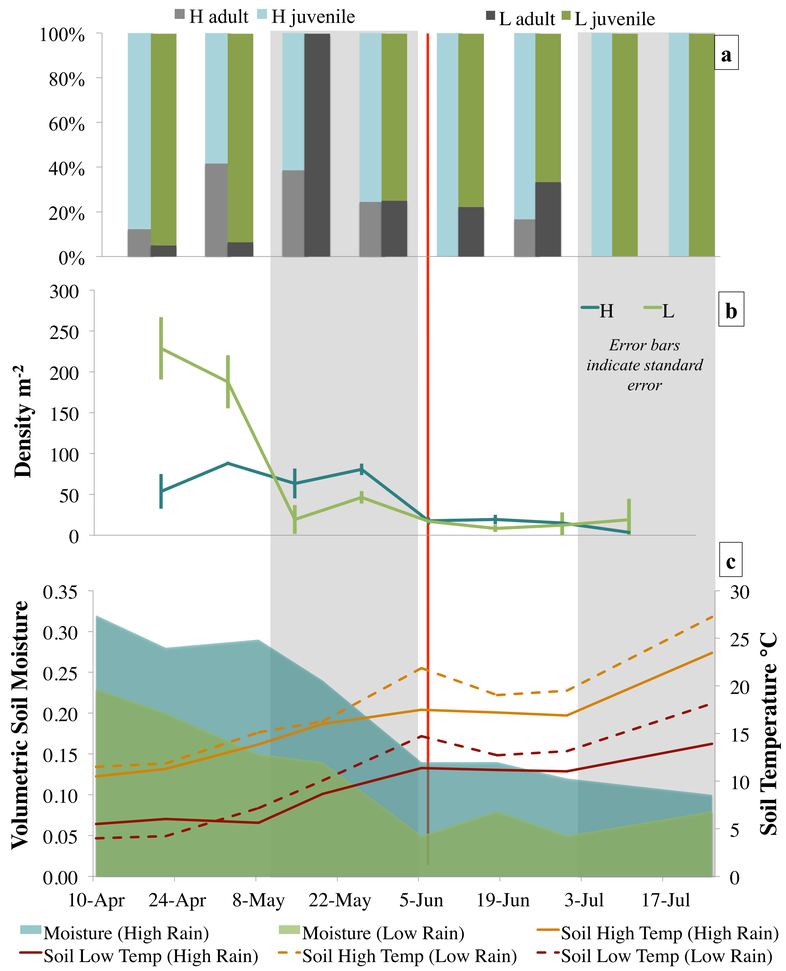


Inland Pacific Northwest agricultural region (inset) and location of sample sites in the Palouse region with mean annual precipitation (MAP).

Results

Seasonal Variation

For each sampling date the average proportion of juvenile and adult earthworms in high (H) and low (L) rainfall zones were measured **(a)**. At most dates juveniles made up a greater percent of the total earthworm population, but the much larger adults made up a greater portion of earthworm biomass when present. Earthworm density **(b)** declined throughout the season with the beginning of earthworm aestivation observed on the same date for all sites (red line). Earthworm populations were generally greater at the low rainfall sites despite there being less soil moisture and higher soil temperatures throughout the season **(c)**.



Earthworm species

The European species *Aporrectodea trapezoides* accounted for almost all of adult specimens collected over the 4 month period. This species is a common invasive earthworm with rapid reproduction allowing it to multiply quickly. Additionally this species is tolerant of a wide range of soil conditions and enters a state of aestivation to survive dry periods. Aestivating worms curl up in a spherical, mucous-lined chamber and enter a reduced metabolism state to conserve moisture. One adult *Lumbricus terrestris* was collected at one of the high rainfall sites on the first sampling date but no other adult specimens of this species were collected.

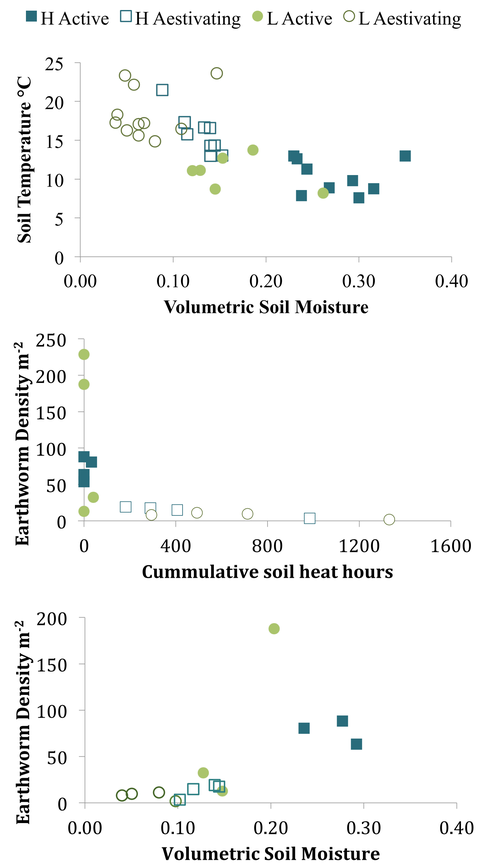
aestivating earthworm

Relationships between soil properties and earthworm populations

Earthworm temperature thresholds are thought to be increased as soil moisture increases. This interaction means that it is unlikely that either soil moisture or temperature alone will adequately explain earthworm variability. Earthworms in both high (H) and low (L) rainfall zones aestivated when soil temperatures rose near 15°C but earthworms remained active near this threshold when soil moisture was higher.

A metric reflecting the accumulation of heat stress (cumulative soil heat hours, CSHH), was developed. CSHH represents the number of hours with soil temperatures greater than 15°C, a temperature considered to be at the top end of *A. trapezoides* optimal range. The preliminary data shows earthworm aestivation beginning around 200 CSHH.

For both rainfall zones earthworms began aestivating when the mean soil moisture in the time since the previous sampling was around 0.15 cm^3cm^{-3}. Earthworm density also generally increased as soil moisture increased.



Conclusions

- The environmental flexibility of *A. trapezoides* and its ability to aestivate likely contribute to its prevalence in IPNW wheat fields.
- Earthworm densities varied over the course of the growing season ranging from 0-320 m^{-2}.
- Low densities of earthworms and short active periods may limit the potential positive impacts of earthworms on wheat production.
- Improved understanding of the interactions among soil moisture, temperature and earthworm activity can contribute to predicting the potential impacts of earthworms on crop yields now and under potential future climates.

Aporrectodea trapezoides

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Acknowledgements

The research was supported by National Institute of Food and Agriculture competitive grant, award number: 2011-68002-30191