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LIFE HISTORY TRAITS OF *Oritrophium peruvianum* IN THE PÁRAMOS OF THE CORDILLERA OF MÉRIDA, VENEZUELA

ATRIBUTOS DE LA HISTORIA DE VIDA DE ORITROPHIUM PERUVIANUM EN LOS PÁRAMOS DE LA CORDILLERA DE MÉRIDA, VENEZUELA

Tiziana Ulian[16], Margaret Smith[17], Anairamiz Aranguren[18]

ABSTRACT

Oritrophium peruvianum (Lam.) Cuatr. is an endemic species of the Páramos of the Cordillera of Los Andes. In Venezuela it is harvested for its medicinal properties in treating asthma and bronchitis. Scientific information on the species is lacking. This project aims to obtain information on the biology and ecology of *O. peruvianum*. The information thus derived could be used to develop management recommendations for the conservation of the species and suggestions for improved harvesting practices. In this work, we present some preliminary results of this project, regarding specifically the following objectives. (1) To analyse the density and the spatial distribution of this species in the study area; (2) To examine the size structure and morphology of the species and; (3) To provide information on its habitat requirements. In order to meet these goals, altitudinal belt transects were laid down in four sites in the Páramo of Gavidia, in the Sierra Nevada of Mérida. Data on density, habitat characteristics and soil for chemical analysis were collected. Preliminary analysis of the mean density and variance revealed a patchy distribution pattern for the species. A morphological study of 100 plants was carried out and linear regression analysis showed that the rosette diameter was correlated to the dry weight of rhizome (r=0.73), which is assumed to determine the size of the plant. The environmental variables did not reveal any particular preference of the species within the Páramo environment.

Key Words: Medicinal plant, *Oritrophium*, distribution pattern, size structure, Páramo.

RESUMEN

Oritrophium peruvianum (Lam.) Cuatr. es una especie endémica de los Páramos de la Cordillera de los Andes. En Venezuela es recolectada por sus propiedades medicinales en el tratamiento del asma y la bronquitis. Hasta ahora es muy poca la información científica sobre esta especie. El objetivo general de este proyecto es obtener información sobre la biología y la ecología de *O. peruvianum.* Esta información podría ser usada posteriormente para desarrollar planes de conservación y mejorar las prácticas de cosecha. En este trabajo se presentan algunos resultados preliminares de este proyecto con los siguientes objetivos específicos: (1) Analizar la densidad y la distribución espacial de esta especie dentro del área de estudio; (2) Examinar la estructura del tamaño y la morfología de la especie; (3) Identificar sus requisitos ambientales. Para ello se trabajó en cuatro localidades dentro del Páramo de Gavidia, en la Sierra Nevada de Mérida. Se tomaron datos de la densidad de la especie, datos ambientales, y de la composición química del suelo. Los resultados preliminares muestran que el patrón de distribución es agregado. Se realizó un estudio morfológico de 100 plantas y un análisis de regresión lineal mostró una correlación significativa entre el diámetro de la roseta y el peso seco del rizoma (r=0.73) con lo que se asume que podemos determinar el tamaño de la planta. Las variables ambientales analizadas no revelaron ninguna preferencia específica de la especie en el ambiente Páramo.

[16] Natural Resource Institute, Agricultural Resources Management Department, University of Greenwich, Kent, U.K. E-mail: T.Ulian@gre.ac.uk
[17] 117a Trafalgar Street, Gillingham, Kent, ME7 4RP, UK
[18] Instituto de Ciencias Ambientales y Ecológicas, Facultad de Ciencias, Universidad de Los Andes, Mérida, Venezuela

INTRODUCTION

Oritrophium peruvianum (Lam.) Cuatr. is an endemic species of the Páramos of the Cordillera of Los Andes (Cuatrecasas, 1961). In Venezuela, where it is known as *Frailejón morado*, it is harvested for its medicinal properties in treating asthma, bronchitis and influenza. However, although some botanical descriptions of the species are available, information on the biology and ecology of this species is lacking.

A project involving the Natural Resources Institute (NRI) at the University of Greenwich in UK, the Instituto de Ciencias Ambientales y Ecológicas (ICAE) at the ULA University in Mérida, Venezuela, and the local NGO Programas Andes Tropicales (PAT) was initiated in April 2000. The aim of this project is to obtain information on the biology and ecology of *O. peruvianum*. The data derived from this project could then be used to develop management recommendations for the conservation of the species and specifically to provide suggestions for improved harvesting practices.

In this paper, we present some of the preliminary results of this project, covering three of the main objectives. First, we will present some information on the density and the spatial distribution of the species in the study area, then we will analyse some aspects of the size structure in relation to its morphology. Finally, we will provide some information on the plant's habitat requirements.

With the exception of a few high value species such as *Panax quinquefolium* (Gagnon, 1999) there has been very little detailed research on the impact of harvesting on wild populations of plants. There is very little information in the literature on what constitutes sustainable harvesting and so it is usually quite difficult to estimate the impact of harvesting. This is mainly because such assessments require detailed field data acquired over a number of years (Wong, 2000). Estimates of mean density, for example, can change significantly at one location from year to year. Most studies are relatively short-term and those detailed data that do exist relate to very few species, mostly trees.

Wild populations of *O. peruvianum* are scarce and difficult to locate in Venezuela and local people report that it is being harvested intensively in some areas. The whole plants are collected by pulling out the rhizomes and are then dried and used to prepare an infusion, called “jarabe” by local people. Collectors can sell either the dry material or the “jarabe” to the local markets or to private individuals in tourist attractions or visitor centers (Aranguren *et al.*, 1996). Unfortunately, there is no control over the amount being harvested each year, and an increase in public interest in this and other medicinal species has been observed in the urban areas of Venezuela, as a consequence of the increasing interest in herbal medicines. There is therefore an incentive to continue harvesting at current levels until the effort required for locating sufficient material becomes too great. However, according to the director of VitaPlant, one of the largest medicinal plant companies in Venezuela, commercial exploitation of this species is unlikely to occur due to the low biomass available for extraction and the big effort required to find the plants.

International bodies such as WHO and IUCN (Akerele *et al.* 1991) recognize the need for conservation of medicinal plants. Since a large number of medicinal plants are found in the tropics and are used traditionally by the indigenous communities, there is a need for undertaking surveys and assessing the species at risk, followed by demarcation of areas to be set aside for *in situ* conservation. Identifying crucial demographic and risk factors is considered a particular challenge for biological conservation (Frankel *et al*. 1995).

STUDY AREA

The study area belongs to the Central Nucleus of the Páramos of the Cordillera of Mérida above 3000 m. Here, according to herbaria specimens, the literature (Aranguren et al., 1996), and interviews with botanists and local people, *O. peruvianum* is present in three localities: the Páramo of Gavidia in the Sierra Nevada; the Páramo of Piedras Blancas and the Páramo of González in the Sierra La Culata.

The Páramo is a neotropical high mountain biome, which latitudinally is located north of the Cordillera de Los Andes. It extends from the Sierra Nevada of Mérida in Venezuela, towards Colombia, Ecuador, as far as the high Andes in northeast of Perú, above an altitude of 3000-3500 m (Monasterio, 1980). Geologically, the Páramos are of recent origin, belonging to the Miocene era, 25 million years ago, with the topography shaped by glacial action (Schubert, 1980). The soils are mostly acidic, rocky and little developed with a low content of inorganic nutrients (Baruch, 1979).

In the Venezuelan Páramos precipitation is seasonal with rains from April to October (Monasterio and Reyes, 1980). However, low evaporation, high cloudiness, and frequent fogs, result in relatively humid conditions throughout the whole year. At the highest elevations, there is occasional snow of short duration. Air temperatures are low, cold at night and cool during the day, with daily oscillations larger than the monthly average oscillations. During the dry season night-frosts become frequent above 3500 m (Baruch, 1984; Cuatrecasas, 1968).

The Páramo vegetation is evergreen with a complete cover at low elevation and sparse cover at high altitude. The life forms include large and small shrubs, stunted trees, cushion plants, grasses and caulescent and acaulescent rosettes (Monasterio, 1980). Many species of these rosette plants belong to the subtribe Espelatiinae, Compositae (Cuatrecasas, 1961) which is endemic and characteristic of the Páramos (they are known locally as frailejones) (Baruch, 1984).

Evidence of human disturbance is found in most of the Venezuelan Páramos (Wagner, 1979). Intense agricultural activity is limited to the lower part of the Páramo, up to 3500 m, while the highlands are mainly used for extensive grazing. Some of the woody species are used for fuels and parts of the Páramo are occasionally burned. All this has resulted in a lowering of the timberline and an increase in width of the Páramo belt. Building of roads and dams and increasing tourism also have negative effects on the existence and dynamics of the Páramo plant communities (Baruch, 1984).

Site selection

At the beginning of this study very little was known about the distribution and abundance of *O. peruvianum* in the study area and no quantitative data were available. The first step, therefore, consisted of consulting various herbaria: the Herbario Ovalles (MYF) in Caracas, the herbarium of the Faculty of Agronomy in Maracay (MY), and the Jardín Botánico (MERC), the herbarium of Pharmacy (MERF), and the herbarium of Forest and Environmental Sciences (MER), in Mérida. In these collections very few specimens from the study area were found; in most cases only a general location was given. Instead, local knowledge turned out to be invaluable in the preliminary stage of the fieldwork.

The first contacts with local people were provided through the help of PAT and through researchers from ICAE. Informants from the Páramo of Piedras Blancas revealed two places where *O. peruvianum* could be found: a population in the locality of Los Caracoles and another one in Mucuró. The first place was visited during April 2000 and reached after 5 hours on horseback. The population was found along a little stream, it had a very low density and it was a harvested one. The second place was not visited because it was even further away and the population was harvested. In addition, several local informants said that *O. peruvianum* is difficult to find in the Páramo of Piedras Blancas and that it is more common in the Gavidia area.

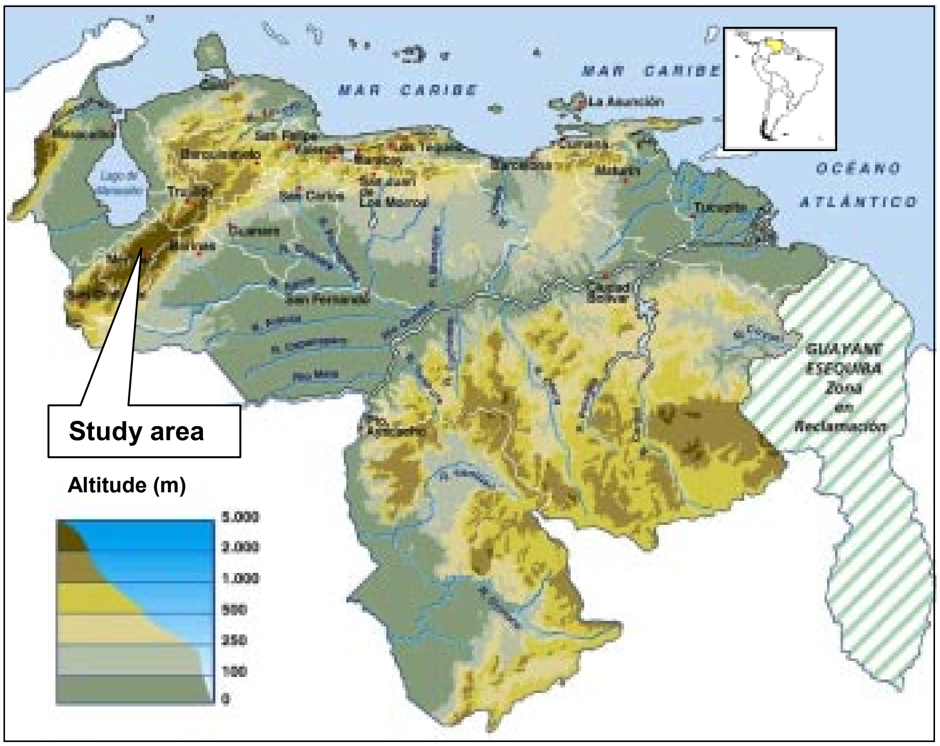

Figure 1 Location of the study area in the Venezuelan Andes (Páramo of Gavidia).

The Gavidia area was visited quite extensively in August 2000 with a local guide who knew the sites where *O. peruvianum* grows. In this area, *O. peruvianum* appeared to have a wider distribution and to be commoner than in the Páramo of Piedras Blancas. The reasons for this are unknown, but a few informants suggested that it has always been that the case and it is because the Páramo of Gavidia is wetter than the Páramo of Piedras Blancas. In Gavidia several populations can be found within 10-30 minutes walking distance of each other. Furthermore, these are more accessible. According to the informants, harvesting is rare in Gavidia, so the populations can be considered unharvested. For this reason, and because of the higher frequency of populations of *O. peruvianum*, and the relative accessibility of several populations, it was decided to focus the study in this locality.

The Páramo of Gavidia is located between 8°35' and 8°45'N and 70°52' and 70°57'W, in the Mérida State (Figure 1). Its population is approximately 500 inhabitants, whose ancestors established the settlements at the beginning of the century (Smith, 1995 cited by Sarmiento, 2000). This area consists of several narrow glacial valleys with altitudes between 3200 and more than 4000 m. The dominant vegetation consists of giant rosettes of the genus *Espeletia* and shrubs of the genus *Hypericum*, *Baccharis*, *Hesperomeles*, *Stevia*, and *Acaena*. Soils are well-drained inceptisolls of sandy-loam texture, very stony and acidic (pH 4.5-5.5), and very rich in organic matter (20%). In this area, agriculture is practiced up to approximately 3800 m (Sarmiento, 2000).

Species information

Oritrophium peruvianum (Lam) Cuatr. is a small rhizomatous perennial herb belonging to the Asteraceae family (Figure 2). It grows in the form of a rosette reaching 10-30 cm in height (Badillo, 1994). The leaves have xeromorphic characteristics (small size, heavy cutinization and pubescence at base level) which enable them to adapt to the Páramo environment conditions where they are subjected to intense radiation, low temperature, physiological water stress and strong winds (Torres et al., 1996). Reproduction occurs mainly by seed but vegetative propagation has been assessed during fieldwork and occurs infrequently.

Figure 2. Picture of ***Oritrophium peruvianum*** (Asteraceae).

There are three subspecies identified in the literature, which differ mainly in their leaf characteristics. These are *O. peruvianum*, *O. lineatum* and *O. perijaense*. The former subspecies also has two forms, *peruvianum* and *intermedium* (Cuatrecasas, 1961)

Specimens in the Kew Garden herbarium in the UK suggest the subspecies used for medicinal purpose in Venezuela, and covered by this study, corresponds to the subspecies *peruvianum*.

Since in the Páramo of Gavidia cultivation occurs up to 3800 m., *O. peruvianum* is most likely to be found in the natural vegetation above this height. Moreover, loss of suitable habitat due to agricultural expansion, deforestation, diseases, closeness to the villages or paths may be reasons for the reported declining availability of *O. peruvianum*.

According to herbarium specimens and the experiences of local botanists, *O. peruvianum* occurs in small fragmented populations and has very specific habitat requirements. It is restricted to riparian habitats in open marshy grassland with or without rocks, on wet soil near to streams, rivers or lakes. Habitats for *O. peruvianum* in Venezuela according to Aranguren et al. (1996) are:

- areas where water spills over from streams in the rainy season
- flat zones in the base of valleys
- areas of landslides which have become flooded
- cracks in rocky outcrops which hold the moisture
- flood plains
- areas subject to seasonal drainage
- areas close to lakes

Although *O. peruvianum* has a broad geographical range (mountain regions in Venezuela, Columbia, Perú and Ecuador), biologically it might be regarded as rare, because of its specific habitat requirements and because the species exists in small populations wherever it is found in Venezuela.

In the absence of detailed field data, this species could be considered to be vulnerable to extinction and would be placed in rarity category 6 *sensu* Rabinowitz et al. (1986). However, Ramsay (1992) reports *O. peruvianum* as a frequent species in the Páramos of Ecuador and botanists from Colombia (contacted via e-mail) consider *O. peruvianum* a characteristic species of the Colombian Cordillera. Therefore, *O. peruvianum* may be more common than has been assumed.

METHODS

In order to meet our three main goals, namely, determining the density and spatial distribution of the species, analyzing the size structure in relation to the morphology, and providing information on the habitat requirements, informal interviews, field survey and laboratory measurements have been carried out.

Density and spatial distribution

Due to the patchy distribution of the species, it was planned initially to sample for density by first counting the number of patches in big grids of 500 m^2, and then to sample the individuals within each patch with the use of smaller grids. However, this method was discarded once in the field for two reasons: first, because visually it was not possible to detect the patches within a selected area, and secondly because of the irregular landscape with steep and rocky slopes, which does not suit this kind of sampling.

In order to sample for the distribution of the species transects were used to describe maximum variation over the shortest distance in the minimum time (Kent & Coker, 1992). Transects were not placed at random because the rarity of the species and its non-uniform distribution, which would have resulted in a high probability of sampling without finding any plants of *O. peruvianum*. Sampling was carried out along the slopes where the presence of *O. peruvianum* was detected and altitudinal belt transects of 20 m width were utilized. At the present time four transects (T1, T2, T3, T4) of respectively 100, 150, 200, 200 m have been sampled, and two more transects have been set up but not sampled yet. The starting point of each transect was laid down at the beginning of the slope and the length was chosen according to the length of the slope. As a rule, each transect ended when a new slope with a different aspect started. Along each transect, sections were chosen at random every 25 m. For each section, five 1x2 m^2 plots were laid out, the central one on the mid-line with 2 randomly placed within 10 m either side of the centre line (Figure 3). Where 100% rock was encountered another plot location was chosen at random. Each plot was also subdivided into eight subplots of 50x50 cm^2 to increase the accuracy in recording the data.

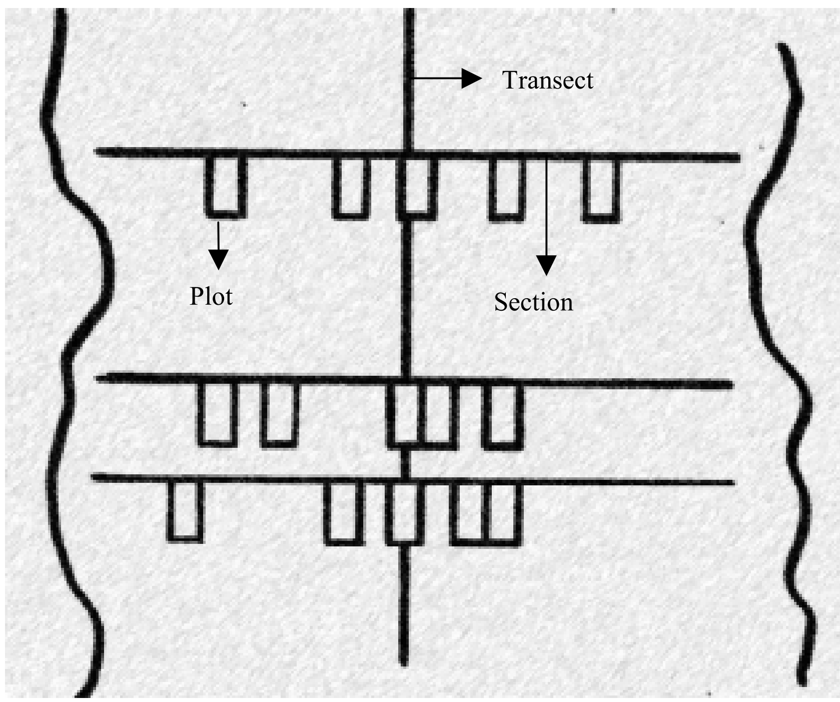

Figure 3. Sketch of an aerial view showing the sampling method utilized. The vertical line shows the transect direction and the horizontal lines show the transect sections with the five plots placed.

The 1x2 m^2 plot size was chosen after several calibration tests. Initially a plot size of 50x50 cm^2 was chosen, then this was doubled to 1x1 m^2, and finally, to 1x2 m^2. A minimum number of almost 100 individuals was required per plot in order to allow statistical analysis later on, and the plot size that gave results closest to this minimum number in the three tested populations was 1x2 m^2. However, the *O. peruvianum* density was found to be very variable in later fieldwork.

The information recorded for each plant includes: the two main rosette diameters; number of leaves including the number of leaflets; number and state of each flower head (flower bud, open, mature, and dry). The state of each plant was also recorded when it appeared unhealthy (sign of diseases, trampling, dead structures).

Size structure and morphology

The rhizome was assumed to be the best indicator of the size of the plant. A destructive sampling of 100 individuals was carried out in order to find the relation between the rhizome and the aerial parts of the plant. Ideally, this should have been done for each studied population, but it was decided to do it just once because of the supposed rarity of the species. Harvesting took place outside the transect plots near Transect T2. The harvested plots were chosen at random along a transect of 100 m. The following morphological characteristics were measured before harvesting: the two main rosette diameters, rosette height from the ground, number of leaves including the number of leaflets, length and width of the three longest leaves, and the number and state of each flower head (flower bud, open, mature, and dry). After collection, the length and the three widths (top, middle, low) of the rhizomes were measured and each plant was weighed and then oven-dried. Dry weights were obtained for the whole plant, the rhizome, the rosette leaves, and the reproductive parts. Roots were not harvested because they are very fragile and difficult to pull out completely.

Habitat-soil characteristics

A soil sample was collected for each plot in Transect T2 in order to assess whether the presence of the species was related to the selected soil characteristics. Soil samples from the A horizon (0-10 cm) only are suitable because the plant roots do not grow below this limit. In fact several plants have been found growing on a rocky surface where soil has accumulated. Soil samples each weighing 100-150 g were collected at the sampling locations (always on the last left hand side of the upper subplot), dried and packed in polythene bags, which were stored at room temperature until analysis. The samples were taken to the laboratory of geography at the University of Los Andes for analysis and the following soil analyses were conducted: textural analysis (soil particle size distribution), soil moisture, pH, % organic matter (loss on ignition), % N, C, C/N, CEC (cationic exchange capacity) and available Ca, Mg, Na and K.

RESULTS AND DISCUSSION

Density and spatial distribution

Analysis on the total number of individuals per plot have been carried out in the four transects. Mean values and standard deviations have been calculated per each section over the five plots (Table 1).

Table 1. Density of plants per section across the 5 plots (1x2 m^2).

Transect	Section	Density (plants/plot)	
		Mean	**S.D.**
T1	1 (0-25 m)	0.2	0.4
	2 (25-50 m)	103.0	92.7
	3 (50-75 m)	23.0	26.3
	4 (75-100 m)	0.0	0.0
T2	1 (0-25 m)	53.4	50.3
	2 (25-50 m)	13.8	20.6
	3 (50-75 m)	0.0	0.0
	4 (75-100 m)	0.0	0.0
	5 (100-125 m)	0.0	0.0
	6 (125-150 m)	0.0	0.0
T3	1 (0-25 m)	36.4	16.8
	2 (25-50 m)	0.4	0.9
	3 (50-75 m)	0.6	1.3
	4 (75-100 m)	0.0	0.0
	5 (100-125 m)	0.0	0.0
	6 (125-150 m)	0.0	0.0
	7 (150-175 m)	0.0	0.0
	8 (175-200 m)	0.0	0.0
T4	1 (0-25 m)	0.0	0.0
	2 (25-50 m)	12.2	21.1
	3 (50-75 m)	3.4	5.4
	4 (75-100 m)	0.0	0.0
	5 (100-125 m)	0.0	0.0
	6 (125-150 m)	0.0	0.0
	7 (150-175 m)	0.0	0.0
	8 (175-200 m)	0.0	0.0

The mean values for each section show big differences within each transect and the standard deviations calculated are very high, giving variance: mean ratios indicative of a patchy distribution.

Size structure and morphology

This experiment was carried out in order to relate the chosen morphological characteristics of the plant to the rhizome size by using simple linear regression analysis. This was carried out in order to relate the rhizome to the aerial parts of the plant. The linear regression analysis showed that the rosette diameter had the best correlation (r= 0.73) with the dry weight of rhizome (see Fig 4).

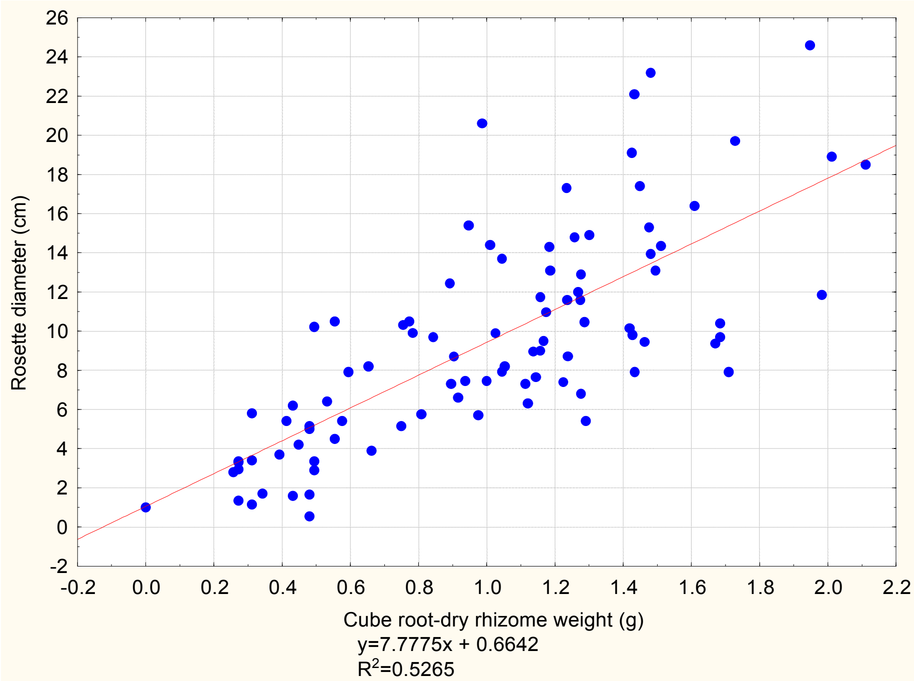

Figure 4. Rosette diameter plotted against the cube root of dry weight of the rhizome.

Habitat-Soil Characteristics

In order to find the soil characteristics of the species data were analysed graphically to identify differences between plots with *O. peruvianum* present or absent. The ANOVA analysis was also used and Multivariate Analysis (Principal Component Analysis) was applied in order to find the main soil characteristics of the species. The results, according also to the opinion of a soil specialist, Mr. P. Brinn, from NRI, do not show any particular soil preference for the plant. There is very little variation in soil characteristics between plots with and without *O. peruvianum* (Table 2) and in both the values found are typical of the Páramo environment (Fariñas, 1975). The pH mean value of the soil where *O. peruvianum* grows is 4.5 and it is also similar to the value found in the plots without the species. The percentage of organic matter, which is directly related to the organic Carbon content, is slightly lower where *O. peruvianum* is present (13.9 %). The CEC value, which is probably more important in determining plant distribution than the individual quantities of Ca, Mg, Na and K since it indicates how much of these elements are available to the plant, is also slightly lower (16.9 meq/100g). Unfortunately, textural classes (% sand, clay, and silt) which are also important indicators of the soil type could be determined only in 4 samples because not enough soil was collected. Textural analysis is an indirect measure of moisture content which initial field observations suggest is an important determinant of *O. peruvianum* distribution. Moisture content is difficult to determine directly because it varies throughout the year. Therefore soil texture may be an important characteristic to analyse during future fieldwork as a surrogate for soil moisture.

Table 2. Soil Analyses for transect T2. Mean and Standard Deviation are calculated across the samples with (n=8) and without (n=20) *O. peruvianum*.

O. peruvianum		**Present**		**Absent**	
		Mean	**S.D.**	**Mean**	**S.D.**
pH		4.5	0.2	4.6	0.3
C	(%)	8.1	2.1	8.4	2.0
OM	(%)	13.9	3.7	14.6	3.5
N	(%)	0.5	0.2	0.5	0.2
C/N		16.9	2.1	16.6	2.7
CEC	(meq/100g)	16.9	4.9	17.6	5.6
Ca	(meq/100g)	0.1	0.1	0.3	0.6
Mg	(meq/100g)	0.0	0.1	0.2	0.2
Na	(meq/100g)	0.2	0.0	0.2	0.1
K	(meq/100g)	0.3	0.2	0.4	0.3

CONCLUSIONS AND FUTURE WORK

The preliminary analysis of the mean density and variance revealed a patchy distribution of the species. However, the density and distribution of *O. peruvianum* have been investigated only within the transects so far and further sampling needs to be carried out in order to assess the distribution of the species in the study area. Therefore, transects need to be extended to cover a greater range of altitudes by continuing along the slopes with different aspects and the width of each transect need to be enlarged in order to explore the distribution at a larger scale.

Furthermore, as preliminary field observations suggested that the distribution of *O. peruvianum* might be linked to the presence of water, it would be worth sampling along a gradient of moisture. However, because of the continuous changes of the small-scale drainage depending on the weather conditions, this is unlikely to be possible along the slopes. Instead, a further survey is planned to look at the abundance of the species around lake edges. This will consist of the use of short belt transects, where plots are laid out next to each other. Transects will be set up at random in three selected lakes.

The analysis of the relationship of above ground measurements to the rhizome showed a good correlation of the rosette diameter with the dry weight of rhizome. The rosette diameter represents then a good estimator of the size of the plant and it could be used as a parameter to categorise the individuals in size classes. It should help then to illuminate information collected in the field on population size and structure and on frequency of flowering plants.

The analyses of the soil samples did not show any particular environmental preference of the species within the Páramo environment. Nevertheless, it is essential to repeat the textural analysis, which is an indirect measure of moisture and it may be then related to the presence of *O. peruvianum*. However, during the fieldwork more detailed information on habitat and vegetation was compiled for each plot, but it has not been analysed yet. The landform and any biotic influence were noted, and the percentage of bare patches, rock and soil covered by water recorded, although the former variable probably is very dependent on the weather conditions. Finally, the percentage of each vegetation layer, the plant species found, and the most abundant species were listed. Principal Component Analysis and other ordination techniques, and cluster analyses will be then used to investigate the associations of *O. peruvianum* distribution with the selected environmental variables and to identify different plant communities with which *O. peruvianum* might be associated.

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