Leaf Me Alone:

Effects of moisture, temperature, and elevation on arthropod density and diversity in leaf litter of forests in Robber's Cave State Park

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Abstract

Studies have shown that moisture, temperature, and elevation play key roles in the density and types of arthropods. We predicted that the lower the elevation moisture and the higher the temperature, the more arthropods would be found in the leaf litter collected from Robber's Cave State Park near Wilburton, Oklahoma.

We gathered samples from two different locations, one riparian and one upland, on two different dates exhibiting the patterns of cool and wet and warm and dry respectively. We put out samples through a process of drying using funnels and desk lamps. On the final day of the experiment, we recorded our findings.

The area with the most individuals was the dry upland area with seventy-nine specimens. The area with the most diversity was the wet upland area. This experiment indicated a preference for the wet area, higher area, and cooler area

Introduction

The presence of moisture, temperature, and elevation all play important roles in the day to day-to-day lives of the members of the phylum Arthropoda. Several studies have shown the different effects of moisture, temperature, and elevation on the density and diversity of arthropod species in different parts of the world.

Burgess, Ponder, and Goddard (1999) found a link between the density of arthropods and moisture of leaf litter in a study conducted during a three-year period from 1991-1993 in several different coastal forest locations of Tanzania. In this study, it was found that nine orders (Aranae, Isopoda, Diplopoda, Chilopoda, Homoptera, Heteroptera, Coleoptera, Hymenoptera, and Orthoptera) of arthropods seemed to prefer moist conditions over completely wet conditions and dry condition. It was also found that the type of environment (ridge-top and valley-bottom) also played important roles in the density of arthropods. Over all, most of the arthropods preferred the higher ridge-top environments except during the dry season.

A study by Saska1, van der Warf, Hemerik, Luff, Hatten and Honek (2013) examined the effects of temperature on pitfall catches of arthropods from the Czech Republic, the Netherlands, and the United States. It was found that higher temperatures produced higher catch rates in the pitfall traps, which is expected since arthropods are ectothermic, meaning that they derive their body heat from outside sources (i.e. the sun), and poikilothermic, meaning that their body temperature fluctuates (Lithicum, "Animal Body Types - Basics", 2011).

The effects of elevation were tested by a study conducted by Ghosh-Harihar. In this study, the effect of elevation along with temperature and precipitation were study for a period of several months during the summer in the Himalaya Mountains of Nepal. In the study, it was found that six orders of arthropods (Hemiptera, Aranae, Coleoptera, Diptera, Ants (Hymenoptera), and

Lepidoptera) all preferred a certain zone of elevation between the low elevations and higher elevations, except the ants, which preferred lower elevations.

In light of all the information found in these studies, we decided to test the effects moisture, temperature, and elevation on the density and diversity of arthropods in leaf litter found in Southeastern Oklahoma. We looked for the optimal location for collecting from a riparian location and an upland location and thus chose Robber's Cave State Park near Wilburton, Oklahoma, which varies greatly in elevation for an area in Southeastern Oklahoma and has a decent variety of flora and fauna, since the park is protected. We looked for optimal windows in the weather forecast for collection days. The first day of the experiment was to be rainy and cool so we thus decided to test the areas under wet conditions first. Before choosing a day to collect from the areas under dry conditions, we looked for a day where we would have several days without rain before collecting to ensure that samples would be as dry as possible.

We predicted that there would be significantly higher numbers in the dry riparian area, since the factors of temperature and moisture would be higher in this area. We also predicted that we would see a marginal increase in the number of different arthropods collected from the dry riparian area. We did not predict that elevation would play a significant role because the differences in elevation throughout the park is only 100 m or so.

In order to collect arthropods from the leaf litter, we decided upon a method, recommended to us by our instructor, in which we would set up funnels and lamps with a small container of ethyl alcohol bellow the funnel for trapping the arthropods.

Materials and Methods

We began the experiment by setting up our equipment in the lab. We used four metal ring stands with the clamp set to 8 cm above the bottom plate on each one. On the ring, we mounted four plastic funnels, each with a 2 L volume. In the bottom of each funnel, we placed metal mesh with 5mmx5mm gaps, cut to fit the area of the funnel where the cylindrical section meets the conical section. We taped the plastic funnels to the ring stands with transparent packing tape for added stability. Below each of the funnels, we placed 100 ml containers filled with 50 ml of denatured ethyl alcohol (Fisher Scientific, 300 Industry Drive, Pittsburgh, PA 15275), in order to catch the arthropods fleeing the light. We put each ring stand in chairs and four 26.5 com tall desk lamps, each with a GE energy efficient, soft white 60w, 750 Lumen lightbulb in each on the table above the funnels. We positioned each of the lamps so that the lightbulb in each desk lamp was 12 cm above the top inner ring of each funnel. We labeled each of the funnels, lights, and containers with the labels “wet riparian”, “wet upland”, “dry riparian”, and “dry upland” to ensure that all of the components remained in place.

Since it had been raining that day (April 14, 2015), we decided to collect our wet samples first. The first site, the wet riparian area, is located near the caves in Robber’s Cave State Park, in Latimer County, Oklahoma, United States of America (35°00’18”N 95°20’06”W), at an approximate elevation of 272.186 m above sea level. The ambient temperature, humidity, dew point, wind speed/direction, and rainfall totals were unavailable because of the absence of cellular phone service at that part of the park. The temperature, humidity, dew point, and rainfall totals were recorded at the upland sight, where cellular service was achieved, approximately 5.6 km away. The ambient temperature was 13.8889°C, with a dew point at 12.2222°C. A slight wind blew from the northeast at 11.2654 km/h. Humidity was high at 85% and 4.826 cm of rain had fallen at that point in the day, which was at 4:01 pm, CST. The overcast was heavily cloudy at the riparian site.

The first sample was collected within 2 m of a creek at 3:41 pm, CST. We measured a half-meter square of litter. We dug down about 4 cm, which was enough to collect the leaves, detritus, and a quantity of soil, about 1 cm deep. We placed the sample in a plastic sack and tied it to ensure that the moisture content of the sample was preserved. We covered the area with surrounding litter to ensure that a similar sample could be taken when dry conditions were tested. A flag was planted in the middle of the sight to demarcate the exact location of where the sample was taken.

After collecting at the riparian location, we traveled to the upland area, which is located near the lodge at Robber's Cave State Park, in Latimer County, Oklahoma, United States of America (34°58'47"N 95°21'01"W), at an approximate elevation of 288.341 m above sea level. The temperature was 13.8889°C, with a dew point at 12.2222°C. A wind blew from the northeast at 11.2654 km/h. Humidity was high at 85% and about 4.826 cm of rain had fallen at that point in the day, which was 4:01 pm, CST. The heavy overcast persisted.

The collection procedure was repeated. We covered the area with surrounding litter to ensure that a similar sample could be taken when dry conditions were tested. A flag was planted in the middle of the sight to demarcate the exact location of where the sample was taken.

On return to the lab, the samples were opened and the leaves were identified. The wet riparian sample contained leaves of *Platanus occidentalis* (American sycamore), *Quercus macrocarpa* (bur oak), *Ulmus rubra* (slippery elm), *Quercus alba* (white oak), *Quercus nigra* (water oak), and *Celtis laevigata* (Sugar berry). The wet upland sample contained leaves of

Quercus stellate (post oak), *Quercus nigra* (water oak), *Pinus echinata* (short-leaf pine), *Ulmus americana* (American elm), *Quercus palustris* (Pin oak), *Quercus alba* (white oak), *Pinus taeda* (loblolly pine), and *Ulmus alata* (winged elm).

After the identification of leaves, we measured 225 g of each sample in 75 g increments because the scale we were using had a low maximum weight. The increments were placed in their respected funnels. We made sure the lamps were plugged in and thus finally turn them on. The samples were left to dry, which would cause the arthropods to travel toward the bottom of the funnel, fall into the alcohol and die. The samples remained in the funnels for seventeen days.

We were finally able to collect our dry samples on April 29, 2015, when dry conditions persisted long enough for us to collect samples without exceeding the time restrictions of the experiment. We returned to our original sites to gather dry samples.

The first dry sample to be collected, the upland sample, was gathered at 11:35 am, CST. The temperature was 21.111°C. The wind blew from the northwest at 8.0467 km/h. The dew point was at 8.8889°C and the humidity was at 45%. There was little to no overcast and the sun was shining. The process of collection was repeated and the sample was successfully gathered.

The riparian sample, was collected at 11:45 am, CST. The ambient temperature was approximately 18.8889°C. The wind came from the northwest at a speed of 11.2654 km/h. The dew point was at 8.8889°C and humidity was at 45%. There was little to no overcast sill and the sun was shining. The collection process was repeated and the sample was successfully gathered.

On return to the lab, we measured 225 g of each sample using the same technique. The samples were placed in their respected funnels. We made sure the lamps were plugged in and thus finally turned them on. The samples remained in the funnels for two days.

On May 1, 2015, we turned of our lamps and examined each of the vials that were placed below the funnels. We took each vial and dumped their contents into four different petri dishes. We placed each petri dish underneath a dissecting microscope. Using small forceps, we sifted through each sample, carefully trying to isolate any arthropods that were visible. We took droppers and carefully gathered arthropods that appeared to be morphologically similar and placed each type in its own vial. We identified as many organisms as possible and later, our instructor helped us to identify even more.

Results

Upland	Riparian
Quercus stellata (Post oak)	*Platanus occidentalis* (American sycamore)
Quercus nigra (Water oak)	*Quercus macrocarpa* (Bur oak)
Pinus echinata (Short-leaf pine)	*Ulmus rubra* (Slippery elm)
Ulmus americana (American elm)	*Quercus nigra* (Water oak)
Quercus palustris (Pin oak)	*Celtis laevigatta* (Sugar berry)
Quercus alba (White oak)	
Pinus taeda (Loblolly pine)	
Ulmus alata (Winged elm)	

Table 1 Survey of tree species' leaves found in litter from areas

Table 1 contains a survey of all the trees the leaves of which were identified in the litter. The upland liter contained more species than the riparian liter and thus was denser.

Upon examination of the vials of alcohol, arthropods from the orders Entobryomporpha (springtails), Aranae (spiders), Acariformes (mites), Hymenoptera (ants), Coleoptera (rove beetle), Diptera(flies, gnats, cranefly larvae (family Tipulidae), midge (family Chironomidae), humpback fly (family Phoridae)) Thysanoptera (thrips), Parasitiformes (ticks), Polydesmida (millipedes), and Pseudoscorpionida (pseudoscorpion) were found (Table 2). Springtails were predominant in all areas; whereas, in some cases, only one representative of a species were found only in one of the four areas.

The area with the most individuals was the dry upland area with seventy-nine specimens. The area with the most diversity was the wet upland area (Figure 1). Figure 2 shows the preferences of the arthropods in terms of moisture, elevation, and temperature.

	Wet Riparian	Dry Riparian	Wet Upland	Dry Upland	Total
Entobryomporpha	19	13	38	47	117
Aranae	0	0	6	11	17
Acariformes	1	1	18	15	35
Hymenoptera	0	0	1	5	6
Coleoptera	0	0	1	0	1
Diptera	6	0	2	0	8
Thysanoptera	0	0	1	0	1
Parasitiformes	2	1	0	1	4
Polydesmida	3	0	0	0	3
Pseudoscorionida	0	0	1	0	1
TOTAL	**31**	**15**	**68**	**79**	**193**

Table 2 shows the numbers for each order identified in all areas as well as the totals for all areas and the total number of individuals collected.

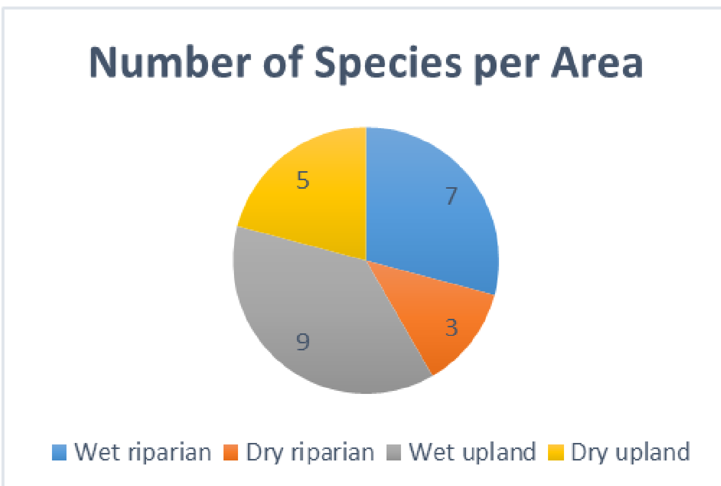

Figure 1 shows the numbers of species found in each area.

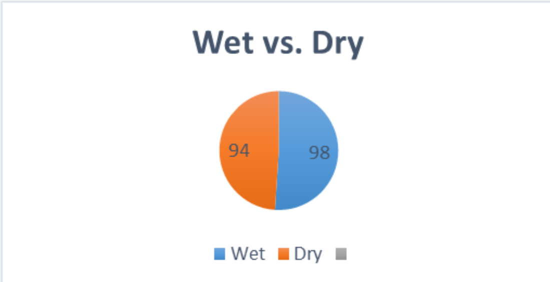

Chart 1 shows the number of specimens found in the different moisture contents

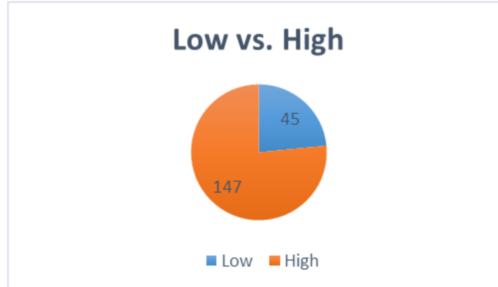

Chart 2 shows the number of specimens found at different elevations

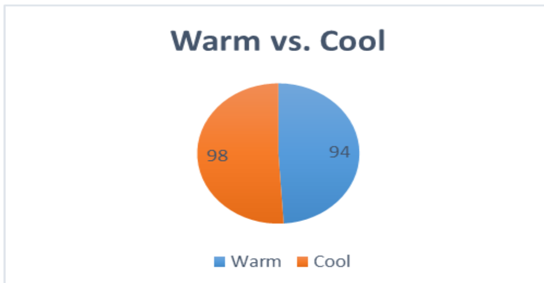

Chart 3 shows the number of specimens found in the different temperatures.

Figure 2 contains charts that depict the preferences for the tested conditions in the tested areas.

In this experiment, it was found that there was a preference for the wet area, higher area, and cooler area. The area that apparently had the best conditions for the most individuals was the dry upland area and the area that had the best conditions of the most species was the wet upland area.

Discussion

We found that level of moisture and elevation seemed to play the biggest roles in density and diversity of arthropods in leaf litter.

Springtails were predominant in all area with a preference for the dry upland area. Springtails need moisture and are attracted to light (Perry, "How to Manage Pests", 2014), thus meaning that the dry upland area provided enough moisture and light to suit their needs, since the upland area had fewer trees and sunlight could easily filter down into the leaf litter. Spiders also share a preference for light which may be the reason that they were found in the dry upland are as well (Jacobs, "Spider Management - Entomology (Penn State University)", 2002). Ants often nest in warm moist places (Rust, Choe, "How to Manage Pests", 2014). While the upland area may not be the moistest, it does offer more sunlight. Since arthropods are endothermic and poikilothermic, one can see why they would prefer the upland area (Lithicum, "Animal Body Types - Basics", 2011).

The rove beetle on the other hand was found in the wet upland area. Its distribution is restricted to moist micorhabitats and are often found in dark areas (Frank, "Rove Beetles - Staphylinidae", 1999, 2012), such as caves. Its being found in the wet upland area is no surprise because the sky was cloudy that day and offered optimal conditions for the rove beetle. One specimen of thrips was found in the wet upland area as well. Thrips inhabit flowers, leaf litter, and fungi throughout the world (Meyer, "Classification & Distribution", 2009). Some predatory thrips feed on ticks and mites (Meyer, "Classification & Distribution", 2009), which may explain why we found a thrips in this area, since the highest concentration of mites was encountered there. A single midge was collected in this area. Midges are attracted to light and thus would not be out of the question to find one on sunny days (Pinder, A., Davis, J. and Lane, J. “Managing the Midge”, 1992). The humpback fly was found in this area which would be a suitable place for breeding (Benson, "Humpedback Flies", 1999). The solitary pseudoscorpion specimen found was also in this area, possibly because of the abundance of other arthropods in this area on which it preys (Jacobs, "Pseudoscorpions ", 2004, 2013).

There were no major numbers of arthropods found in the dry riparian area. All of the species collected in the dry riparian area were found in more abundance in the upland areas or the wet riparian area. This could be that the dry riparian area offered the least amount food or offered the least hospitable conditions than the other areas.

The two species that seemed to prefer the wet riparian area were the flies and the gnats. They are most likely prevalent in the wet riparian area because the larvae stages need a semi-aquatic environment (Meyer, "Diptera", 2009), which would make the wet riparian the most preferable.

The weather would not cooperate with this experiment’s time frame. We had trouble finding a day on which it had not been raining much less a day where it had not rained for several days, which is characteristic of Southeastern Oklahoma during the spring, which is usually the wet season. If the weather conditions would have prevailed like we wanted them, we would have collected the dry samples sooner in order to provide a maximum time for drying the sample. With time running out, we decided on April 29. It had been raining the days before but it was the first day with higher temperatures and sunny skies that would give us enough time to at least let our dry samples sit under the lamps for at least two days.

If this experiment were to be repeated, we suggest to do it during the summer months when the weather is drier. It would be easier to find a day when it rains in the summer than a day that the weather is sunny in the spring. If the experiment were then performed in the summer, it may be possible to find more arthropods because conditions would be better suited for arthropod activity. The addition of a moist third-area sample could help the nature of the experiment. A moist area would be medium between wet and dry and could yield a difference in results.

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