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SHORT COMMUNICATION

Microhabitat distribution of *Drapetisca alteranda*, a tree trunk specialist sheet web weaver (Araneae: Linyphiidae)

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Abstract. We conducted systematic sampling to examine the microhabitat distribution of the Nearctic linyphiid *Drapetisca alteranda* Chamberlin 1909; adults are found almost exclusively on tree trunk surfaces. Sampling was conducted in a 1 ha plot in which all trees over 10 cm dbh had previously been identified, mapped, and measured. Tree trunks were sampled for *D. alteranda* by brushing spiders into beating sheets. We sampled equal trunk surface areas (0.5–2.0 m) of the four most abundant tree species on the plot: *Quercus alba*, *Fraxinus pennsylvanica*, *Tilia americana*, and *Carya ovata*. We measured tree bark furrowing depth at 15 locations around each tree. We analyzed the data with a General Linear Mixed Model, assuming Poisson distribution. Tree species and furrowing depth, but not tree size, were significant predictors of total number of *D. alteranda* collected. Eighty-four percent of the spiders were collected on *T. americana*, and the relationship between spider abundance and furrowing depth was negative. As a separate test for *D. alteranda* vertical distribution, we divided the lower 3 m of selected tree trunks into six 0.5 m sections, sampling each separately. Regardless of tree species, height above ground was a significant predictor of female (but not male) *D. alteranda* occurrence, with 52% of the females found 0.5–1.0 m above the forest floor. These results suggest that the microhabitat distribution of *D. alteranda* is broadly similar to that of the Eurasian species *D. socialis*, a species that matures in leaf litter and migrates mostly to the lower regions of tree boles to forage as adults.

Keywords: Linyphiid spider, habitat selection, vertical distribution, *Drapetisca socialis*

Microhabitats (i.e., small scale, localized environments) are characterized by unique ecological features including temperature, humidity, substrate types, species assemblages, and predator-prey relationships (Ziesche & Roth 2008). Microhabitat selection is important to the survival and successful reproduction of many species of arthropods and has been shown to play a pivotal role in regulating population dynamics and maintaining biodiversity (Michel & Winter 2009). Trees provide important sources of microhabitats in forest ecosystems due in part to their large biomass and structural complexity. Specific microhabitat types include foliage, branches, and trunks, as well as smaller scale features such as cavities, cracks, scars, broken tops, bowls, and burls (Szinetar & Horváth 2005; Michel & Winter 2009).

Numerous spider species have evolved a specialized life history that depends on the microhabitats that tree trunks provide (Aikens & Buddle 2012). However, relatively few studies have been published on tree-trunk-dwelling spiders, and much remains unknown about their ecology and life history (Szinetár & Horváth 2005). Several of the five species (Platnick 2013) of the sheetweb-weaving spider (Linyphiidae) genus *Drapetisca* represent examples of tree-trunk microhabitat specialists. Most of what we know about the ecology of *Drapetisca* is from studies of the Palearctic species *Drapetisca socialis* (Sundevall 1833). This species is occasionally found under leaves on the ground, but adults are usually collected from the surface of various species of deciduous and coniferous trees (Toft 1976; Schütt 1995, 1997; Simon 2002; Szinetar & Horváth 2005).

The study species is *Drapetisca alteranda* Chamberlin 1909, which occurs in forested areas of Alaska and Canada, eastern United States as far south as the Appalachians in Tennessee and North Carolina, and in higher elevation forests in the Rocky Mountains as far south as New Mexico (Buckle et al. 2001; M.L. Draney, unpublished data). *Drapetisca alteranda* is so morphologically similar to the Palearctic species *Drapetisca socialis* that *D. alteranda* was confused with *D. socialis* before it was distinguished by Chamberlin (1909). This morphological similarity suggests a null hypothesis of ecological similarity, and the available evidence supports this idea. Like *D. socialis*, *D. alteranda* is occasionally found under leaves on the ground, but is usually collected from the surface of various species of deciduous and coniferous trees, including aspens, birches, and beeches (Gertsch 1949), cedar and pines (Stratton et al. 1979), and spruce and elm (Kaston 1948).

The objective of this paper is to document the microhabitat preferences of *D. alteranda* in a northern temperate deciduous forest. Specifically, we wanted to learn whether the presence of *D. alteranda* was related to tree species, tree size, or depth of bark furrowing, and whether the distribution of the spider within a tree was random with respect to distance from the forest floor. We also determined whether the microhabitat distribution within and among trees was related to the sex of the individual.

This study was conducted in the Mahon Woods Forest Dynamics Plot located on the University of Wisconsin–Green Bay campus in Brown County, Wisconsin, USA (44° 31′41.19″N, 87° 55′39.90″W). The Cofrin Arboretum Forest Dynamics Plot was established in 2005 and is one hectare subdivided into 27 20 m × 20 m subsections. Trees greater than 10 cm in diameter at breast height (DBH) have been measured, given a unique identification number, and classified to species (A. Wolf; unpublished data). Thus, the location of each tree can be mapped (Fig. 1), specific individuals within the plot can be located easily for sampling, and quantitative data are readily available for tying species occurrence to specific microhabitat features. Examples of tree species commonly found within the plot are *Carya ovata*, *Fraxinus pennsylvanica*, *Acer negundo*, and *Prunus serotina*. Ground layer plants include *Circaea lutetiana*, *Geranium maculatum*, *Geum canadense*, and *Arisaema triphyllum*.

Sampling was conducted from September through October 2012 between 1000 and 1700 h, times when catch rates of *D. alteranda* were thought to be the highest (M.L. Draney; unpublished observ.). Sampling for spiders was conducted by brushing the entire

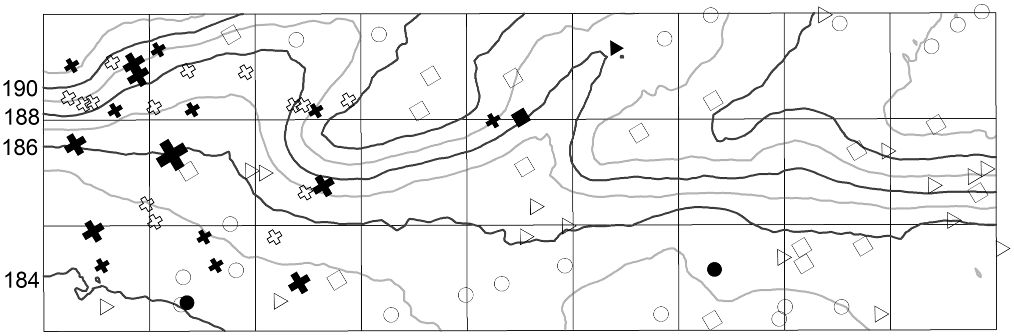

Figure 1.—The spatial distribution of *D. alteranda* (n = 33) collected on 93 of the four most abundant tree species. Symbols indicate the presence (closed symbols) or absence (open symbols) of *D. alteranda* by tree type: *Tilia americana* (cross), *Quercus alba* (square), *Fraxinus pennsylvanica* (circle), and *Carya ovata* (triangle). The size of each closed symbol is proportional to the number of *D. alteranda* caught on each tree, ranging from one to five. The contour lines represent two-meter intervals.

circumference of tree trunks using horsehair drafting brushes. Spiders were brushed onto white nylon ripstop beating sheets (1 m × 1 m; Bioquip, Inc., Rancho Dominguez, CA), placed in labeled plastic jars and later preserved in 70% ethanol. All spider identifications were confirmed by the first author, and vouchers were deposited at the Field Museum of Natural History, Chicago, Illinois, USA. Brushing continued until no more organisms were observed; our observations suggest this method reduces the possibility of catching more spiders on surfaces where the method works more efficiently, because more time was spent brushing larger trees and trunks with more deeply furrowed bark. Four to five collectors participated in each of the two sampling protocols below. In order to reduce between-collector variability, the first author trained all collectors to use the same technique, and collectors always worked in pairs, rather than sampling trees individually. Selected trees were never resampled during the study.

Twenty-one of the 27 subplots within the Mahon Woods Forest Dynamics Plot were randomly assigned to this study objective, and the four most abundant species were selected including *Quercus alba*, *Fraxinus pennsylvanica*, *Tilia americana*, and *Carya ovata*. Individual trees were ranked by DBH within each species. We calculated the surface area of the part to be sampled of each tree, which was 0.5 to 2.0 m above ground level, assuming trunks are cylinders without bark furrowing, etc., using the formula 1.5 m × circumference. We selected trees starting with the species that had the fourth largest surface area, and sequentially selected trees of the other three focal species, from largest to smallest, until a similar cumulative trunk surface area was obtained (i.e., surface areas were standardized). Furrowing of tree bark (grooves in bark) was determined by measuring the depth of furrows at 15 random locations around each tree. Measurements were averaged for a proxy of furrowing depth (Michel et al. 2011). *Drapetisca alteranda* was collected from a 1.5 m section on the tree, 0.5–2.0 m above the ground.

Six 20 m × 20 m subplots within the Mahon Woods Forest Dynamics Plot were randomly selected to test whether *D. alteranda* microhabitat selection was random with respect to tree trunk height. Plots and trees (>10 cm DBH) within plots were randomly selected each day of sampling. Focal trees were divided into six 0.5 m sections with flagging, starting where the tree trunk intersected with the forest floor. Sections (from forest to canopy) included: 0–0.5 m, 0.5–1.0 m, 1.0–1.5 m, 1.5–2.0 m, 2.0–2.5 m, and 2.5–3.0 m. For the assessment of vertical distribution, the sex of captured individuals was determined in the field using the structure of the genitalia.

The effect of explanatory variables including tree species, tree trunk height relative to the forest floor, tree diameter, and furrowing depth on the total number of *D. alteranda* collected were analyzed using a generalized linear mixed model (GLMM) implemented using the GLIMMIX procedure in SAS (Enterprise Guide 5.1). The GLIMMIX procedure was selected because unlike other approaches (e.g., MIXED), GLIMMIX generalizes data analysis in that response variables can have a non-normal distribution (see below). Pair-wise correlations and standard residual analyses (Shapiro-Wilk test, α = 0.05) were conducted between all explanatory variables to detect colinearity, deviations from normality and non-normal residual structure. No evidence of multicolinearity between independent variables was found. The number of *D. alteranda* collected was considered Poisson distributed due to the low capture rate of spiders, which were skewed heavily towards zero.

All possible combinations of model variables (including two-way interactions) were fit, and each statistical model was evaluated using the Akaike Information Criteria (AIC) to select the most parsimonious set of variables explaining variation observed in the total number of spiders collected. Statistical significance of variables was declared at $P \leq 0.05$ for all tests. Models were also evaluated separately for each sex when the information was available. Post hoc tests were used to determine significant differences between categorical variables such as tree height.

Sixty-two trees were sampled to test for the effect of tree species, tree diameter and furrowing depth on spider abundance (n = 15, *Q. alba*; n = 16, *F. pennsylvanica*; n = 16, *T. americana*; and n = 15, *C. ovata*). Total surface area of tree trunk sampled was 317 m^2. Average diameter at breast height (± SD) for all trees combined was 110.6 ± 33.5 cm (113.3 ± 30.8 cm in *Q. alba*, 107.3 ± 45.6 cm in *F. pennsylvanica*, 110.3 ± 21.3 cm in *T. americana*, and 111.3 ± 36.5 cm in *C. ovata*). Average DBH was not significantly different among species (ANOVA, $F_{3,57} = 0.08$, $P = 0.91$). Average furrowing depth (± SD) was 5.7 ± 3.7 mm (7.3 ± 4.6 mm in *Q. alba*, 6.1 ± 4.2 mm in *F. pennsylvanica*, 3.5 ± 1.4 mm in *T. americana*, and 5.9 ± 3.1 mm in *C. ovata*). Furrowing depth was significantly different among tree species, and *T. americana* had the least furrowed bark on average (ANOVA, $F_{3,57} = 3.32$, $P = 0.02$).

Nineteen *D. alteranda* were collected for this study objective and generally found in the greatest abundance on the western edge of the Forest Dynamics Plot (Fig. 1). *Drapetisca alteranda* was observed on ~ 20% of the trees sampled. The best fitting GLMM model to the data based on AIC included furrowing depth, tree diameter, and tree species. However, only tree species (GLMM, $\chi^2 = 19.30$, $P = 0.0002$) and furrowing depth (GLMM, $\chi^2 = 10.98$, $P = 0.0009$) were significant predictors of the total number of *Drapetisca* collected. The greatest proportion of spiders collected (~84%) was found on *T. americana*, and ~5% (n = 1) on each of the other three tree species (Fig. 2). The relationship between spider abundance and furrowing depth was negative ($\beta = -0.54$). We also found evidence of a weak, but significant, species × furrowing depth interaction (GLMM, χ^2 = 10.62, $P = 0.01$), indicating that within a species *D. alteranda* is positively associated with individual trees that are significantly less furrowed.

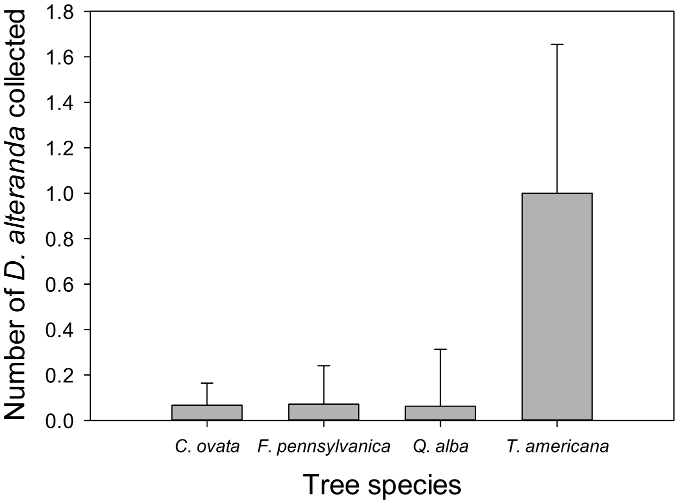

Figure 2.—The average number (+ SE, per tree) of *D. alteranda* collected on the four most abundant tree species within the Mahon Woods Forest Dynamics Plot, Green Bay, Wisconsin.

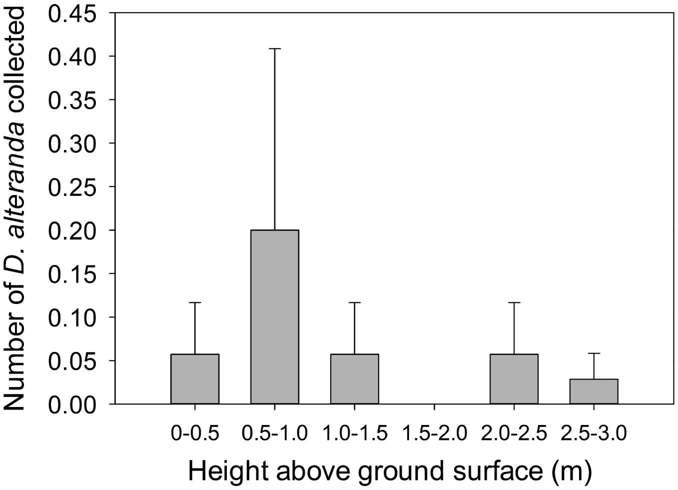

Figure 3.—The average number (+ SE) of *D. alteranda* collected across six subsections of tree trunk within the Mahon Woods Forest Dynamics Plot, Green Bay, Wisconsin. 0–0.5 m, 0.5–1.0 m, 1.0–1.5 m, 1.5–2.0 m, 2.0–2.5 m, and 2.5–3.0 m beginning at the interface of the trunk and the forest floor.

Thirty-five trees (surface area = 732 m^2) across nine different species (the four focal species from the above study, plus *Acer saccharum*, *Populus tremuloides*, *Prunus serotina*, *Quercus rubra*, and *Quercus macrocarpa*) were randomly selected and sampled to test for the effect of tree trunk height on spider abundance. Twenty *D. alteranda* (14 female and 6 male) were collected on 18 trees from six of the nine tree species (52% of those sampled) from mid-September through mid-October, 2012. The best-fitting GLMM model to the data based on AIC included both tree trunk height and tree species. Tree species was a significant predictor of spider occurrence (GLMM, $\chi^2 = 16.41$, $P = 0.03$), and *T. americana* was again the preferred species (55% of the total). Although ~ 45% of *D. alteranda* collected were found at the 0.5–1.0 m height category, the distribution of *D. alteranda* with respect to distance from the forest floor was non-significant (GLMM, $\chi^2 = 6.61$, $P = 0.25$) or random when sexes were analyzed together. However, when analyzed separately by sex using the same model parameters, tree trunk height was a significant predictor of female *D. alteranda* occurrence (GLMM, $\chi^2 = 11.84$, $P = 0.03$; Fig. 3), with 52% of the individuals found 0.5–1.0 m above the forest floor. There was no evidence of such a relationship for males. The interaction between tree species and tree trunk height was also non-significant ($P > 0.05$), indicating that the behavior of spiders is consistent regardless of tree species.

This study is the first to document the microhabitat preferences of *Drapetisca alteranda*. Our results show that *D. alteranda* is not randomly distributed either among or within tree trunks. On the plot level, collections of *D. alteranda* were concentrated toward the western side of the plot. However, examination of the sampled tree species shows that most *D. alteranda* were sampled from *T. americana*, and that the selected trees were very much aggregated toward the western side of the plot. Thus, at the plot level, *D. alteranda* distribution seems to be controlled by the distribution of tree species, and Fig. 1 reflects tree species distribution rather than spatial distribution of *D. alteranda* per se.

Drapetisca alteranda were found significantly more often on *Tilia americana* than on the other three most abundant tree species examined, and *Tilia americana* had significantly shallower bark furrowing (i.e., smoother macro-scale bark texture). Furthermore, it was observed that *D. alteranda* microhabitats were positively correlated with individual trees that are significantly less furrowed within a species. Thus, the data suggest that the spider selects trees with less bark furrowing to locate the web site. There are a number of possible reasons for this. It seems likely that a smoother trunk surface facilitates construction or function of the reduced signaling web or that smooth bark facilitates foraging using the setal trap (Schütt 1995, 1997).

Height above ground surface is predictive of the catch of female, but not male, *D. alteranda*. The majority of females were collected at 0.5–1.0 m above the forest floor. The different vertical distribution patterns of males and females is not altogether surprising, given that males probably wander somewhat randomly over the surface of tree trunks in search of receptive females, whereas females seem to exhibit a high level of microsite fidelity. As demonstrated in other species (Romero & Vasconcellos-Neto 2005), microsite selection is potentially strongly related to reproductive success among females, because the web site influences both survival and foraging success.

Our results on the microhabitat distribution of *D. alteranda* are in broad agreement with what is known about the Palearctic species *Drapetisca socialis* and suggest that the two species are not only morphologically but also ecologically similar. Although tree species choice has not been rigorously tested in *D. socialis*, Schütt (1995, 1997) found that the species was strongly associated with *Fagus sylvatica*, a species that, even more than *Tilia americana*, has relatively smooth bark. Two studies of vertical distribution of *D. socialis* are broadly consistent with what we found for *D. alteranda*. Schütt (1997) found the majority of specimens at 0.5–1.75 m above ground level. Also in agreement with our study, Schütt (1997) found no individuals below 0.25 m. Simon (2002) found more than 80% of the individuals of *D. socialis* at the lowest level (1.5 m), less than 15% at 5 m, less than 3% at 10 m, and no individuals were located at 13 m or in the crown of the tree. Simon (2002) shows very clearly that *D. socialis* is a specialist on the lower bole of the tree and not the canopy, and our data are consistent with the hypothesis that *D. alteranda* is similar in that regard. Interestingly, the few known specimens of the Chinese species *Drapetisca bicruris* (Tu & Li 2006) were not found specifically on tree trunks, but were collected “from the roots of a tree, and especially the hollow in an old tree” (Shuqiang Li pers. comm.).

The present study provides evidence that *Drapetisca* is a lineage of ecological specialists whose adults inhabit the surface of the lower portion of tree trunks. Our study suggests that even such tree-dwelling “microhabitat specialists” as *Drapetisca* are highly affected by their adjacent soil and ground layer environment, and that persistence of these specialists requires maintenance of these ecosystem components. These basic findings not only begin to elucidate the ecology of *D.*

alteranda, but further allow us to ask more sophisticated questions about their functional role in the forest ecosystem. Additionally, these findings should increase the efficiency by which these somewhat cryptic animals can be sampled, by focusing sampling efforts on smooth-barked trees at 0.5–1.0 m above ground level. This should enable researchers to better study the animals, and enables the taxon to be included in forest management planning and monitoring activities.

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