Final report on the 5th Tropical Ecology Field Course Venezuela 2011

Instytut Nauk o Środowisku Uniwersytetu Jagiellońskiego (INoS UJ)

Muzeum Zoologiczne Uniwersytetu Jagiellońskiego (MZ UJ)

Instituto Venezolano de Investigaciones Científicas (IVIC)

Museo del Instituto de Zoología Agrícola Francisco Fernández Yépez (MIZA)

Kraków – Caracas – Maracay

COURSE PROGRAMME

Wednesday 29th June 2011:

3:00-5:00 pm. Arrival of Polish participants (6 students and Professor Ryszard Laskowski). Meeting at the airport of Maiquetía (Caracas). Brief visit to La Guaira.
6:00-7:00 pm. Transportation to IVIC (Altos de Pipe, 11 km SW of Caracas).
7:00 pm. Arrival to the residences at IVIC.
8:30 pm. Welcome dinner in San Antonio de Los Altos, courtesy of IVIC.

Thursday 30th June 2011:

9:00 am. Breakfast at IVIC refectory.
10:00 am. Talks.
10:00-11:00 am. Angel Viloria, Centre of Ecology: *Presentation to the course: The Venezuelan Institute for Scientific Research and its Centre of Ecology.*
11:00-11:30 am. Coffee.
11:30 am-12:30 pm. Jafet Nassar, Director of CIET-UNESCO: *Animal-plant interactions.*
12:30 pm Lunch at IVIC refectory.
2:00 pm. Talks.
2:00-3:00 pm. Francisco Herrera, Centre of Ecology-IVIC: *Venezuelan caves and their ecology.*
3:00-3:30 pm. Coffee.
3:30-4:30 pm. Hugo Cerda, Simón Rodríguez University and Centre of Ecology-IVIC: *The ecology of transgenesis.*
5:00-5:45 pm. *Brief tour around the cloud forest of IVIC* (guided by Saúl Flores, Centre of Ecology-IVIC).
6:30 pm. Dinner at IVIC refectory.

Friday 1st July 2011:

8:30 am. Breakfast at IVIC refectory.
10:00 am. Talks.
10:00-11:00 am. Ascanio Rincón, Centre of Ecology, IVIC: *Palaeontology of tar pits in Venezuela.*
11:00-11:30 am. Coffee.
11:30 am-12:30 pm. Margarita Lampo, Centre of Ecology, IVIC: *Amphibian extinctions: emergent diseases and climatic changes.*
12:30 pm. Lunch at IVIC refectory.
2:30 pm. Talks.
2:30-3:30 pm. José Vicente Montoya, Centre of Ecology, IVIC: *Benthic ecology of sandy beaches in a large floodplain river.*
3:30-4:00 pm. Coffee.
4:00-5:00 pm. Jesús Mavarez, Centre of Ecology, IVIC: *Speciation in Heliconius butterflies.*
6:30 pm. Dinner at IVIC refectory.

Saturday 2nd July 2011:

9:00 am. Breakfast at IVIC refectory.
10:30 am. Talks.
10:30-11:30 am. Ángel L. Viloria, Centre of Ecology, IVIC: *The enigma of the Catatumbo lightning, a unique meteorological phenomenon in Western Venezuela.*
11:30 am-12:30 pm. Włodzimierz Jedrzejewski, Centre of Ecology, IVIC: *Recent ecological studies on the Jaguar in Venezuela.*
1:00 pm. Lunch and free afternoon shopping in San Antonio de Los Altos (3 km from IVIC).

Sunday 3rd July 2011:

7:00 am. Departure to Sucre State. Guyacán Field Station in Chacopata (Universidad de

Oriente).
-Breakfast and lunch on the way.
7:00 pm. Arrival to the station and accommodation. Dinner.

Monday 4th July 2011:

8:00 am. Breakfast at Guayacán Field Station.
9:30 am.- 12:00 m. Tour around the coastal area of Chacopata (observation of dry forest habitats, salt marshes, arid beaches).
12:30-1:30 pm. Lunch at Guayacán Field Station.
2:00- 6:30 pm. Trip to small islands near Chacopata: Isla Caribe and Isla de Lobos (exploration of xerophile forest, snorkeling and recognition of tropical marine coastal ecosystems).
8:00 pm. Dinner at Guayacán Field Station.

Tuesday 5th July 2011:

7:00 am. Breakfast at Guayacán Field Station.
8:00 am. Trip to Caripe (Monagas). Visit to Cueva del Guácharo (oilbird's cave): recognition of subterranean tropical landscapes and ecology, underground creeks, oilbird biology –guided tour by local guards of the National Park.
4:00 pm. Late lunch in Caripe.
5:30 pm. Return to Cueva del Guácharo. Watching of Guacharo's leaving the cave at dusk.
7:00 pm. Return to Guayacán Field Station.
9:00 pm. Late Dinner at station.

Wednesday 6th July 2011:

7:00 am. Breakfast at Guayacán Field Station.
8:00 am. Trip to Playa Medina (Sucre). Visit of several localities on the way (Península de Paria). Lunch at Playa Medina. Recognition of rainforest landscape and tropical beaches (with coconut palms)
5:00 pm. Return to Guayacán Field Station.
8:00 pm. Dinner at Guayacán Field Station.

Thursday 7th July 2011:

7:00 am. Breakfast at Guayacán Field Station.
8:30 am. Departure from Chacopata
All day trip to Henri Pittier National Park (Rancho Grande Biological Station). Arrival estimated at 9:00 pm.

July 8th – July 21:

Rancho Grande Biological Station – field work and evening lectures and seminars.

The important part of the course was the work on "mini research projects" performed by the students during their stay in Rancho Grande field station. On the following pages students' reports are presented. The reports were the final requirement for the course completion.

The Institute of Environmental Sciences, all course participants and myself (R. Laskowski) in particular express their deepest gratitude to our colleagues in Venezuela who helped to make the course a success. Special thanks are due to dr Angel Viloria, dr Astolfo Mata, dr Hugo Cerda, prof. José Clavijo and dr John Latke. Financial and organizational support from IVIC and great help from MIZA is greatly appraciated. We would also like to thank all the teachers and staff of IVIC and Rancho Grande field station for their invaluable help, and to all not mentioned here who made our stay in Venezuela not only successful but also very nice and social.

Differentiation of Avifauna in the South and North of Portachuelo Pass

Kaja Chmura*, Izabela Sadza**

*Faculty of Chemistry, Jagiellonian University, Kraków, Poland
**Institute of Zoology, Jagiellonian University, Kraków, Poland

Report submitted in partial fulfillment of the requirements for the course "Tropical ecology" (WBNZ-801), at the Faculty of Biology and Earth Sciences, Jagiellonian University, Kraków, Poland. 2011

Abstract

The aim of the study was to compare bird biodiversities in two areas: south of Portachuelo Pass and north of Portachuelo Pass in Sierra de la Costa, Venezuela. Observations of birds were made around two locations, each on one side of the pass. Photos of birds were taken and species identified. Obtained results reveal a statistically significant difference between the two observation areas, which may be caused by the differences in quality of the habitats.

Key words: tropical birds, biodiversity

1. Introduction

Henri Pittier National Park (Figure 1; 67^{o} 38.00' W, 10^{o} 25.47' N) in Venezuela covers an area of 107,800 ha and it is located in Aragua and Carabobo States (BirdLife International 2011). There are two ecoregions within the area of the park: Cordillera de la Costa montane forest and coastal xeric shrublands. Six habitats can be also distinguished: dry semi-decidous forest, coastal shrub forest, savanna, evergreen rain forest, cloud forest and mangroves (Parkswatch webpage). Henri Pittier National Park is an area abundant in bird species. Within the borders of the park as much as 582 bird species were noted and they represent 43% of all bird species in Venezuela (BirdLife International 2011). Moreover, there are 22 bird species endemic for the region, many threatened by extinction (BirdLife International 2011). For example: *Crax pauxi, Pharmachrus fulgidus, Aulacorhynchus sulcatus, Pipreola formosa*, and humming birds such as *Chlorostilbon alice, Sternoclyta cyanopectus*. Portachuelo Pass is a migration route for 79 species to the Northern hemisphere. Most common species are: *Falco peregrinus, Coccyzus americanus, Progne tapera, Riparia riparia, Hirundo rustica, Caldris sp., Charadius sp., Pluvialis sp., Tyrannus sp., Contopus sp.* Most common species belong to

the families of *Thraupidae* and *Tyrannidae*. There are also ant birds from the families of *Thamnophilidae* and *Formicariidae* and also *Dendrocolaptes* sp., *Cyanocorax inca* and other (Laskowski et al. 2009).

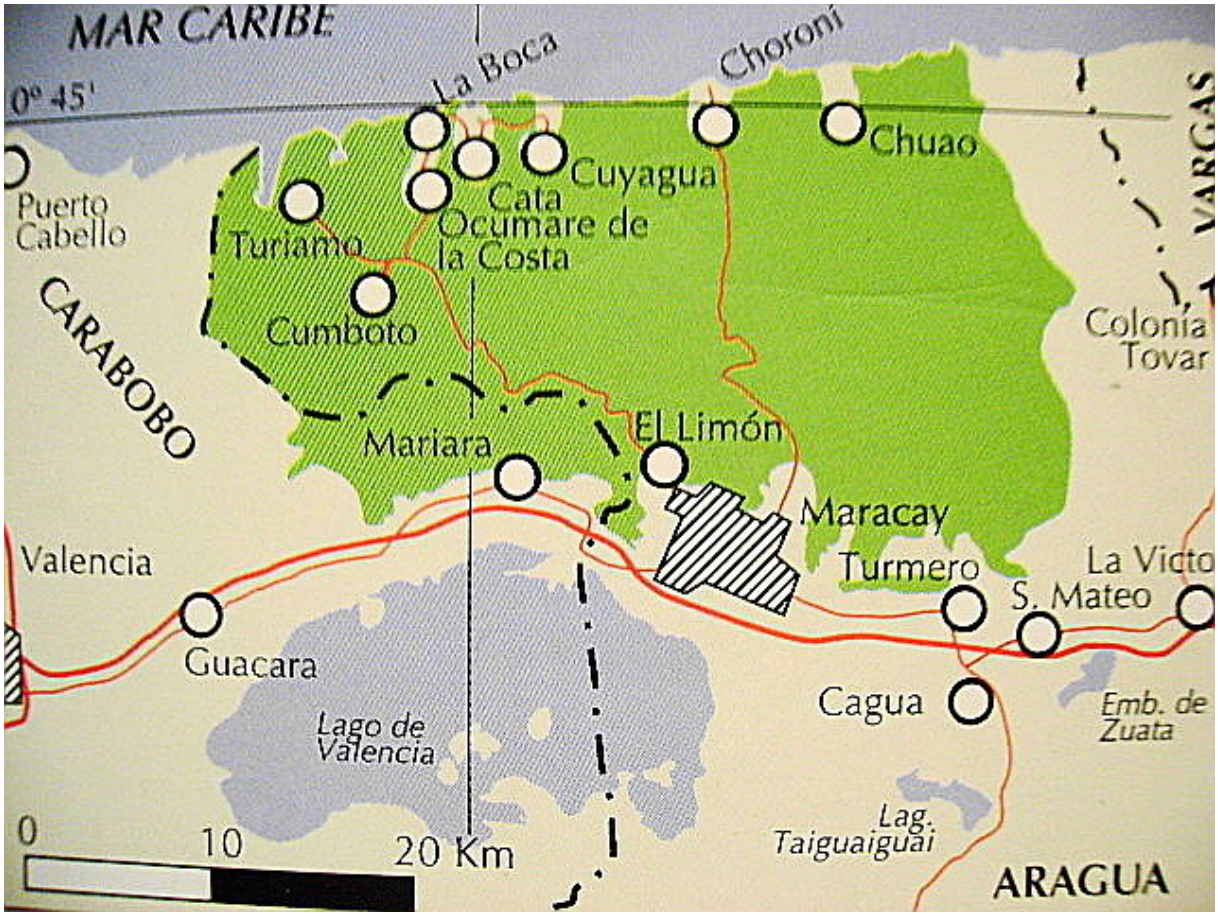

Figure 1. Map of Henri Pittier National Park (marked in green)

[Source: http://www.skyscrapercity.com/showthread.php?p=55135301]

In this study an attempt is done to determine whether the area in the south of Portachuelo Pass differs in terms of bird species diversity from the area in the north of the Pass. It is highly probable that this kind of research had never been done before in this area, since scientific reports about such investigation have not been found.

2. Materials and Methods

2.1 Study area

The research was conducted in Venezuela, in Henri Pittier National Park. Two bird observation posts were established at approximately same distance from the Portachuelo Pass.

The first place was north of the Pass (10° 20’39,6”N, 67°42’45”W), located 863 meters above sea level and it was named “Chapel Virgen del Carmen”. The second post was south of Portachuelo Pass (10°20’50.1” N, 67° 39’41” W), 918 meters above sea level, and it was named the “Picnic Place”.

2.2 Data collection and analysis

In July, during the tropical ecology field course, birds were observed with binoculars (Olympus 10x15, DPS I), and pictures of all specimen were taken if possible (Canon EOS 1000D, Sigma 75-300). The observations were regular and always lasted from 8:00 a.m. to noon for three days, every second day at each post. In “Chapel Virgen del Carmen” the birds were observed while walking slowly along the Ocumare-Maracay road near the observation point. In the “Picnic Place” observations were performed in the same way except that we were walking in the opposite direction. Afterwards, the species were identified according to “Birds of Venezuela” (Hilty, 2003).

After collecting the data, we used program “Past” and Microsoft Excel for statistical analyses.

3. Results

During the observation 42 bird species were noticed, from which 34 species were identified. In Table 1 bird species along with number of individuals of each species are listed. Most frequently encountered species were: *Psarocolius angustifrons oleagineus, Ramphocelus carbo venezuelensis, Traupis episcopus, Sporophila nigricollis, Parula pitiayumi* and birds belonging to the genus *Chaetura sp.* They were all encountered at the area south of Portachuelo Pass (Picnic Place). Other species often observed were *Coragyps atratus* and *Aulacorhynchus sulcatus.* They were seen north of the Pass (Virgen del Carmen Chapel) (Figure 2).

Table 1. Species of birds observed in two places in Henri Pittier National Park.

Species	Picnic place (individuals)	Virgen del Carmen Chapel (individuals)	Notes
Psarocolius angustifrons oleagineus	20	0	
Ramphocelus carbo venezuelensis	17	0	
Thraupis episcopus	16	0	
Parula pitiayumi	9	2	
Sporaphila nigricollis	9	0	
Chaetura sp.	8	0	
Pyrrhomiyas cinnamomea viellotioides	3	1	
Tachyphonus rufus	3	0	
Thlypopsis fulviceps	3	0	
Contopus fumigatus cineraceus	2	0	
Cyclaris gujanensis	2	0	
Icterus chrysater	2	0	
Miscellenous large flycatchers	2	0	
Sporophilia sp.	2	0	
Amazilia tobaci	1	0	
Chondrohierax uncinatus	1	0	
Cyanocorax yncas guatimolensis	1	0	
Dysithamnus mentalis	1	0	
Galbula ruficauda	1	0	
Molothrus bonariensis venezuelensis	1	0	
Sternoclyta cyanopectus	1	3	
Tangara guttata chrystophrys	1	0	one observed out of observation time
Tangara gyrola	1	2	
Trogon collaris exoptatus	1	0	one observed out of observation time
Unknown 1	1	0	
Unknown 2	1	0	
Unknown 3	1	0	
Unknown 4	1	0	
Unknown 5	1	0	
Unknown 6	1	0	

Amazilla fimbriata	0	1	
Aulacorhynchus sulcatus	0	8	
Buteo sp.	0	1	
Chalybura buffonii emeralds	0	1	
Coragyps atratus	0	12	
Euphonia xanthogaster	0	2	
Myiobius sp.	0	1	
Piculus rubiginosus meridiensis	0	4	
Saltator striatipectus	0	2	
Sittasomus griseicapillus	0	1	
Unknown 7	0	1	
Unknown 8	0	1	

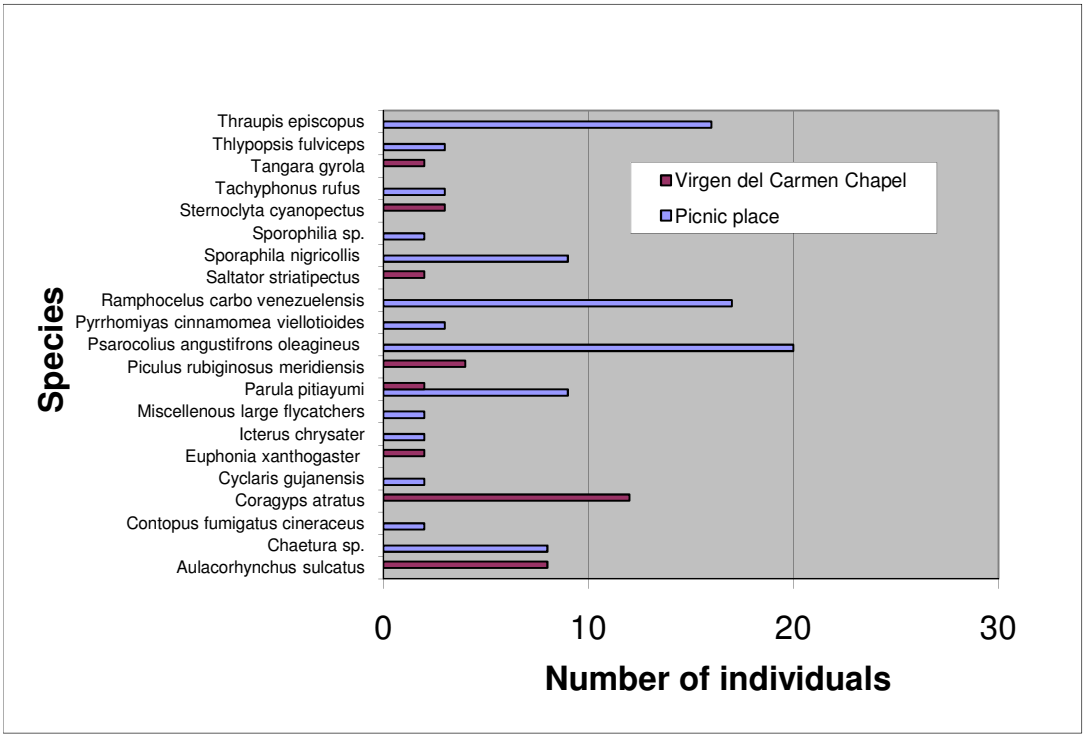

Figure 2. Most numerous species in the north (Virgen del Carmen Chapel) and in the south (Picnic Place) of Portachuelo Pass

Table 2. Values of biodiversity indexes for both observation points calculated in PAST program.

	Picnic Place	Virgen del Carmen Chapel
Taxa S	30	17
Individuals	114	46
Dominance D	0.09495	0.1257
Berger-Parker	0.1754	0.2609
Evenness e^H'/S	0.5259	0.6711
Equitability J	0.8111	0.8592
Simpson 1-D	0.905	0.8743
Shannon H'	2.63	2.26
Menhinick	2.81	2.507
Margalef	6.123	4.179
Fisher alpha	13.27	9.75

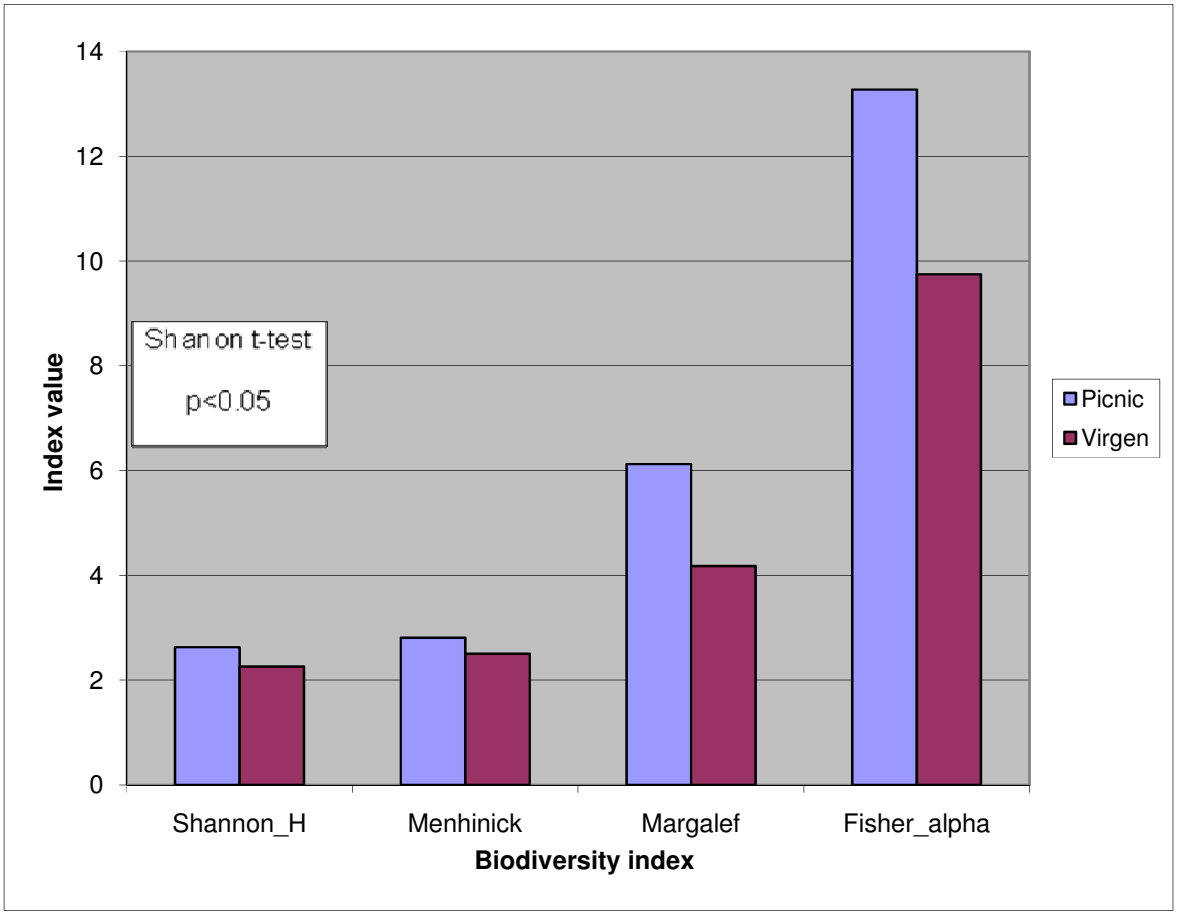

Figure 3. Biodiversity indexes (richness).

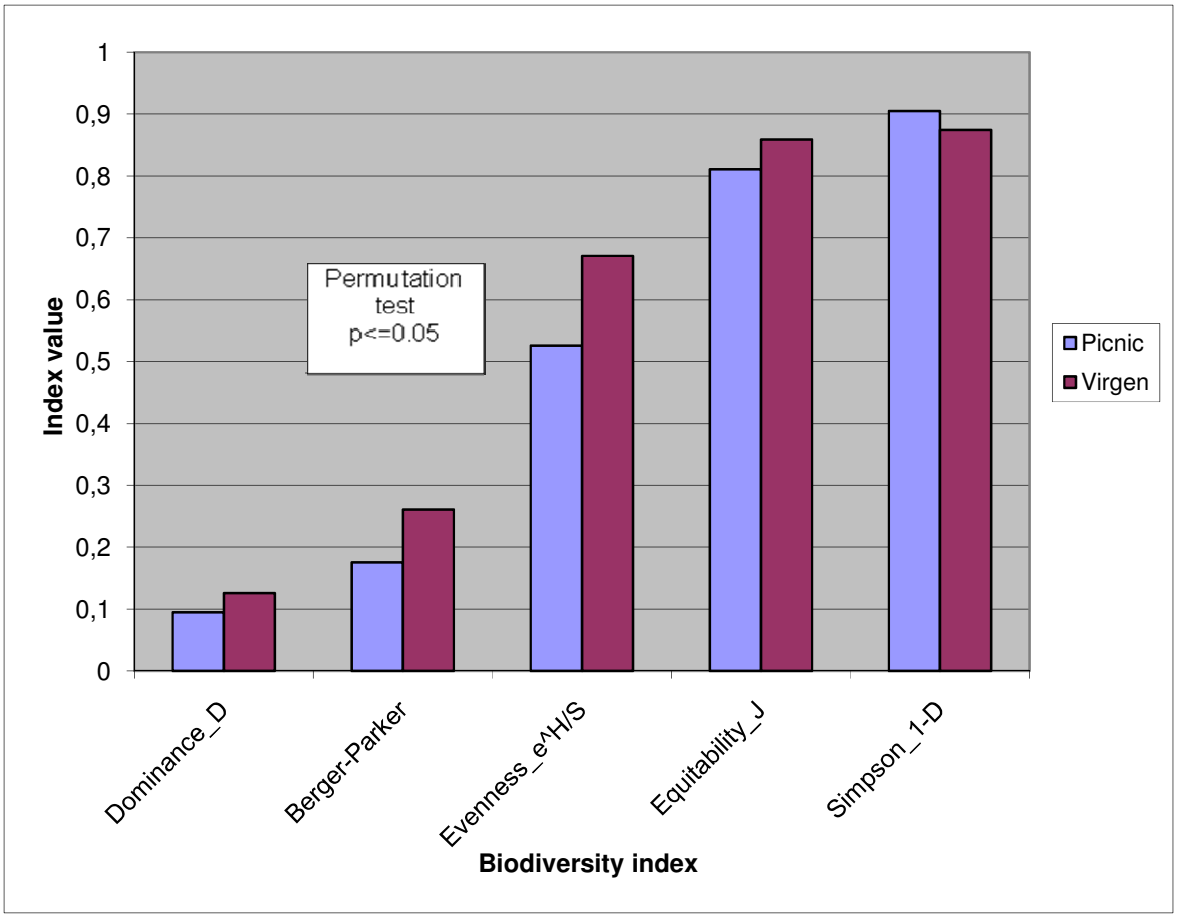

Figure 4. Biodiversity indexes (evenness and dominance).

Table 3. Shannon diversity indexes of the two study sites and their comparison (t test).

Picnic place		Virgen del Carmen Chapel	
S	30	**S**	16
Index	2.6314	**Index**	2.1719
Variance	0.011139	**Variance**	0.024477
t	2.435		
df	84.447		
p(same)	0.016999		

Figure 3 shows a group of biodiversity indexes which determine the richness of species in a habitat. At „Picnic Place" all these indexes are clearly higher, which is confirmed by statistically higher H' at Picnic Place. Figure 4. illustrates the indexes of biodiversity, which focus on evenness and dominance. In this case, higher values were found at "Chapel Virgen del Carmen" post. However, only two indexes (Shanon H' and Berger-Parker) show statistically significant difference between the two studied areas.

4. Discussion

In this study an attempt was done to answer the question whether there is a difference in bird biodiversity between the south and the north of Portachuelo Pass. Two biodiversity indexes indicate that the areas differ from each other in species richness (H') and evenness (Berger-Parker). The Berger-Parker index concerns the number of individuals in dominant taxons. Shannon H' shows that the habitat south of Portachuelo Pass is more species abundant than the habitat in the northern slopes of the Pass. The observed difference may result from the fact that south of Portachuelo Pass there is a transition zone between two types of forest: montane cloud transition forest and wet broadleaf partly evergreen forest (Huber, 1986). This habitat can, thus, be considered an ecotone, meaning that it is richer in species. The direct reason may be, e.g., different types of food available in the two forest types. This in turn is followed by greater diversity of animals, including birds which may use the broader range of foods. Number of potential nesting places is as well higher, creating better places for reproduction.

According to the observations and analyses presented herein, Cordillera de la Costa, where the two posts were located, despite the fact that is connects two Americas through the well-known migration route in Portachuelo Pass (Birds of Venezuela, 2003), is a geographical barrier preventing animals from migration between these two habitats. The hypothesis about differences of bird biodiversity on both sides of the pass has been confirmed. We were wondering if the Portachuelo Pass allows the local birds to migrate freely or not. The final conclusion of our study is that although local migration exists, the southern and northern slopes of the range maintain their distinct bird communities. Nevertheless, in order to verify this statement and make it more reliable, further and longer research would be necessary. Furthermore, additional environmental factors, such as day time or season, should be taken into account.

Acknowledgments

We would like to thank prof. dr hab. Ryszard Laskowski for all his support, sharing his knowledge during the course and also for helping us with this report and the fieldwork. We would also like to thank for financial support provided by Jagiellonian University Vice-Rector for Research and International Relations prof. dr hab. Szczepan Biliński, Faculty of Biology and Earth Sciences UJ Dean prof. dr hab. Kazimierz Krzemień and Fundacja im. Jana

Kochanowskiego. Special thanks to dr Angel Viloria and IVIC for all the support and warm welcome in Venezuela.

References

1. Parkswatch webpage, www.parkswatch.org
2. BirdLife International (2011) Important Bird Areas factsheet: Parque Nacional Henri Pittier. Downloaded from http://www.birdlife.org on 23/09/2011
3. Laskowski R, Pyrcz T, Weiner J, Wojtusiak J. (2009) Ekologia tropikalna- zajęcia terenowe (WBNZ 801) Przewodnik do pospolitych gatunków roślin i zwierząt Wenezueli, Kraków 2009
4. Hilty S. L. 2003. Birds of Venezuela. Princeton University Press, Princeton and Oxford.
5. Huber O., 1986: La Selva Nublada de Rancho Grande, Parque National "Henri Pittier": El Ambiente Fisico, Ecologia Vegetal y Anatomia Vegetal. Fondo Editorial Acta Cientifica Venezolana. Seguros Anauca C.A, Caracas.

Joanna Nabielec, Wojciech Tokarz

Succession of organisms in flower bracts of *Heliconia sp.*

Institute of Environmental Science, Jagiellonian University, Cracow, Poland

Report submitted in partial fulfilment of the requirements for the course "Tropical ecology – field course" (WBNZ-850), at the Faculty of Biology and Earth Sciences, Jagiellonian University.

Abstract

Fluid held by five inflorescences of *Heliconia sp*. in their flower bracts were examined to determine factors influencing densities of invertebrates. On the base of morphospecies, animals were divided into seven main groups: fly larvae (*Syrphidae*), mosquito pupae, mosquito larvae (additionally divided into 3 size classes - smaller than 3 mm, between 3-6 mm and bigger than 6 mm), organisms belonging to copepods and beetle larvae. Copepods were the dominant invertebrate category in flower bracts, while in artificial cups the domination of mosquito larvae was observed. Densities of the majority of investigated groups show the significant relationship between flower bract position (age) and liquid volume. Since the time of the experiment was not long enough, it was impossible to detect which factors (colour, location above the ground, or throughfall) have an impact on colonisation of artificial cups.

Key words: *Heliconia***,** flower bracts**,** colonisation, invertebrates

Introduction

Almost every container filled with rainwater and a small amount of organic matter can be colonised by organisms and acts as ephemeral ecosystem. Tropics is the area where this colonisation can be studied relatively easily because the process undergoes very quickly there.

Phytotelmata – water bodies held by different plant species can be dwelled by numerous animals including insects, mites, annelids, crustaceans, and anurans (Fish, 1983). In this study waterholding bracts of plants belonging to *Heliconia* genus were investigated as representatives of phytotelmata. The advantage of studying microecosystems within *Heliconia* flower bracts (modified leaves accumulating water) is that the plants can be found easily even in dense forest thanks to large, bright red inflorescences. What is more, a number of plant individuals can occur in the same habitat, allowing for replicated studies, and flower bracts create proper conditions for diverse fauna development (Cotgreave e*t al*., 1993).

Heliconias are tropical herbs growing in understorey of wet lowland and mid–elevation

forests. Many species develop inflorescences with brightly coloured, sequentially aged, fluid filled bracts. At least some fluid is of plant origin – newly opened bracts already contain a little. (Lounibos & Machado-Allison, 1993). According to one hypothesis, the presence of this liquid is a protection against herbivory of flowers and seeds. Such a protection enables, however, invading bracts by aquatic insects belonging to two main groups: A) fly (nonmosquito) larvae and beetles (both larvae and adults) or B) mosquito (*Culicidae)* larvae (Seifert, 1982). A cyme, consisting of 10 – 20 flowers, is located within each bract (Richardson & Hull, 2000). Flowers open one by one, and after flowering corollas and stamens fell down into the bract's fluid (Naeem, 1990). These decaying flower parts together with nectar, yeast and bacteria form the first element of the food chains within flower bracts (Richardson *et al.*, 2000).

Due to the bracts structure (one bract is sheltered by another growing above), there is little or no input of detritus from outside (Richardson & Hull, 2000). A lifespan of an average bract is eight weeks. Within this time, species whose larvae living space is confined to bracts must complete their development. During this period, larvae face changes in the amount of organic matter inside bracts as well as physical state and pH of bract fluid. It happens because the cymes within bracts undergo changes. Firstly occurs flowering and nectar production, followed by the decay of flower parts, and finally fruits, and seeds develop (Richardson & Hull, 2000).

The main aim of our research was to investigate the succession of organisms living in *Heliconia* flower bracts. Our prediction was that there should be a positive relationship between the age of bracts and diversity and population sizes of communities inhabiting them. In this report we also show other factors influencing the colonisation of *Heliconia* bracts like pH and liquid volume.

Study area

Our study was conducted in the subtropical cloud forest near Dr Alberto Fernandez Yepez Biological Station in Rancho Grande, in the confines of Henri Pittier National Park (10° 21' N 67° 41' W) situated in north-central Venezuela (Sanchez & Liria, 2009). Fig. 1 shows the location of *Heliconias* from which samples were taken. The majority of plants grew along the education path just near the station. Data were collected between 14 and 20 July.

The cloud forest in Henri Pittier National Park is one of the best known in South America. It boasts an international fame for its high biodiversity. The evergreen vegetation is composed of trees, epiphytes, arborescent ferns, mosses, palms, *Heliconia* and aroids (Fernandez-Badillo, 2000). The forest presents the climatic pattern from humid to superhumid – high relative humidity occurs almost all year round. Very short dry season lasts from January to April, while high precipitation occurs from June to November. September is the wettest month. The annual temperature is almost constant around 20-22°C (Sanchez & Liria, 2009).

1. 10°20’996” N
   67°41’055” W
   1200 m.a.s.l.
2. 10°21’013” N
   67°41’078” W
   1208 m.a.s.l.
3. 10°21’073” N
   67°41’083” W
   1246 m.a.s.l.
4. 10°20’974” N
   67°41’067” W
   1175 m.a.s.l.
5. 10°21’099” N
   67°40’579” W
   1150 m.a.s.l

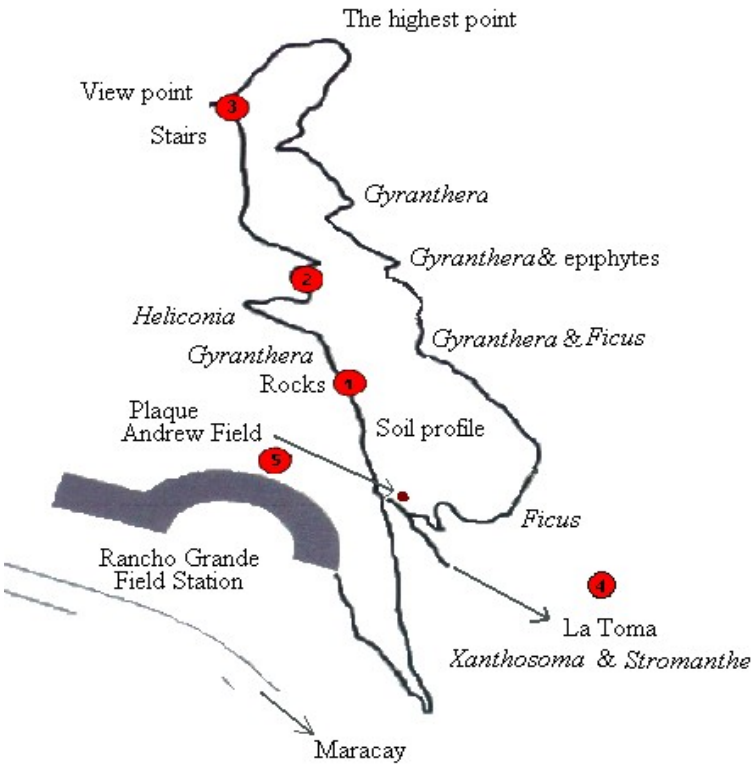

Fig. 1. The location of *Heliconias* from which samples came.

Materials and methods

Heliconia plants, from which samples came, were chosen from widely separated plants, growing in vicinity of Rancho Grande station. Five *Heliconia* inflorescences, consisted of 5 – 7 bracts, were used in the study. The bracts of each plant were numbered from the top (the youngest ones) to the bottom (the oldest) as shown at Fig. 2.

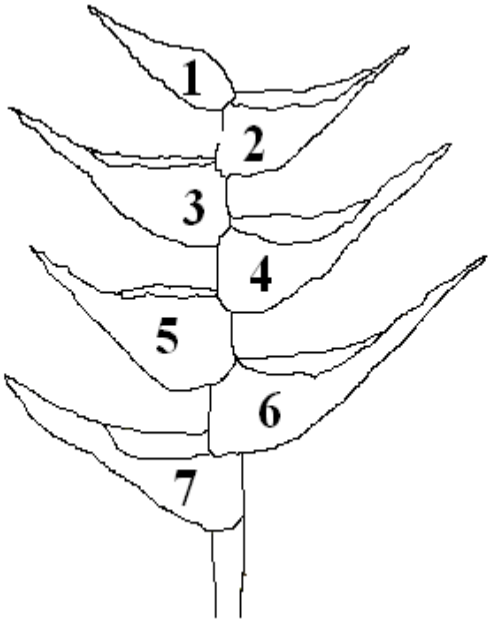

Fig. 2. The way of numbering bracts

Before emptying a bract, fluid pH was measured with electronic pH meter calibrated at pH 4 and 7. Then, fluid from each individual bract was pipetted into the calibrated cylinder to measure its volume, and then transferred into labelled bags. To ensure that all organisms were collected, each bract was flushed with water and the liquid was pipetted once more into bags.

Creating artificial *Heliconia* flower bracts was an additional part of the study. The principal goal of this experiment was to determine main factors influencing succession in bracts. Three main (colour, location above the ground and the importance of throughfall) and two additional factors (light and pH) were examined. Near the sites where inflorescence for the first part of the study were chosen, five sets of artificial *Heliconia* bracts were created. They consisted of a combination of three coloured plastic cups (red, white and yellow) installed on sticks on two levels above

the ground (5 and 75 cm) as presented at Fig. 3.

To check the impact of throughfall and light on colonisation, two cups of each experimental set were covered with "roofs" made of leaves.

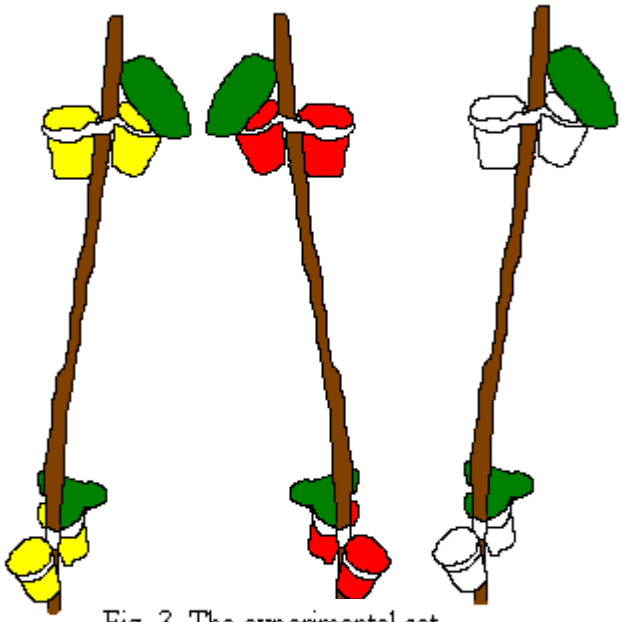

Fig. 3. The experimental set

After bringing samples to the laboratory, animals were preserved with formalin. All found larvae and pupae were identified to morphospecies and counted for each bract using binocular loupe with magnification x10 (for all animals except copepod*s* where magnification x40 was used). Invertebrates were divided into nine groups: fly larvae from *Syrphidae* family, mosquito pupae, mosquito larvae which were additionally divided into three size classes three size classes (smaller than 3 mm, between 3-6 mm and bigger than 6 mm) organisms belonging to copepods (the dominant group) and beetle larvae. The last category refers to the total number of organisms living in bracts. The next step was to convert the number of invertebrates from every bract to their density. Such recalculated data were used in statistical analysis.

Statistical analysis

Throughout the study, the bract position was assumed to be approximately equivalent to its age. Consequently, the summary statistics for densities and total number of organisms were calculated for each bract position (age) using the subset analysis. This was used not only to estimate mean densities and variances but also to test for normality of distributions and possible outliers. The data set was considered normally distributed if standardized kurtosis and standardized skewness were both inside the -2 to +2 limits. To obtain a normal distribution, numbers of mosquito pupae were ranked. Results of these calculations were summarized as box-and-whisker plots (Fig.. 4). The far outliers (points which lied more than 3 times the interquartile range above or below the boxes in the box-and-whisker plots) were removed.

After removing far outliers and normalization of distributions where necessary, the relationships between densities of each group of invertebrates and the measured factors were tested with General Linear Models. The dependent variables used in the model were densities of organisms per 100 ml of liquid, the categorical factor was the flower bract position, while liquid volume and the pH level were treated as quantitative factors. Results of this analysis are presented in Table 1.

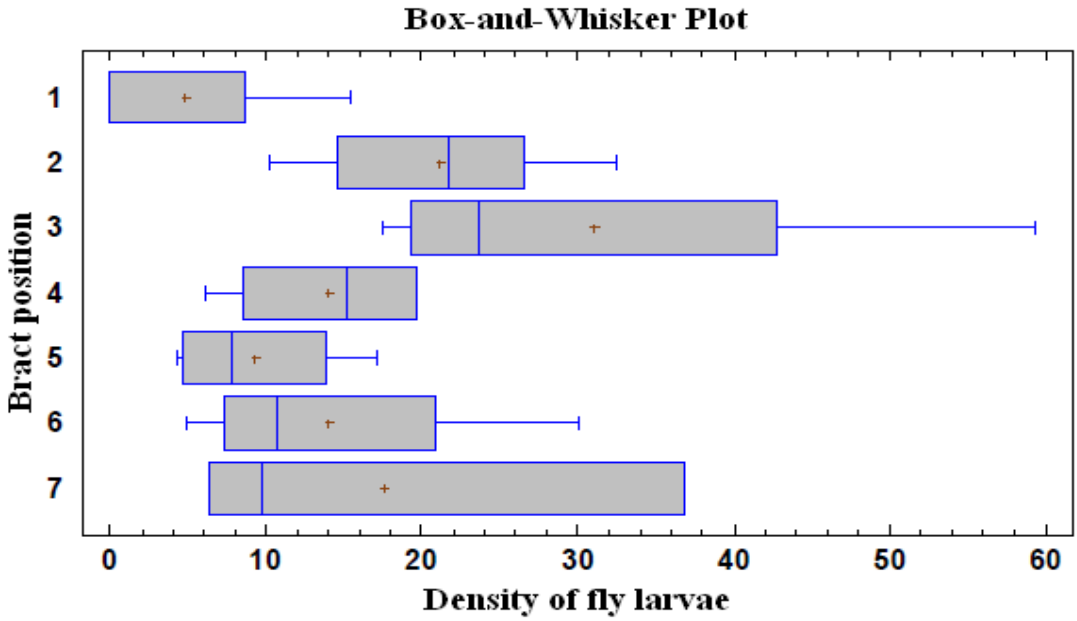

Fig. 4. The example of the subset analysis results for the fly larvae (*Syrphidae*). The graph shows box-and-whisker plots, one for each level of flower bract position. The rectangular part of the plot extends from the lower quartile to the upper quartile, covering the center half of each sample. The center lines within each box show the location of the sample medians. The plus signs indicate the location of the sample means. The whiskers extend from the box to the minimum and maximum values in each sample.

In case of significant interaction between bract position and any quantitative factor, multiple regression was used to test the relationships between the dependent variable and quantitative factors for each bract position separately. For statistically significant relationships, post hoc tests were performed. To show the relationship between density of mosquito pupae, copepods, beetle larvae and the density of total number of invertebrates in bracts and each factors simple regression was used (Fig. 4.).

All statistical procedures were performed using computer program STATGRAPHICS Centurion XVI Version 16.1.11.

Results

General Linear Models were significant ($p<0.05$) for five groups of organisms (except medium mosquito larvae, copepods, beetle larvae and the total number of organisms; Table 1). The majority of investigated groups (fly and mosquito larvae and mosquito pupae) showed significant relationships between the density of animals and the bract position, that is its age. Even if mosquito larvae were divided into three size classes, the tendency was still visible in small and large mosquito larvae. Nevertheless, the most clear relationship with this factor ($p<0.0001$) was seen for all mosquito larvae.

Table 1. The table shows results of general linear model (GLM) analysis. Numbers represent the p- values from the analysis of variance performed in the GLM for each data set (densities of each group of organisms, first column), dependent on categorical and quantitative factors with the statistically significant values marked red.

Dependent variable	Model	Tank position	Volume	pH	Tank position* volume
Fly larvae	0.0130	0.0005	0.0113	0.5608	0.0021
Mosquito pupae	0.0010	0.0338	0.2283	0.9474	0.6319
Small mosquito larvae (<3 mm)	0.0008	0.0001	0.3364	0.3145	0.0002
Medium mosquito larvae (3-6 mm)	0.2703	0.8289	0.6675	0.1125	0.9953
Large mosquito larvae (>6 mm)	0.0001	0.0001	0.0044	0.4674	0.0017
Mosquitoes total	0.0000	0.0000	0.0442	0.6686	0.0000
Gammaridae	0.1303	0.1618	0.0067	0.8023	0.8831
Mr Plate	0.1250	0.7333	0.4026	0.0023	0.4055
Total	0.0886	0.1408	0.0047	0.9142	0.8326

Densities of fly, large and all mosquito larvae and copepods in *Heliconia* bracts were coincident with water level in bracts. The density of the total number of organisms also showed a significant ($p= 0.0047$) relationship with liquid volume in bracts.

Water pH turned out to have an influence on the density of only one group – beetle larvae. Additionally, for fly (*Syrphidae*), small, large and all mosquito larvae GLM found the statistically significant interaction between bract position and liquid volume. Post hoc tests showed that density of mosquito pupae was positively related ($p<0.001$) to bract position. The densities of copepods ($p=0.038$) and all organism ($p=0.034$) were negatively correlated with water volume, while the density of beetle larvae ($p=0.027$) was negatively related to pH level (Fig. 5.).

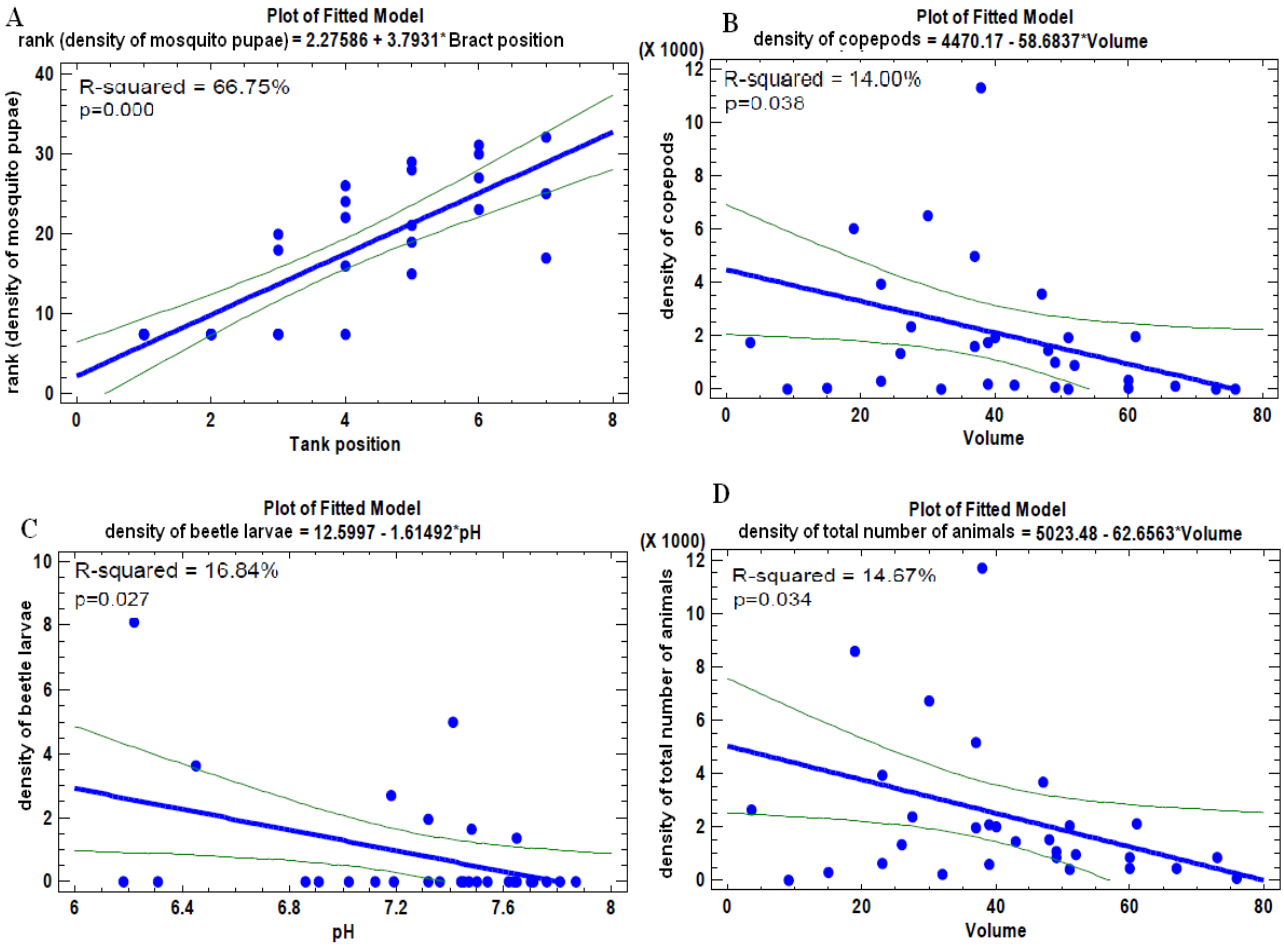

Fig. 5. The relationships between densities of mosquito pupae (A), copepods (B), beetle larvae (C) and all invertebrates (D) and the most significant factor for each group (simple regressions).

Multiple regression tests (Fig. 6.) show positive, statistically significant relationships between bract position and fluid volume and densities of fly ($p=0.007$) and large mosquito larvae ($p<0.001$).

To sum up, according to GLM, densities of fly and mosquito larvae and mosquito pupae depend primarily on age of flower bracts. The most significant factor for copepods and all organisms found in *Heliconia* bracts, was the water volume. Water pH occurs to be the determinant for density of beetle larvae. No relationship was found ($p >0.05$) between density of medium-size mosquito larvae and any of the independent variables.

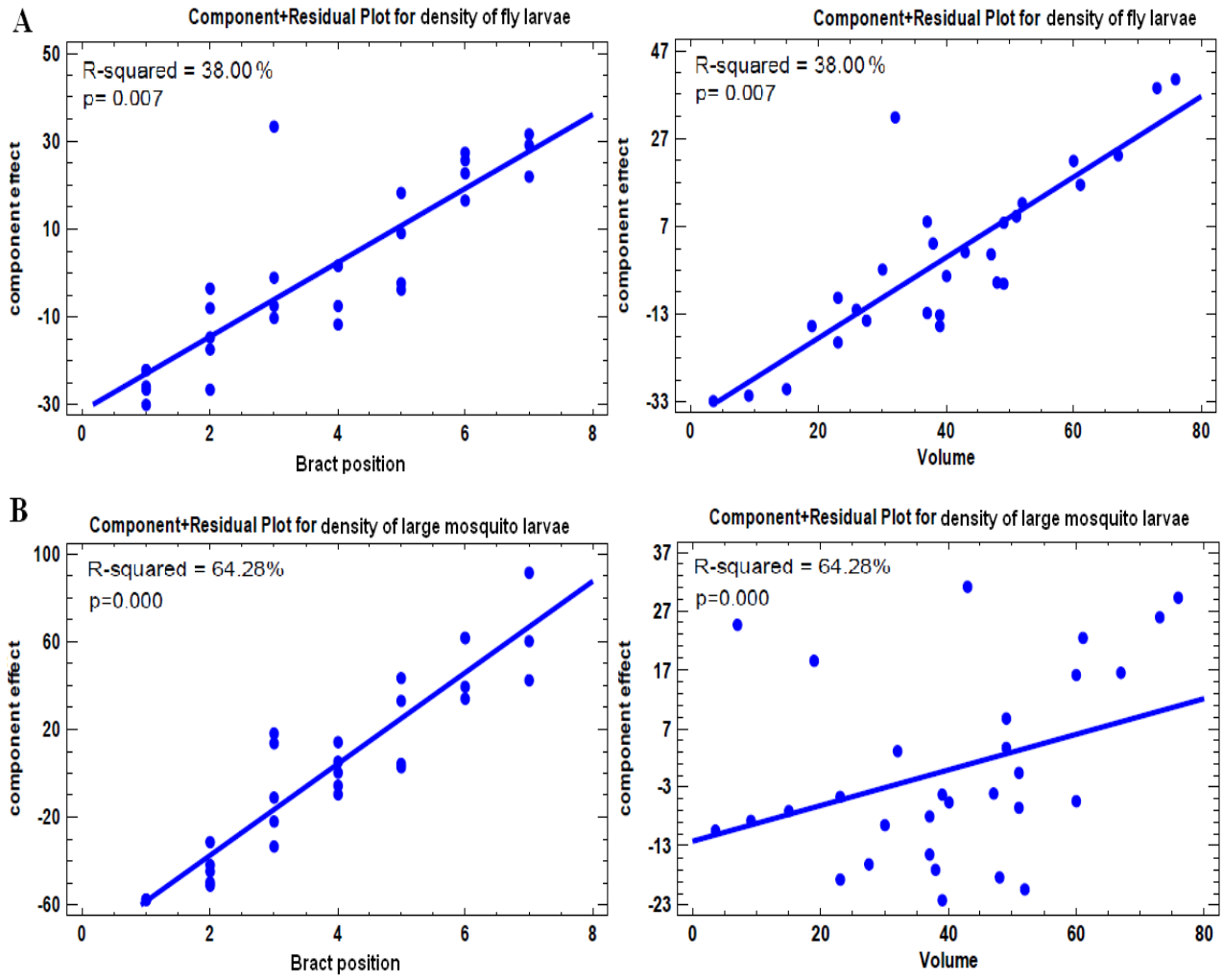

Fig. 6. The most significant relationships as found by multiple regression analysis; lines show the relative change in the predicted values of densities of *Syrphidae* (A) and large mosquito larvae (B) which occurs when changing bract position or volume over their observed ranges.

In artificial cups, flies and other insect larvae, annelids and nematodes were found. Surprisingly, although copepods were the dominant group in natural flower bracts, they were no present in artificial pots. Here, the majority of animals belonged to mosquito larvae – 141 individuals were found. This does not seem surprising because mosquito larvae have quite fast development and typically are the first invertebrates to pupate in bracts of *Heliconia,* on average 10 – 12 days after oviposition (Seifert & Seifert, 1979). It occurred that mosquito females preferred laying eggs into bottom cups. There were no effects of colour or cover (roof's presence/absence) preferences (Fig. 7).

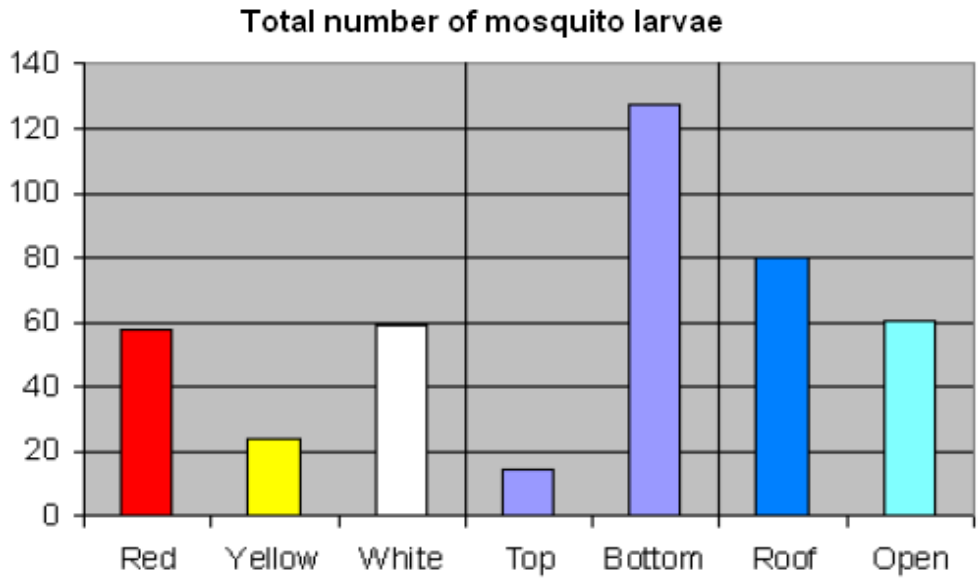

Fig. 7. Results from artificial bracts experiment. Distribution of 141 mosquito larvae depending on colour, location above the ground and presence/absence of a roof.

Discussion

Distribution patterns in bracts sequences mirror the selection of oviposition sites, nutrients availability or other conditions in the flower bracts of *Heliconias*. What is more, some insect larvae (including mosquitoes) have been observed moving along the rachis. They can, thus, leave older bracts to exploit food sources in younger ones (Naeem, 1988). Oviposition depends mainly on visual, chemosensory and tactile cues. Bright red colour of bracts seems to be a cue whose role is attracting insects to the plant. It is likely that there exist subtle differences in bracts chemistry (decay products, sugar content and presence of other animals) which can have an impact on selection of oviposition sites (Richardson & Hull, 2000).

Species richness can be also limited by space and longevity of a habitat – older, lowermost bracts of *Heliconias* can suffer leakage as they become moribund (Richardson e*t al*., 2000). Results presented above clearly indicate that the time is a most important factor influencing the succession of organisms in *Heliconia* bracts. It is obvious that the longer the container exists the higher the probability of colonising it. It also happens because animals have to complete their life cycles before the bracts loose their water-holding capacity (approximately two months), so in older bracts live more larvae and pupae than in newly formed ones. Fluid volume occurs to be an important factor, too. Water levels varies due to input of rainwater, evaporation during rainless days and bract position.

Except for the presence of beetle larvae, communities were not considered to be structured by water pH in the bracts.

The experiment with artificial bracts lasted for 10 days and, unfortunately, it occurred to be a too short period for invertebrates to colonize the pots in substantial numbers. In consequence, the data collected are not very trustworthy. Nevertheless, we present them in the report as some trends could be observed even after such a short time. The period of time in which the research was performed was apparently too short to bring more clear results. Because of that, no statistical analyses were performed.

Nevertheless, it should be stated that if the experiment had lasted longer, results would have been different most probably, which shows that there is a need for a more precise study focused on succession in *Heliconia* flower bracts.

Acknowledgements

We would like to express our thanks to Instituto Venezolano de Ivestigationes Cientificas and Universidad Central of Venezuela for their advice and hospitality. Special thanks are due to Dr Angel Viloria for all his help during our stay in Venezuela, and to Dr John Latke for providing us with equipment crucial for the laboratory work. We are very grateful to Prof. Ryszard Laskowski for his guidance and scientific support during our project. We also would like to thanks Rancho Grande Field Station staff for providing us with comfortable accommodation.

Literature

1. Cotgreave, P., Hill, M.J., Middleton, J.A.G. (1993) The relationship between body size and population size in bromeliad tank fauna. *Biological Journal of the Linnean Society*, 49, 367-380.
2. Fish, D. (1983) Phytotelmata: flora and fauna. *Phytotelmata: Terrestrial Plants as Hosts for Aquatic Insect Communities*, 1-27. Plexus Publishing Inc., Medford, New Jersey.
3. Fernandez – Badillo, A. (2000) El Parque National Henri Pittier. *Revista Alcance 60. Publicacion de la Facultad de Agronomia. Universidad Central de Venezuela.* 284.
4. Lounibos, L.P., Machado – Allison, C.E. (1993) Field test of mosquito ovipositional cues from Venezuela phytotelmata. *Florida Entomologist*, 76, 593-599.
5. Naeem, S. (1988) Predator – prey interactions and community structure: chironomids, mosquitoes and copepods in *Heliconia imbricata* (Musaceae). *Oecologia,* 77, 202-209.
6. Naeem, S. (1990) Resource heterogeneity and community structure: a case study in *Heliconia imbricata* phytotelmata. *Oecologia*, 84, 29-38.
7. Richardson, B.A., Hull, G.A. (2000) Insect colonisation sequences in bracts of *Heliconia caribaea* in Puerto Rico. *Ecological Entomology*, 25, in press
8. Richardson, B.A., Rogers, C., Richardson, M.J. (2000) Nutrients, diversity and community structure of two phytotelm systems in a lower montane forest, Puerto Rico. *Ecological Entomology*, 25, 348-356.
9. Sanchez. E., Liria. (2009) Relative abundance and temporal variation of macroinvertebrates in a Venezuelan cloud forest habitat. *International Journal of Tropical Insect Science*, 29, 3-10.
10. Seifert, R.P. (1982) Neotropical *Heliconia* insect communities. *Quarterly Rewiev of Biology,* 57, 1-28.
11. Seifert, R.P., Seifert, F.H. (1979) A *Heliconia* insect community in a Venezuelan cloud forest. *Ecology*, 60, 462-467.

The relationship between soil epifauna and altitude on the trail to Pico Periquito in Sierra de la Costa (Venezuela)

Katarzyna Stępień, Anna Szatoń

Institute of Environmental Sciences, Jagiellonian University, Kraków, Poland

e-mail: k.stepien@uj.edu.pl, anna.szaton@uj.edu.pl

Abstract

Many studies indicate that organism richness decreases with the increase of altitude. We were wondering if the same pattern occurs over relatively small altitude scale in tropical mountains. To verify this we examined the relationship between the altitude and soil epifauna in a tropical mountain cloud forest in Henri Pittier National Park (Venezuela). We collected soil and litter samples from five spots located at different altitudes and after sifting and extracting of animals we identified most abundant taxa. Our study did not show any relationship between altitude and organism richness in most of studied groups of organisms, with the exception of the number of ants (Formicidae), which decreased with the increase of altitude at a statistically significant level.

Introduction

It is generally believed that there is a certain analogy between the altitudinal zonation, and latitudinal zonation. The decrease in species richness from the equator toward the poles is one of the most universal biogeographic patterns (Rahbek 2006). Likewise, with the increase in height above sea level, change is observed in the flora and fauna of the area, which is influenced mostly by climatic factors, especially temperature and humidity. Many studies have found a decreasing trend in species richness with increasing elevation (Bhattarai & Vetaas 2006, Grytnes & Vetaas 2002, Olson 1994). Although it is considered as a general pattern, some studies indicate mid-elevational peaks in species richness (McCoy 1990).

Most of research focuses on the differences on a large scale (AxmAcher & Fiedler 2008, Bhattarai & Vetaas 2006, Fleishman, Austin & Weiss 1998, Olson 1994). We wanted to see whether the same relationship can be applied to the soil epifauna on a smaller scale,

within the same ecosystem, where the plant formation remains generally unchanged and cannot influence the results obtained.

Materials and methods

The project was realized in Henri Pittier National Park - the oldest national park in Venezuela, located between Aragua and Carabobo states, the largest national park of the Cordillera de la Costa region. Samples were taken near a trail heading from Portachuelo Pass to Pico Periquito, which was located near Rancho Grande field station (1100 m a.s.l.). The sampling area laid within a tropical mountain cloud forest (Selva nublada propiamente dicha).

Five sampling spots were settled, with the 1st on the Pico Periquito ridge and the 5th near Portachuelo Pass and three other in between, giving an elevation gradient of 180 m. The altitude of each point was marked using a GPS (Fig. 1).

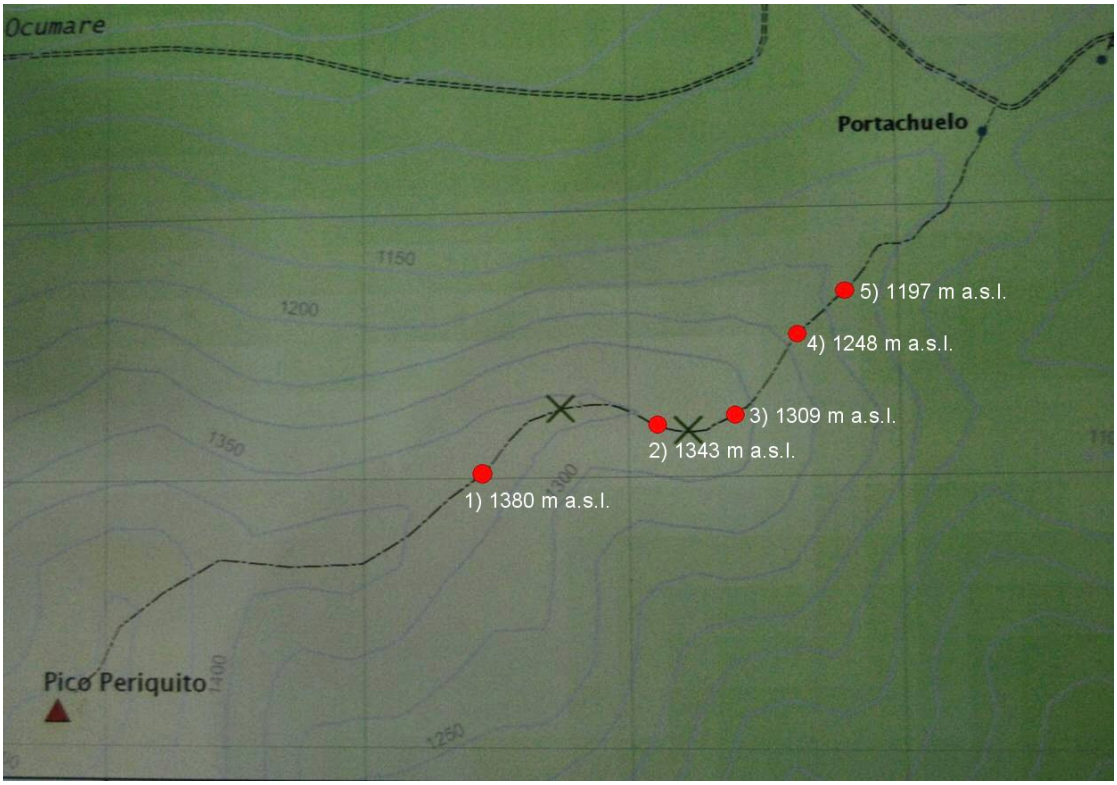

Fig. 1. Map of the trail to Pico Periquito. Red dots mark positions of the sampling points.

Samples of litter and soil were collected for five days (12-14.07.2011 and 16-17.07.2011) each time from an area of 250 cm^2, giving 25 samples together. After being sifted, they were put in passive Winkler extractors for 60 hours. Extracted animals were identified to major taxa and analyzed under a stereoscopic microscope.

All statistical analysis were done in Statgraphics Centurion XVI. First, Simple Analysis procedure was used, to check if the data needed transformation. The relationship between soil epifauna richness and altitude was tested using simple regression. Differences between sampling points were checked using One-Way ANOVA. For statistical analysis we took only those groups of organisms, which were present in more than 50% of samples. In addition, the abundance of all organisms together was examined.

Results

Six groups were present in more than 50% of samples: Diptera, Coleoptera, Formicidae, Arachnide, Diplopoda and Isopoda. The largest group were Coleoptera and the smallest - Isopoda (Table 1). Groups that were present in less than 50% of samples were taken into account when calculating the overall density of organisms.

Simple Regression showed that there is no statistically significant relationship between the number of all animals and altitude. The same situation occurred in most of individual groups of organisms: Diptera, Coleoptera, Arachnide, Diplopoda and Isopoda ($p>0.05$), so there was no statistically significant relationship between abundance of these groups and altitude at the 95,0% confidence level. The largest P-value was for Isopoda: 0.774 (Table 3, Fig. 2-7).

Only one group showed a reduction of their numbers with increasing altitude - Formicidae. The P-value was 0.0221, indicating a statistically significant relationship between altitude and number of ants at the 95% confidence level. The R-Squared statistic indicated that the model explained 20.8% of the variability of abundance in Formicidae (Table 3, Fig. 8).

In One-Way ANOVA the F-ratio ranged from 0.53 to 2.07. In all cases the P-value of the F-test was greater than 0.05, so there was no statistically significant difference between the mean of abundances of the studied groups at the 95% confidence level (Table 4).

Table 1. Number of individuals per 1 m^2.

data	*nr*	*m a.s.l*	*Diptera*	*Coleoptera*	*Formicidae*	*Arachnide*	*Diplopoda*	*Isopoda*	*all animals*
12.07	1	1380	8	20	0	0	4	0	32
12.07	2	1343	8	64	32	12	12	12	152
12.07	3	1309	20	40	28	4	12	8	136
12.07	4	1248	8	68	116	0	4	4	216
12.07	5	1197	12	28	108	16	8	4	176
13.07	1	1380	4	4	0	0	0	0	8
13.07	2	1343	4	60	16	4	0	0	84
13.07	3	1309	4	32	16	0	0	0	52
13.07	4	1248	0	42	0	0	4	0	54
13.07	5	1197	0	40	40	8	0	0	92
14.07	1	1380	0	52	20	4	4	4	88
14.07	2	1343	4	88	28	4	4	4	132
14.07	3	1309	24	68	12	0	0	0	104
14.07	4	1248	4	68	16	0	8	12	128
14.07	5	1197	4	64	28	8	4	4	120
16.07	1	1380	28	112	52	4	4	4	208
16.07	2	1343	172	148	28	32	16	28	448
16.07	3	1309	16	108	16	12	28	28	232
16.07	4	1248	24	116	60	48	12	12	280
16.07	5	1197	16	76	24	36	36	24	216
17.07	1	1380	20	60	4	0	4	4	104
17.07	2	1343	164	128	44	8	8	8	372
17.07	3	1309	8	12	0	0	0	4	24
17.07	4	1248	20	60	4	4	1	8	97
17.07	5	1197	16	28	96	4	8	0	164
sum			588	1586	788	208	181	172	3719

Table 2. Coefficients for Simple Regression.

	Parameter	*Least Squares Estimate*	*Standard Error*	*T Statistic*	*P-Value*
all animals	Intercept	282.1	422.5	0.668	0.511
	Slope	-0.103	0.326	-0.316	0.755
Diptera	Intercept	-162.1	174.5	-0.929	0.363
	Slope	0.143	0.135	1.07	0.298
Coleoptera	Intercept	-29.7	147.4	-0.202	0.842
	Slope	0.0719	0.114	0.633	0.533
Formicidae	Intercept	319.8	117.5	2.72	0.012
	Slope	-0.223	0.0906	-2.46	0.022
Arachnide	Intercept	78.1	48.3	1.62	0.119
	Slope	-0.0539	0.0372	-1.45	0.161
Diplopoda	Intercept	44.3	34.5	1.28	0.212
	Slope	-0.0286	0.0266	-1.08	0.293
Isopoda	Intercept	16.8	34.0	0.492	0.627
	Slope	-0.0076	0.0262	-0.290	0.774

Table 3. Simple regression.

	Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*	*Correlation Coefficient*	*R-squared [%]*
all animals	Model	1140.2	1	1140.2	0.10	0.755	-0.0657	0.432
	Residual	262778.0	23	11425.1				
	Total (Corr.)	263919.0	24					
Diptera	Model	2211.7	1	2211.7	1.13	0.298	0.217	4.70
	Residual	44838.5	23	1949.5				
	Total (Corr.)	47050.2	24					
Coleoptera	Model	556.8	1	556.8	0.40	0.533	0.131	1.71
	Residual	31983.3	23	1390.6				
	Total (Corr.)	32540.2	24					
Formicidae	Model	5332.5	1	5332.5	6.03	0.022	-0.456	20.8
	Residual	20341.7	23	884.4				
	Total (Corr.)	25674.2	24					
Arachnide	Model	312.3	1	312.3	2.09	0.161	-0.289	8.35
	Residual	3429.1	23	149.1				
	Total (Corr.)	3741.4	24					
Diplopoda	Model	88.3	1	88.3	1.16	0.293	-0.219	4.79
	Residual	1754.3	23	76.3				
	Total (Corr.)	1842.6	24					
Isopoda	Model	6.3	1	6.26	0.08	0.774	-0.0604	0.365
	Residual	1706.4	23	74.2				
	Total (Corr.)	1712.6	24					

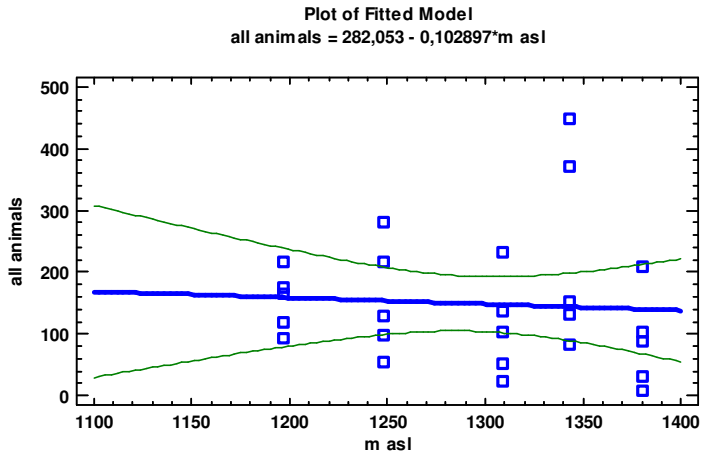

Fig. 2. Simple Regression - abundance of all animals vs. altitude (m a.s.l.)

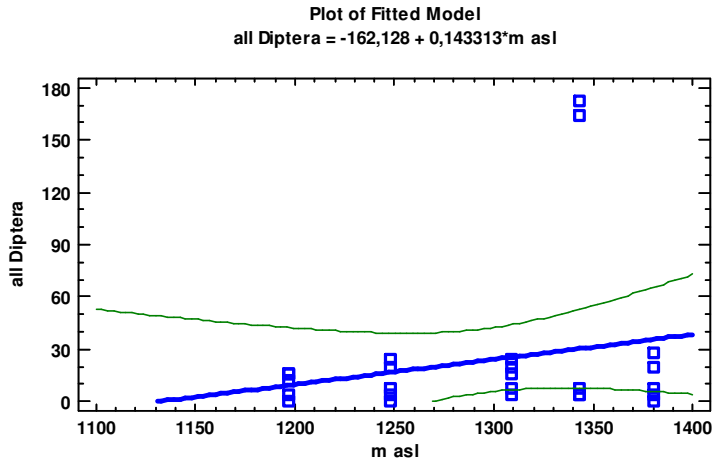

Fig. 3. Simple Regression - abundance of Diptera vs. altitude (m a.s.l.).

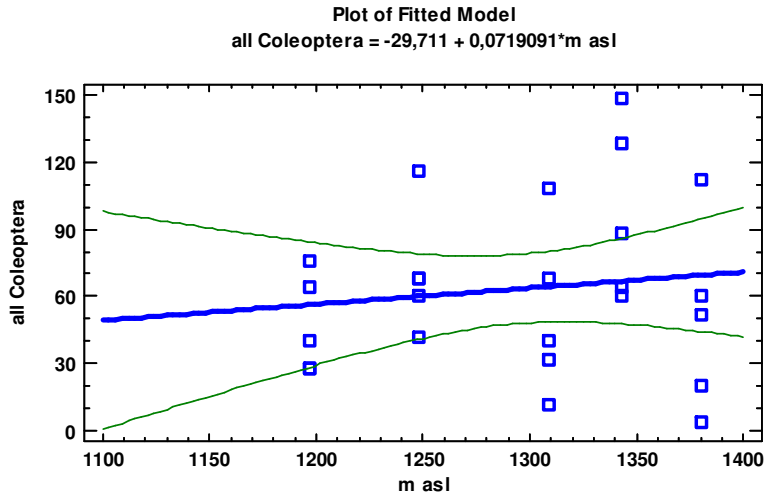

Fig. 4. Simple Regression - abundance of Coleoptera vs. altitude (m a.s.l.).

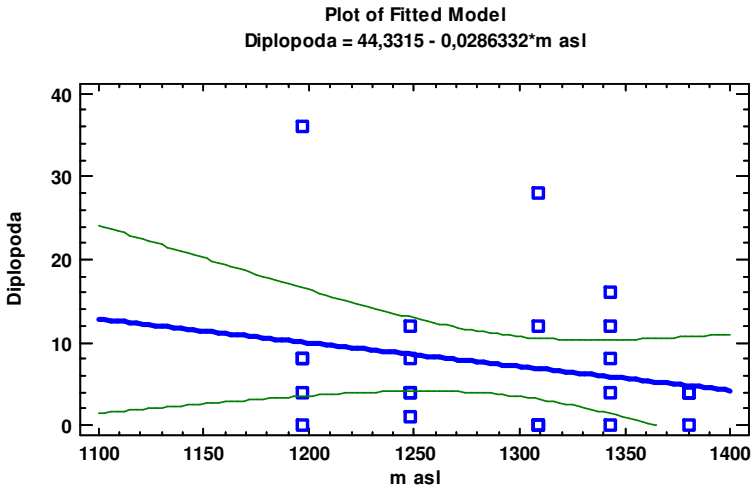

Fig. 5. Simple Regression - abundance of Diplopoda vs. altitude (m a.s.l.)

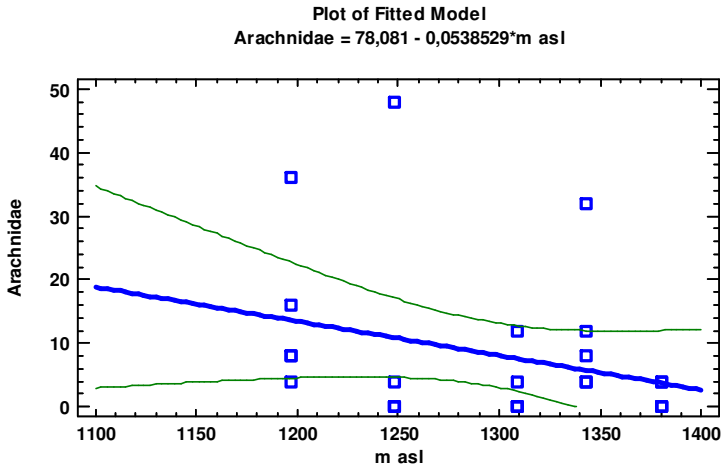

Fig. 6. Simple Regression - abundance of Arachnida vs. altitude (m a.s.l.).

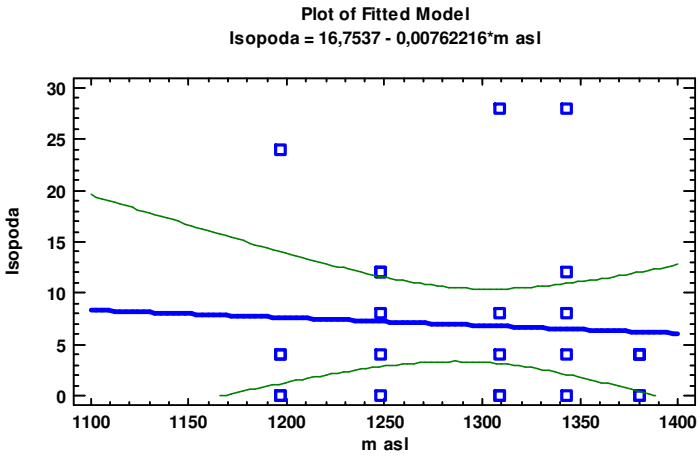

Fig. 7. Simple Regression - abundance of Isopoda vs. altitude (m a.s.l.).

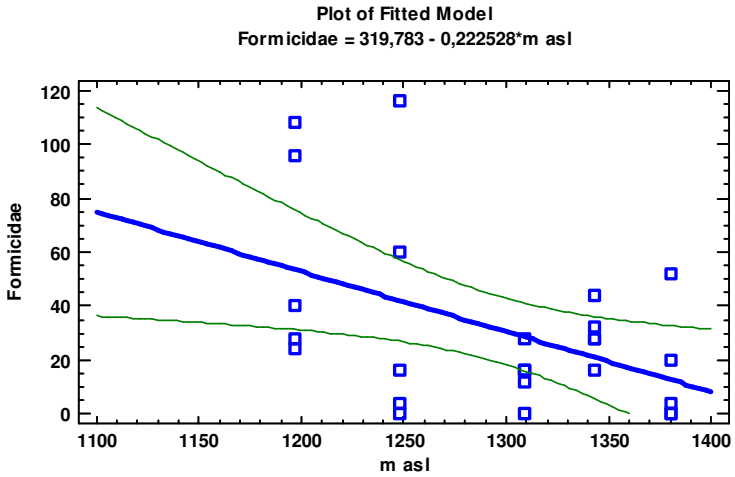

Fig. 8. Simple Regression - abundance of Formicidae vs. altitude (m a.s.l).

Table 4. One-Way ANOVA.

	Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
all animals	Between groups	65901,0	4	16475,2	1,66	0,198
	Within groups	198018,0	20	9900,9		
	Total (Corr.)	263919,0	24			
Diptera	Between groups	13795,8	4	3449,0	2,07	0,122
	Within groups	33254,4	20	1662,7		
	Total (Corr.)	47050,2	24			
Coleoptera	Between groups	9036,2	4	2259,0	1,92	0,146
	Within groups	23504,0	20	1175,2		
	Total (Corr.)	32540,2	24			
Formicidae	Between groups	6941,4	4	1735,4	1,85	0,158
	Within groups	18732,8	20	936,6		
	Total (Corr.)	25674,2	24			
Arachnide	Between groups	631,0	4	157,8	1,01	0,424
	Within groups	3110,4	20	155,5		
	Total (Corr.)	3741,4	24			
Diplopoda	Between groups	176,2	4	44,0	0,530	0,716
	Within groups	1666,4	20	83,3		
	Total (Corr.)	1842,6	24			
Isopoda	Between groups	170,2	4	42,6	0,550	0,700
	Within groups	1542,4	20	77,1		
	Total (Corr.)	1712,6	24			

Discussion

The differences caused by the change of altitude were apparently generally too small to exert a decisive influence on the species richness of soil epifauna. The fact that only the number of ants decreased with altitude could be due to the fact that factors causing variation in species richness may differ between different organisms (Bhattarai & Vetaas 2003). It

conforms to the observations that ants prefer more open and dry habitats. Humid habitat conditions limit their foraging ability and reduces the time available for foraging on the litter floor (Sabu, Vineesh & Vinod 2008).

It must be also noted that not only altitude determines species composition, but also other factors, such as humidity, sunlight access and general microclimatic conditions of the area are important as well. In our study we focused at only one factor, ignoring others. Additionally, some studies indicate that species richness is highly dependent on the specific characteristics of habitats (AxmAcher & Fiedler 2008), while we focused on altitude. A wider research would be appropriate and could help in interpretation the results.

We are also aware of the fact that in our study we set too few sampling spots and collected not enough samples and, which may be most important, the time of extraction was probably too short to efficiently extract all animals from the samples. After 60 hours of extracting we could still see animals living in our samples, that is why we realize that our results are incomplete.

Nevertheless, we believe that our study may serve in future as a preliminary study.

Acknowledgments

We would like to thank prof. Ryszard Laskowski for help with planning the research and statistical analysis, and dr John Latke for providing necessary equipment. We are also thankful to our colleagues for their help during field work.

References

1. AxmAcher J. C., Fiedler K. (2008) Habitat type modifies geometry of elevational diversity gradients in geometrid moths (Lepidoptera Geometridae) on Mt Kilimanjaro, Tanzania. Tropical Zoology 21: 243-251
2. Bhattarai K. R., Vetaas O. R. (2006) Can Rapoport's rule explain tree species richness along the Himalayan elevation gradient, Nepal? Diversity and Distributions 4: 373-378
3. Bhattatai K. R., Vetaas O. R. (2003) Variation in plant species richness of different life forms along a subtropical elevation gradient in the Himalayas, east Nepal. Global Ecology & Biogeography 12: 327 – 34

4. Fleishman Erica; Austin George T.; Weiss Andrew D. (1998) An empirical test of Rapoport's Rule: elevational gradients in montane butterfly communities. Ecology 79: 2482-2493
5. Grytnes A., Vetaas O. R. (2002) Species Richness and Altitude: A Comparison between Null Models and Interpolated Plant Species Richness along the Himalayan Altitudinal Gradient, Nepal. The American Naturalist 3: 294-304
6. McCoy Earl D. (1990) The distribution of insects along elevational gradients. OIKOS 58: 313-322
7. Olson D. M. (1994) The distribution of a leaf litter invertebrates along a Neotropical altitudinal gradient. Journal of Tropical Ecology 10: 129-15
8. Rahbek Carsten (1995) The elevational gradient of species richness: a uniform pattern? Ecography 18: 200–205
9. Sabu T. K., Vineesh P. J., Vinod K. V. (2008) Diversity of forest litter-inhabiting ants along elevations in the Wayanad region of the Western Ghats. Journal of Insect Science 8
10. Stevens G. C. (1992) The elevational gradient in altitudinal range: an extension of Rapoport’s Latitudinal Rule to altitude. American Naturalist 140: 893-91