May 2009

The effects of elevation and land use on ant activity and ant species diversity

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ABSTRACT

In today's world, it is becoming increasingly important to understand the effects that humans have on Earth's ecosystems. Approximately 39 to 50% of the Earth's land has been transformed or degraded by human activity (Vitousek *et al.* 1997). Ten to fifteen percent of that land has been altered for row-crop agriculture or for industrial development and six to eight percent has been converted to pastureland. These transformations represent the leading causes of decreases in biodiversity. As a result, they alter the global biogeochemical cycles and have considerable effects on climate change. Humans contribute more and more every day to climate change and it is known that many species are moving up in elevation in response to these changes. The purpose of this study was to examine the effects of elevation and land use on ant activity and ant species diversity. I recorded the time it took for ants to arrive at a bait trap on an elevational gradient (1000 masl, 1375 masl, 1550 masl, and 1800 masl) in forest sites versus pasture sites in the Monteverde area. Then, I separated the collected ants into morphospecies in order to calculate species diversity. I found that as elevation increases, ant activity and ant species diversity decreases in the pasture sites. Also, ant activity and species diversity were higher in the pasture sites than in the forests sites. These results indicate that elevation and land use affect ant activity and ant species diversity. Provided that ants are good bioindicators, elevation and land use also impact invertebrate activity and diversity.

RESUMEN

En el mundo actual se está volviendo sumamente importante entender el efecto que los humanos ejercen sobre los ecosistemas en la Tierra. Aproximadamente entre un 39 y un 50% de la tierra en el planeta ha sido transformada o degradada por la actividad humana. Diez a quince por ciento de la tierra ha sido alterada con fines agrícolas o para desarrollo industrial, y entre un seis y ocho por ciento ha sido convertido en pastizales. Esta transformación representa una gran causa en la disminución de la biodiversidad. Como resultado, se han alterado los ciclos biogeoquímicos globales teniendo un impacto importante en el cambio climático. El propósito de este estudio fue examinar el efecto de la altitud y el uso de las tierras en la actividad y diversidad de especies. Tomé el tiempo que les tomaba a las hormigas para llegar al cebo en un gradiente de elevación de 1000 a 1800 msnm en bosque y pastizales en el área de Monteverde. Luego separe las hormigas colectadas en morfo especies para calcular la diversidad de especies. Encontré que conforme aumenta la altitud la actividad y diversidad de especies disminuye en los pastizales. Además, la actividad y diversidad de hormigas es mayor en pastizales que en bosques. Estos resultados demuestran que la elevación y el uso de las tierras afectan la actividad y diversidad de especies. Demostrando que las hormigas son buenos bioindicadores, la elevación y el uso de la tierra también impactan la actividad y diversidad

INTRODUCTION

Effect of humans on ecosystems

It is necessary that we perform an environmental impact assessment to better understand the intensity of humans' effects on Earth's ecosystems and bioindicators can be used to aid us in this process. Invertebrates are becoming an increasingly common taxon that are used as bioindicators because they are ubiquitous, abundant, and easily sampled

(Rosenberg *et al.* 1986; Anderson *et al.* 2002). They fill important roles in various ecological functions such as soil decomposition, soil nutrient cycling (Hancock 1994), and they provide food for many fish and wildlife species. Similarly, land use alterations may alter invertebrate species richness and abundance, indicating that invertebrates are useful bioindicators for assessment of the impact of land use (Rosenberg *et al.* 1986). An example of how different land uses can affect invertebrates is with dung beetles in tropical dry forest habitats (Andresen 2008). Anderson found that dung beetle community diversity decreased with a decrease in forest cover.

A specific invertebrate taxon that is commonly used as a bioindicator in studying the effects of land use is ants. Like many other invertebrates, ants occupy a variety of niches in nature and thus, fill many important roles in ecological processes (Bestelmeyer and Wiens 1996; Post and Jeanne 1982). This allows ants to represent the effects of land transformation and elevation for the entire ecosystem (Anderson and Majer 2004).

In addition to the various effects of land use on ecosystems, elevation also impacts ecological interactions. In recent years these elevation effects have been especially important to understand because many species are changing their elevational ranges in response to climate change (Hodkinson 2005). In 1994, Olson conducted a study that examined how leaf litter invertebrates were distributed along a Neotropical altitudinal gradient. He found that as elevation increases, species richness decreases and suggests that these trends correlate with ecotones. When the cloud layer was reached, he observed a much sharper decline in invertebrate species richness than in other altitudinal transitions. He proposes that some invertebrate's species could not occur at these elevations because of the low temperatures reduced solar radiation, and high mist levels. These conditions affect metabolic processes and limit optimum foraging conditions.

I collected data on the time it took for ants to arrive at a bait trap, the proportion of baits visited and the ant species diversity all along an elevational gradient in forest sites versus pasture sites. I predicted that as elevation increased, ant activity and ant species diversity would decrease. In addition, I predicted that ants in the forests would respond more quickly to the bait traps than ants in the pastures.

MATERIALS AND METHODS

I conducted my study across a gradient that consisted of two habitats, a forest and a pasture, at four elevations in the Monteverde Area. The first elevation was located at 1000 masl and was conducted at The University of Georgia at Costa Rica (UGA). The second elevation was located 1350 masl for the forest site in Bajo del Tigre and 1400 masl for the pasture site at Frank Joyce's pasture in Bajo del Tigre. Since the elevations for these locations were different for the forest and the pasture, I averaged them together to have a common number of 1375 masl for figures and tables. The third elevation was located at 1550 masl and was conducted at the Monteverde Biological Station. The fourth elevation was located at 1800 masl and was conducted at the continental divide for the forest site and the television towers for the pasture site. For each forest site, I walked in approximately 20 m to avoid edge effects.

At each location I set up three transects with three baits per transect. The transects and the baits were all five meters apart. At each of the nine locations I placed a marking flag, and a Petri dish with a nickel-sized portion of tuna. I collected data for four hours from 1200 to 1600 checking the baits for ants every half hour. As I checked the baits, I recorded the time it took for the first ant to arrive, and collected that ant in a separate vial. I then collected any other additional ants from the baits. I placed the collected ants in separate vials for each bait for later identification. Ants were preserved in 95% alcohol. Ants were identified to subfamily and separated into morphospecies.

The diversity of ant species at different elevations and between different land uses were estimated using Shannon-Weiner's Diversity Index and tested for differences in diversity with a t-test.

RESULTS

Effects of Elevation

As elevation increases, the time for the first ant to arrive increases in pastures beginning at 1375 masl (Fig. 1). The proportion of baits visited decreases as elevation increases in all pasture sites (Fig. 2). At the 1000 masl pasture, 89% of the traps were visited and at the 1800 masl pasture, 11% of the traps were visited (Fig. 2).

As elevation increases, the diversity of ant species in the pasture sites decreases (R^2 = 0.964, p-value = 0.018, N = 2605 individuals). The pasture site at 1000 masl is the most diverse with a Shannon-Weiner's Diversity Index value of 1.10. The forest site at 1550 masl is the most diverse with a Shannon-Weiner's Diversity Index value of 0.57 (Fig. 3).

Effects of Land Use

The proportion of baits visited is higher in the pasture sites than in the forest sites at all elevations (Fig. 2). Overall, the ant species collected in pasture sites are more diverse than those of the forest sites (Fig. 3).

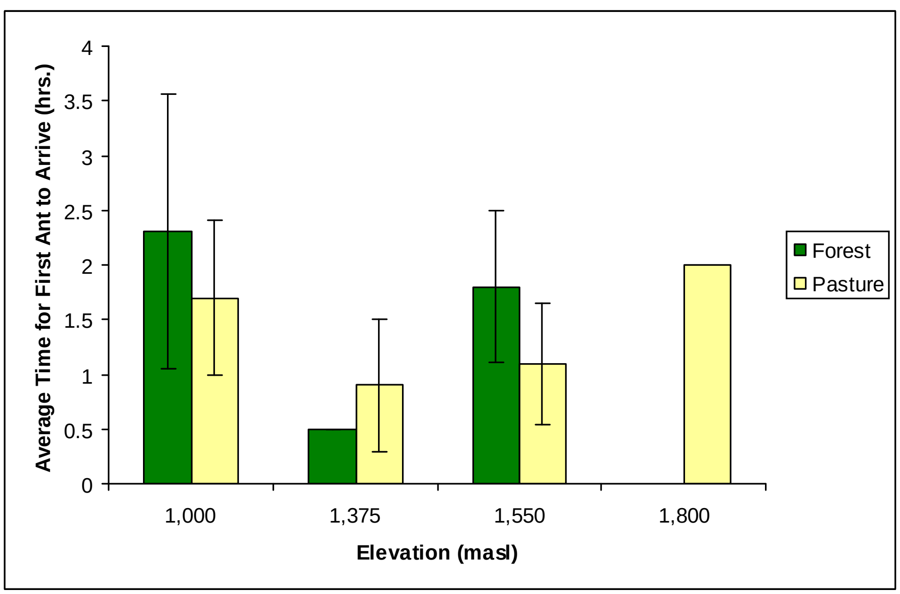

FIGURE 1. The average time (hrs.) it took for the first ant to arrive (N = 9 baits per site) at each forest and pasture site among four elevations in the Monteverde area, Costa Rica.

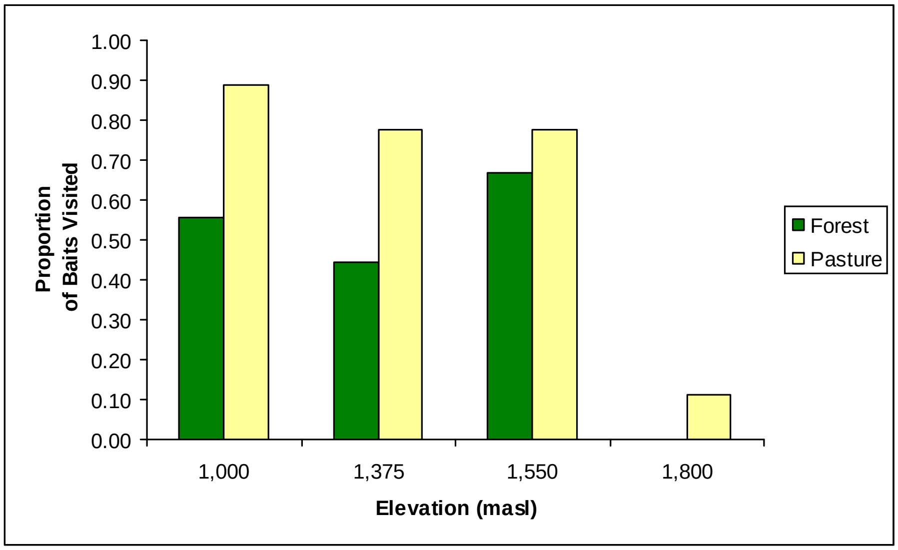

FIGURE 2. The proportion of baits visited (N = 9 baits per site) at each forest and pasture site among four elevations in the Monteverde area, Costa Rica.

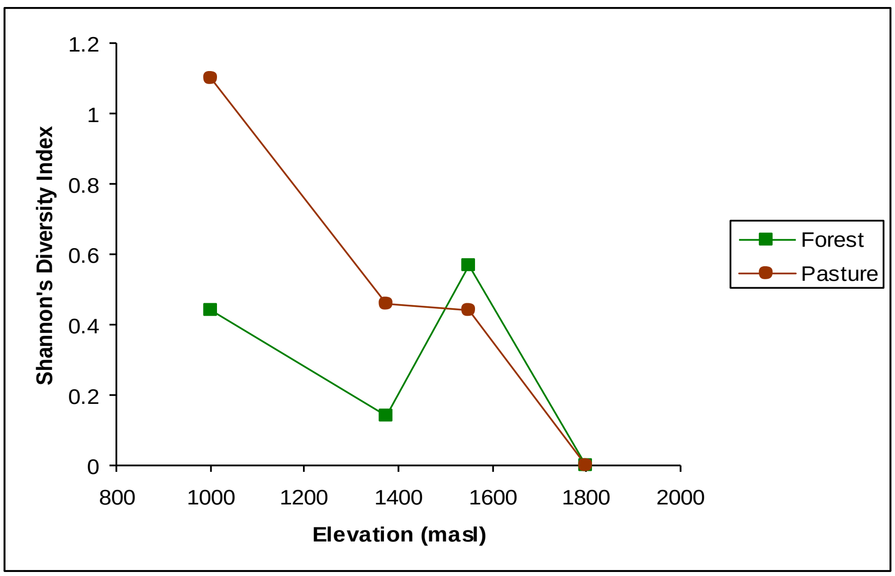

FIGURE 3. The Shannon's Diversity Index Values (N = 2605 individuals) at forest and pasture sites for four elevations in the Monteverde area, Costa Rica.

DISCUSSION

I expected that elevation and land use would both affect ant activity and ant species diversity. I found that as elevation increases, ant activity decreases in pastures. This is observed in the relationship between elevation and the time it takes for the first ant to arrive and also between elevation and the proportion of baits visited. This trend is found in many previous studies and is often attributed to the impaired efficiency of invertebrates at lower temperatures and misty conditions (Hodkinson 2005). As elevation increases, the cloud layer is eventually reached and at these conditions, invertebrates decrease their activity because they are poikilothermic. This means that their body temperature tends to be very close to that of the ambient temperature (Romoser and Stoffolano 1998). This could also explain why I found that the species diversity in the pasture sites decreases as elevation increases. An explanation as to why this relationship was observed in the pasture sites and not in the forest sites could be because the ground layer, the location of the bait traps, in pasture sites are more immediately affected by the temperature and misty conditions than in the forest sites.

There was more activity and more species diversity in the pasture sites than in the forest sites. Despite this result being the opposite of many other studies (Silva *et al.* 2007) and of my prediction, it could be due to the increased amount of obstructions such as leaves, twigs and saplings for the ants in the forest sites. As a result, these obstructions could cause a change in ant foraging strategies (Jeanne 1979). In the pastures, the bait sites were very open and easily accessible for the ants. However, in the forests, the bait sites were surrounded by leaf litter, twigs and saplings. Jeanne (1979) found that ant predation rates were higher in low second-growth vegetation than in forests. He attributed this result to changes in foraging strategies between the two sites.

Some other explanations as to why I received these results are my very small sample size and my flawed experimental design. I placed the tuna baits on Petri dishes and this may have had an effect on the ant activity. Also, I think that if I had used more tuna per bait, more ants would have arrived.

To conclude, it is clear that an increase in elevation causes a decrease in ant activity and species diversity. This indicates that ants are less active and less diverse at higher elevations. With global annual temperatures increasing at alarming rates and recent changes in species ranges, it would be interesting to repeat this study in the future to investigate whether ant activity and ant species diversity is increasing at higher elevations and whether this change is significantly correlated with changing temperatures. I also found there to be higher ant activity and ant species diversity in pasture sites than forest sites. It is evident that land use and elevation have major impacts on ecological processes of ants and of other species as well assuming that ants are good bioindicators.

ACKNOWLEGEMENTS

I would like to first and foremost thank Anjali Kumar for her endless assistance and enthusiasm. I would also like to thank my parents, William and Philinda Heil, for their encouragement and for giving me the opportunity to study abroad and St. Michael's College for supporting all of my academic endeavors. Also, thank you to Yi-men Araya for his vast knowledge of biological statistics and to José Carlos Calderon Ullmoa for providing me with all of my supplies. A final thank you to the Monteverde Biological Station, The University of Georgia at Costa Rica and Bajo del Tigre for allowing me to collect data on their property.

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