FACTORS DETERMINING DISTRIBUTION AND ABUNDANCE OF PASSALID BEETLES AND PHORETIC MITES IN A HIGH ELEVATION PARAMO FOREST.

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Abstract: Passalid beetles feed on rotting oak logs and the microorganisms contained within them. We hypothesized that passalids would be most abundant under logs with the highest microbial biomass and at some intermediate level of decay. We measured respiration rate, decay level, soil temperature, soil moisture and diameter of 36 logs in a predominantly oak forest north of the Estación Biologica Cuerici. Beetles were more abundant under logs with an intermediate level of decay, and high microbial respiration rate, suggesting that beetles can either locate areas of high food abundance, or disperse equally to all logs, and simply survive and grow better in areas of high microbial activity. Noticing mites on beetles, we counted them, and the number of mites per beetle increased with beetle size. Further studies examing mite abundance in the substrate are needed to determine whether mites depend on beetles for food or simply for transport to areas of high microbial abundance.

Keywords: decomposition level, high elevation, microbial activity, microbial biomass, mites

INTRODUCTION

Passalid beetles are often found under decomposing oak logs, where they feed on rotting wood and the microorganisms contained within it (White 1983). They have overlapping generations in which larvae feed on wood previously chewed by adults (White 1983). We hypothesized that passalid distribution and abundance is related to the biomass of microorganisms in the rotting wood. If so, passalid abundance should be highest under logs with high microbial activity and at some intermediate level of decay. Logs that have recently fallen may not have enough microorganisms to support beetles, and logs that are too old may be dominated by microbes that are less active. Alternatively, beetle abundance may be determined by other habitat characteristics such as log diameter, soil moisture, and soil temperature. If the distribution and abundance of passalids does not correlate to biotic and abiotic resources, beetle distribution may be limited by the dispersal ability of the beetles.

METHODS

On 28 - 29 January 1998 we sampled passalid beetles under oak logs (Quercus) ~10 - 50 cm diameter within 5 m of the Mirador Trail at the Estacíon Biologica Cuerici (2700 - 2900 m asl). We recorded soil temperature using a temperature probe, soil moisture using a DEMETRA E.M. System Soil Tester, log diameter, decay level, and microbial biomass under 36 logs. We measured decay level as the average of 3 measures of the depth of partially decomposed material on the underside of each log, estimated by stabbing a spade with constant force into the log. We collected samples of this decaying matter and measured microbial respiration rate with soil respirometers to obtain an index of living microbial biomass. For all logs with beetles, we counted total number of beetles (adults + larvae). Adults were weighed and since mites were visible we recorded their numbers on each beetle.

We used Spearman rank non-parametric correlations to test the relationship between beetle abundance vs. log diameter, soil temperature, and soil moisture, and between respiration rate and decay depth. We also correlated beetle abundance with presence of larvae, and number of mites / beetle vs. beetle colony size, with spearman rank non-parametric correlations. To test whether logs of intermediate decay proved optimal beetle habitat, we plotted decay depth versus beetle abundance and used an F test to compare the fit of two curves; a full model (parabola estimated with second degree polynomial) versus a reduced model (linear). We used regression analysis to test for a relationship between log mite abundance per beetle and beetle size.

RESULTS

Beetle abundance increased with microbial respiration rate (Sp-Rho = 0.56, P = 0.0008; Fig 1). Graphical analyses suggest that more beetles were found at intermediate levels of decay, but our polynomial model did not provide significantly better fit than a linear model ($F_{1,31}$ = 2.43, P = 0.15 for full model vs. reduced model; Fig 2). Beetle abundance was not related to soil moisture, temperature, or log diameter (Sp-Rho = -0.30, P= 0.09; Sp-Rho = -0.10, P = 0.59, Sp-Rho = -0.11, P = .54 , for soil moisture, temperature, and diameter respectively). Decay depth and respiration rate were not related ($F_{1,31}$ = 0.14, P = 0.72). There was no relationship between the number of adults (ranging from 0 to 3) and number of larvae (ranging from 0 to 5) under the 26 logs containing beetles (Sp-Rho = 0.12, P = 0.47).

The number of mites per beetle increased significantly with beetle size (r = .48, P = .002; Fig 3), but there was no relationship between beetle colony size and the number of mites found per beetle (Sp-Rho = -0.04, P = 0.80).

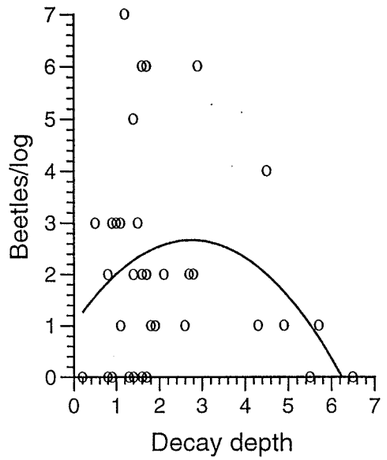

FIG. 2. Total number of beetles (adults + larvae) found under logs with varying levels of decay. (Model = 2nd order polynomial.)

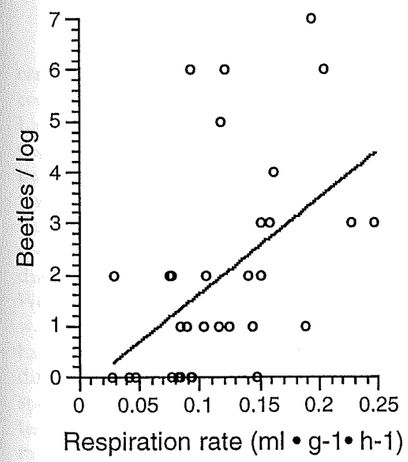

Fig. 1.Number of beetles found under logs with varying respiration rates.

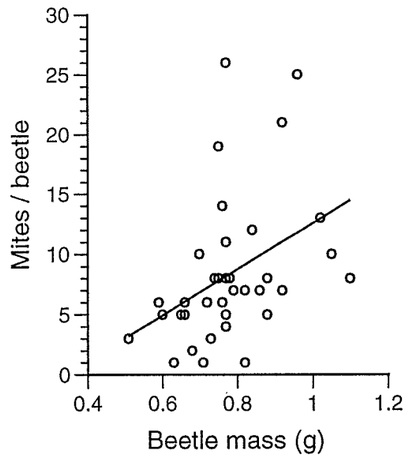

FIG. 3. Number of mites found on beetles of varying masses.

DISCUSSION

Passalid beetles were more abundant under logs with higher microbial activity, probably because higher microbial biomass provides beetles with a larger food source. Logs at an intermediate level of decay may provide an ideal habitat in which passalids can burrow, feed, reproduce. Abiotic factors such as temperature, moisture, and diameter of the log did not appear to be important determinants of abundance. Number of adult beetles was not correlated with number of larvae indicating that passalid beetles do not neccessarily reproduce in the same places they feed. Some logs that appeared to be suitable habitat harbored no beetles (8 of 36 logs), suggesting that beetle distribution patterns could be a function of dispersal as well as habitat quality. If so, there should be a relationship between passalid abundance and the proximity of other logs, but we were unable to test for these spatial patterns in our study.

Because we could not survey mite abundance in the substrate under fallen logs, we are unable to make definitive conclusions about what determines mite abundance and distribution. Beetle size appears to be more important than beetle colony size. We offer two hypotheses to explain patterns in mite abundance: (1) mites feed on some part of the beetle, either a fungus growing on them, or a fluid secreted, and therefore will only be found on beetles, regardless of physical factors, or (2) mites feed on microbes associated with the decaying logs as do passalids, and simply use the beetles for transportation (phoresy) to other logs. Either hypothesis could explain why we found more mites on larger beetles. The mite community probably contained at least two guilds, which we were unable to distinguish: orobatid mites that are grazers of fungi and predatory mites that feed on the orobatids. Further studies examining the relationship between mite abundance in the substrate, mite guild composition, and soil respiration rate could provide insight into the nature of the symbiosis between phoretic mites and passalid beetles.

LITERATURE CITED

White, R.E. 1983. Peterson Field Guides; Beetles. Houghton, Mifflin Company, New York, USA.