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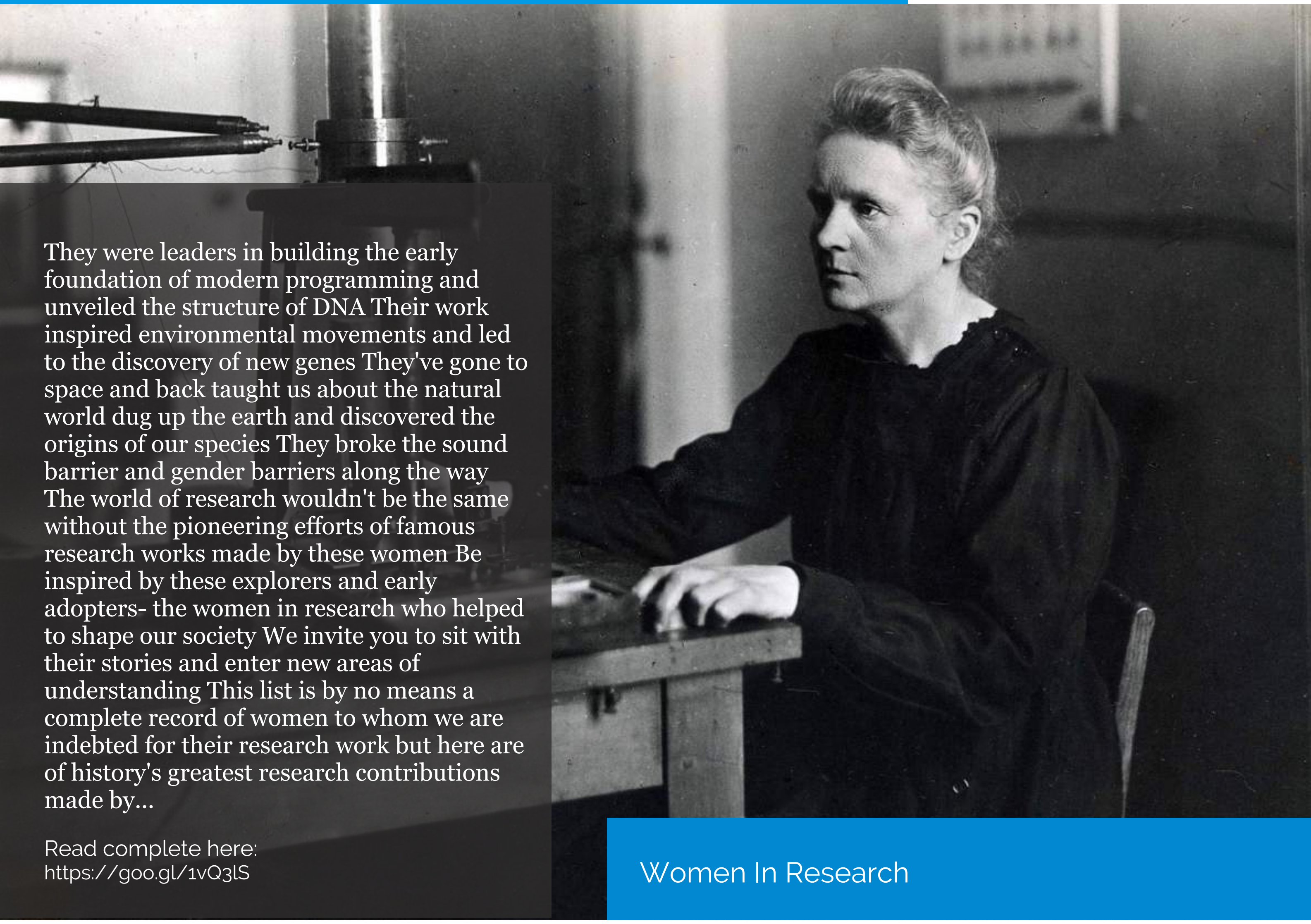

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Mayanin Rodriguez-Morales

Universidad de Los Andes

ABSTRACT

Paramos are an important mountain ecosystem; they are essential water supplier to the Andean population. However, climate change threatens this ecosystem and its hydrological function. Plants could play a vital role in reducing this potential impact. Nevertheless, little is known about the effect of paramos' vegetation on the water cycle. This research aimed to assess the effect of two dominant plant life forms upon soil water content (SWC), evapotranspiration (EVT) and other hydrological fluxes in a Venezuelan paramo. TDR sensors were installed in a 25 m^2 parcel, in the first 10cm, into soils beneath a rosette, a shrub and in bare soil and set up every 10-minute register from March 2012 to November 2013. Water fluxes were evaluated through an ecosystem approach, hydrological balance equations and TDR registers. EVT was estimated through the daily SWC variation in days without rain because, on these days, every flux gets cero, except it. Shrub kept a SWC mean 36% higher than the rosette and similar to bare soils (bs) in the study period. The plants' effects changed notably in the dry and wet seasons. Rosette held a SWC mean close to bs, but its SWCs were more stable despite the decrease in rain and its fluctuation, during the dry season. Bare soils lost water two times faster than soils under plant covers. Shrub retained 120% more water than bare soil, while the rosette maintained 50% more, in the driest month, showing the critical role of plants in keeping water in the ecosystem.

Keywords: evapotranspirations, soil water content, tdrs, caulescent rosette, sclerophyllous shrub, life forms, *espeletia schultzii, Hypericum laricifolium,* andean paramo.

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Keywords: evapotranspirations, soil water content, tdrs, caulescent rosette, sclerophyllous shrub, life forms, *espeletia schultzii, Hypericum laricifolium,* andean paramo.

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I. INTRODUCTION

Andean paramo is a high mountain ecosystem located in north Peru, Ecuador, Colombia and Venezuela, between 2800 m and 4800 m altitude, above the upper limit of forests and under the glacier limit (Cuesta & Becerra, 2009; Monasterio, 1980). Its location in high altitude and the tropics define its weather, dominate by a high solar radiation input (Rodríguez-Morales et al., 2019; Padron et al., 2015), a low-temperature mean 6°C with a wider daily oscillation (between 17°C and -3 °C) than the annual temperature fluctuations (Rodriguez-Morales, 2010). Its rainfall is very low-intensity and high frequency, mainly drizzle (Padron et al., 2015; Rodríguez-Morales et al., 2014) with a markable seasonal pattern, with a wet and a dry season (Sarmiento, 2000). The paramos vegetation is characterized by a high biodiversity and elevated endemism with open canopy dominated by rosettes and shrubs (Llambi et al., 2014 .

Paramos are an essential ecosystem to the Andean population because they are water suppliers (Carrillo-Rojas et al., 2016; Monasterio et al., 2006). The Andean inhabitants and their productive activities, such as agriculture, livestock, and hydro electrical supply, depend directly on this ecosystem (Smith et al., 2011; De Bievre et al., 2006; Hofstede, 1995). Its weather, soils and vegetation determine its hydrological function; they favor the water storage in the wet season and release it in the dry season, regulating and maintaining permanent streamflow (Rodríguez-Morales et al., 2019; Naranjo & Duque, 2004), being this one of its leading environmental services.

In this crucial role, the paramos' vegetation undoubtedly has a significant effect on its hydrological process because plants modify almost all the water fluxes at the ecosystem scale (Pacheco & Ataroff, 2005; Sarmiento, 2000; Belmore & Romero, 1999). Paramos' plants have morphological and physiological adaptations to avoid water deficit stress (Rada et al., 2019). For example, *Espeletia schultzii*, a dominant caulescent rosette, has stomatal control during the dry season (Sandoval et al., 2019); also, its leaves are covered by a dense pubescent, which reduces the gas chance, including water vapor, and it has a medulla to store water. While *Hypericum laricifolium*, a dominant sclerophyllous shrub, has tiny leaves with a leather texture (Rada, 1993). All these mechanisms lessen the transpiration flux. In Addition, vegetation protects the dark soil of Paramo against high solar radiation, providing shade (Sarmiento, 2000), reducing the evaporation rate (Rodriguez-Morales, 2010), and contributing organic matter (Nierop et al., 2007), which favors water soil storage.

This research aimed to deepen the understanding of paramos plants' effects on the hydrological process by assessing the impact of two dominant plant growth-forms, rosettas and shrubs, *Espeletia schultzii* and *Hypericum laricifolium*, upon the water fluxes, emphasizing soil water content and evapotranspiration.

Despite the importance of paramos and its vegetation, anthropic activities such as agriculture, grazing, timber harvest, climate change, and global warming have been changing its structure and function. In this context, agriculture is expanding its frontier over paramos, transforming and replacing its vegetation (Sarmiento, 2000); livestock harms the plant structure by stepping or consuming; the local population extract shrubs and timber for firewood, reducing its biomass and cover. Therefore, there needs to be more information about the role of plants over the paramos' function to generate base information to justify its conservation, support decisions and its sustainable management (Ochoa-Tocachi et al., 2018; Acevedo et al., 2006; Buytaert et al., 2011)..

Additionally, global warming and climate change impact the water function of paramos through the increase of its temperature mean (Anderson et al., 2012; Buytaert et al., 2011), so there is more energy available for the evapotranspiration process, more extended drought periods are warning (Buytaert et al., 20006b), and likely an increase in rain intensity favors the surface fluxes, soil erosion and the restock of water reservoirs will likely be affected, decreasing the water offer (Giorgi & Bi, 2005). Plants could be significant in regulating the evapotranspiration outlet (Ochoa-Sanchez et al., 2020) and other hydrological fluxes, maintaining the water supply service. Also, knowledge about the repercussions of plant growth-forms on hydrology is insight to improve evapotranspiration estimates (Callañaupa et al., 2021) and perform hydrological models, adjusting parameters related to cover and explain part of its uncertainty to research the future sceneries and design strategies to adapt and mitigated to their effects.

1.1 Evapotranspiration

Evapotranspiration (EVT) is one of the main fluxes in water balance; it is the principal water output of mountain ecosystems (Li et al., 2024; Diaz, 2009; De Brieve et al., 2006; Buytaert, 2006c). In the Venezuelan paramos, EVT is more than 60% of the rain inputs (Rodriguez-Morales et al., 2019; Sarmiento, 2000), while in Ecuador, this flux is around 50% (Carrillo-Rojas et al., 2016). Due to EVT being a crucial flux in the water balance of paramos and highly modified by plants, the assessment of vegetation is necessary to understand the hydrological function of this ecosystem.

This water flux is the most complex to measure or to estimate (Carrillo-Rojas et al., 2016) because it is affected by many variables such as the plants' ecophysiology and morphology, edaphic properties, and environmental conditions (Callañaupa et al., 2021; FAO, 1990). There are many methods to estimate or measure EVT. However, for the aims of this research, few of these methods are suitable for evaluating species separated. One of those is lysimeters, the most direct method, but it is methodologically complicated and inaccurate (Ochoa-Sanchez et al., 2019). EVT equations such as Adjusted Evapotranspiration (FAO, 1990) could be helpful but demand knowing a vast number of variables, whose measuring requires specialized devices, specifically for the ecophysiological variables. When there are no measurements of these variables, theoretical coefficients reported in the bibliography are used, expecting they represent the condition in the study area; it incorporates high incertitude.

This research introduces a straightforward method for estimating ETV using an ecosystem approach. This method was developed using the following scientific principles.

1.2 Ecosystem approach

According to Acevedo and Sarmiento (1990), at ecosystem scale, water budget is calculated through the equation 1

$$\text{Tt Pp} = \text{F Int} + \text{R} + \text{D} + \text{EV} + \text{T} \pm \text{S} \text{ (equation 1)}$$

Where, total precipitation (Tt Pp) is the ecosystem water input. The vegetation canopy catches a portion of this; it is foliar interception (F Int); leaves and stems hold this water, and then it is evaporated; this water does not get to the soil surface; it represents an ecosystem water outlet. The water quantity intercepted by vegetation depends on the Leaf Area Index (ratio of leaf area to ground area), cover, and structure. A stratified canopy has a higher foliar interception than a simple and opened one. Additionally, the magnitude, intensity and frequency of rains affect the foliar interception (Ocho-Sanchez et al., 2018) because when the rain magnitude overcomes the water canopy saturation, foliar interception stops. A high rain intensity beats the canopy resistance, minimizing this flux, and the rain frequency determines how much water there is in the canopy and how far it is to get the saturation. For example, A high frequency decreases the F Int because the canopy reaches saturation easily. At the same time, low frequency allows canopy evaporation and the canopy water content goes down, keeping the canopy empty to catch the next rain. When the canopy gets saturated the water starts to drop. The water that reaches the soil turns into two fluxes: infiltration (Inf) or surface runoff (R). Infiltration is the water that gets into the soil, and due to it being a transferred flux, it is not included in the equation. In contrast, R represents an ecosystem egress. This last flux happens under two conditions: when the soil saturation point is surpassed or when the rain intensity is higher than the infiltration rate (Hortonian surface runoff).

Into the soil matrix, if the soil water content reaches the Field Capacity (FC), drainage (D) happens; it is the gravimetric water that goes out to the soil and contributes to the subsurface fluxes, restocking aquifers and the stream. The water is stored (S) if the FC does not rise. Then, this water is evaporated

(EV) or transpired (T) by plants. These two fluxes are integrated by evapotranspiration (EVT), another outlet. Evapotranspiration is affected by environmental conditions, air temperature, solar radiation, wind speed, relative humidity, soil water content, leaf area index, cover and plant height, among others.

At the same time, foliar interception could be expressed such us

$$\text{F Int} = \text{Tt Pp} - (\text{Ef Pp} + \text{Sf}) \quad \text{(equation 2)}$$

Where Ef Pp is the effective precipitation that drops from the canopy after it reaches saturation; additionally, rain directly falls over the soil surface where there is no plant cover. Sf is the stemflow, which is water running down on plants to the soil.

Therefore, another way to describe the water budget is

$$\text{Ef Pp} + \text{Sf} = \text{R} + \text{D} + \text{EVT} \pm \text{S} \quad \text{(equation 3)}$$

Focusing on storage, soil water content variation (ΔS) depends on every water flux rate and their integration. ΔS could be positive when, during a period, the input fluxes are higher than the output ones, and the soil gets wetter, or ΔS is negative when water outputs overcome inputs and soil has lower water content than in the beginning.

$$\Delta S = \text{Ef Pp} + \text{Sf} - \text{R} - \text{D} - \text{EVT} \quad \text{(equation 4)}$$

At this scale, almost all of the water fluxes are directly impacted by plants; for example, Ef Pp and EVT depend on the percentage of cover. Additionally, the canopy shape, leaf area index, vegetation height, phenology, and plant life form affect the F Int and Sf. Similarly, T is customized by the growth-form and other morphological and physiological characteristics such as root deep, stomatic control, and medulla. Surface runoff is reduced by cover, and infiltration usually is favored by it. Indirectly, vegetation produces litter, which turns into soil organic matter, increasing the water storage capacity of soils and decreasing the drainage rate.

1.2 Evapotranspiration estimation

This research uses the ecosystem approach to estimate evapotranspiration, following equation 4 and based on two assumptions: Firstly, considering soil water content (SWC) at a specific time is the integration of all the water fluxes. Secondly, every flux gets value cero except evapotranspiration during no rain days. As a result, during days without precipitation, the ΔS is equivalent to the evapotranspiration rate. It is straightforward method to calculate EVT, but it does have a limitation- it cannot be used during rainy days, particularly in the wet season.

On the other hand, when the water soil content is measured simultaneously under contrasting plant growth-forms and in bare soil in the same environmental conditions, the differences of SWC, EVT and other water fluxes represent the vegetation effect on hydrological fluxes.

Aims

Analyze the effect of two dominant growth-forms on soil water storage, evapotranspiration rates and other water fluxes, by comparing measures of TDR sensors, installed in soils below a rosette (*Espeletia schultzii*), a shrub (*Hypericum laricifolium*) and bare soils in a Venezuelan paramo.

Methods

Study area location

The study area was the Paramo of Mixteque. It is located on the microwatershed of Miguaguo, 8°44´N and 70°53´W, at 3,850 m altitude; it is part of the upper basin of the Chama River, contributing to the

Maracaibo Lake. The paramo of Mixteque is protected in the Sierra Nevada National Park in Merida-Venezuela. However, the local communities use it as a grazing area, to develop tourist activities, to gather woodfires, and depend directly on the water that this paramo supplies for irrigation and consumption (Smith et al., 2011).

Climate

The rain is 1,020 mm annually, distributed in a seasonal pattern with a dry and a wet season. The dry season is from December to March, with very scarce rains, while the wet season is between April and November (Rodriguez-Morales, et al. 2019, Rodriguez-Morales, et al. 2014). The rain characterizes drizzle, very low intensity and high frequency (Rodriguez-Morales, 2010). The annual temperature mean is 6.1°C. Solar radiation is significantly elevated, especially when there are no clouds during the dry season, getting 1,277 W m-2 seg-1, (Rodriguez-Morales, 2010) the highest value that can reach the Earth's surface.

Vegetation

The vegetation is homogenous. It is dominated by two growth-forms, rosettes and shrubs, *Espeletia schultzii* and *Hypericum laricifolium*, respectively (Figure 1) (Rodriguez-Morales, 2010). They are the most common species, representing more than 65% of cover in the paramos of Sierra Nevada Park.

E. Schultz (Family Asteraceae) is a caulescent giant rosette with 30cm long leaves, covered with a dense white pubescence on both surfaces; its stem is protected by a layer of dead leaves, which isolated it against frozen nocturne temperatures. It has a medulla formed by parenchyma tissue, a water reservoir. It can get 125 cm high. In comparison, *H. laricifolium* (Family Hypericaceae) is a sclerophyllous shrub, highly branched with diminutive leaves 3mm long and 80 to 125cm high (Rada, 1993).

Soil characteristics

The paramo of Mixteque is a fluvio-glacial valley with high slopes and sandy loam soils dominated by Entisols and Inceptisols, with a minority of Histosols (7.4%) (Cordoba, 2014). According to Rodriguez-Morales et al. (2019), the soil has a field capacity of 0.29 cm^3cm^{-3}, a permanent wilting point of 0.20 cm^3cm^{-3}, saturation of 0.52 cm^3cm^{-3}, and saturated hydraulic conductivity of 0.90 cm h^{-1}.

Figure 1: Experimental plot where the TDRs and weather station were installed. Surrounding the fence are shrubs of *Hypericum laricifolium* with small olive-green leaves and a rosette of *Espeletia schultzii* with big white leaves in the right-centre of the picture. Paramo of Mixteque, Merida-Venezuela.

Monitoring of water soil content

The soil water content (SWC) was monitored using four TDR sensors, model S-SMC-M005, brand HOBO, installed in the first 10cm depth. Two of them were in the bare soils and the other two below a rosette of *Espeletia schultzii* and under a shrub of *Hypericum laricifolium* in a 25 m^2 parcel next to a weather station with rain, solar radiation, air temperature and wind speed sensors. The TDRs and the weather station were set up to measure every 10 minutes. The TDRs were calibrated with soil water content samplings collected during the fieldwork using the gravimetric method, ensuring the highest level of accuracy.

To the gravimetric method, soil samples were taken in the first 10 cm close to the TDRs, using metal cylindrical (15cm diameter). The soil in the cylinders was wrapped with cling film to keep the soil humidity intact. They were brought to the laboratory, weighed, dried using a heater for 48 hours and 105 C degrees, and then weighed again. The weight initial less the weight final is the water weight and divided by the dry soil (weight final) is the soil water content in gr gr^{-1} units; to convert to m^3m^{-3}, they were multiplied by the soil's bulk density reported by Rodriguez-Morales (2010). The calibration function was created through regression analysis between SWC gravimetric measures versus SWC measured with TDRs on the same date and time the gravimetric samples were collected and finally the TDR registers were right.

The study was developed between 8th March 2012 and 9th November 2013. Although there was a data gap between the 7th and 25th of July 2012, unfortunately, it is a period excluded from the analysis . To analyze the soil water content in a continuous period were used the registers from 25th July 2012.

Comprehensive analyses of the SWC were performed on a daily, monthly, seasonal, and full-period basis in the different covers. The soil water discharge was estimated using the daily trend slopes in the transition wet-dry seasons and after isolated rains during the dry season. The drainage was analyzed, estimating how often the SWC reached the field capacity. Surface runoff was analyzed by examining how often the SWC rose to soil saturation.
For evapotranspiration rate calculations, daily rain was recorded. The days without precipitation were filtered, and the soil water content variations (ΔS) were calculated through the difference between 6 am and 7 pm %SWC registers, light sun hours in tropical regions when there is the highest latent heat of vaporization in the ecosystem. Additionally, 24 hours ΔS was calculated as well. When the soil water content variations were negative (when the SWC initial was lower than the SWC final) were eliminated from the analysis.

The SWC and the ΔS units were transformed from m^3m^{-3} to mm, using a 100-unit factor derived from the 10 cm depth where TDRs were installed. ΔS was equivalent to the evapotranspiration rate where TDRs were below vegetation and the evaporation rate where TDRs were in bare soils.

The Kruskal Wallis test and U de Mann-Whitney test were used to compare SWC and EVT means under the kind of covers, and the paired t-test was used to evaluate differences between the 12-hour and 24-hour analyses.

II. RESULTS

During the study period, the daily rain was 3.2 mm on average and 0.3 mm median, showing very low rainfall magnitude. The daily maximum was 39.8 mm. Figures 2a and 2b show the rain distribution in the study period. The dry season is clearly from November to March, with few isolated rainy days, and a wet season between April and October. Monthly rains in the dry season do not exceed 60 mm, while in the wet season, the rains can rise more than 200 mm per month. In the whole study period, the total rain was 1583 mm. Noticeably, just 5% (73 mm) of these incomes entered during the dry season, suggesting marked differences between seasons. In other words, during the dry season, the water input decreases, the environmental water demands increase in favor of evapotranspiration flux, the soil water stock is affected, and plants are under water stress pressure. While in the wet season, there is a high water income in the ecosystem, the rains are widespread, the saturation of the canopy is favored, and it is expected a rise in effective precipitation, high relative humidity, and more water enabled for plants, the soil is more likely to reach the saturation.

Figure 2c depicts the solar radiation inputs in the paramo, with a daily mean of 170 W m^{-2}. Notably, this increases to 265 W m^{-2} during the dry season when clouds are scarce and clear skies dominate. This surge in solar radiation plays a crucial role in the dry season, facilitating a temperature increase in the air, leaves, and soil surface, and a rise in evapotranspiration demands.

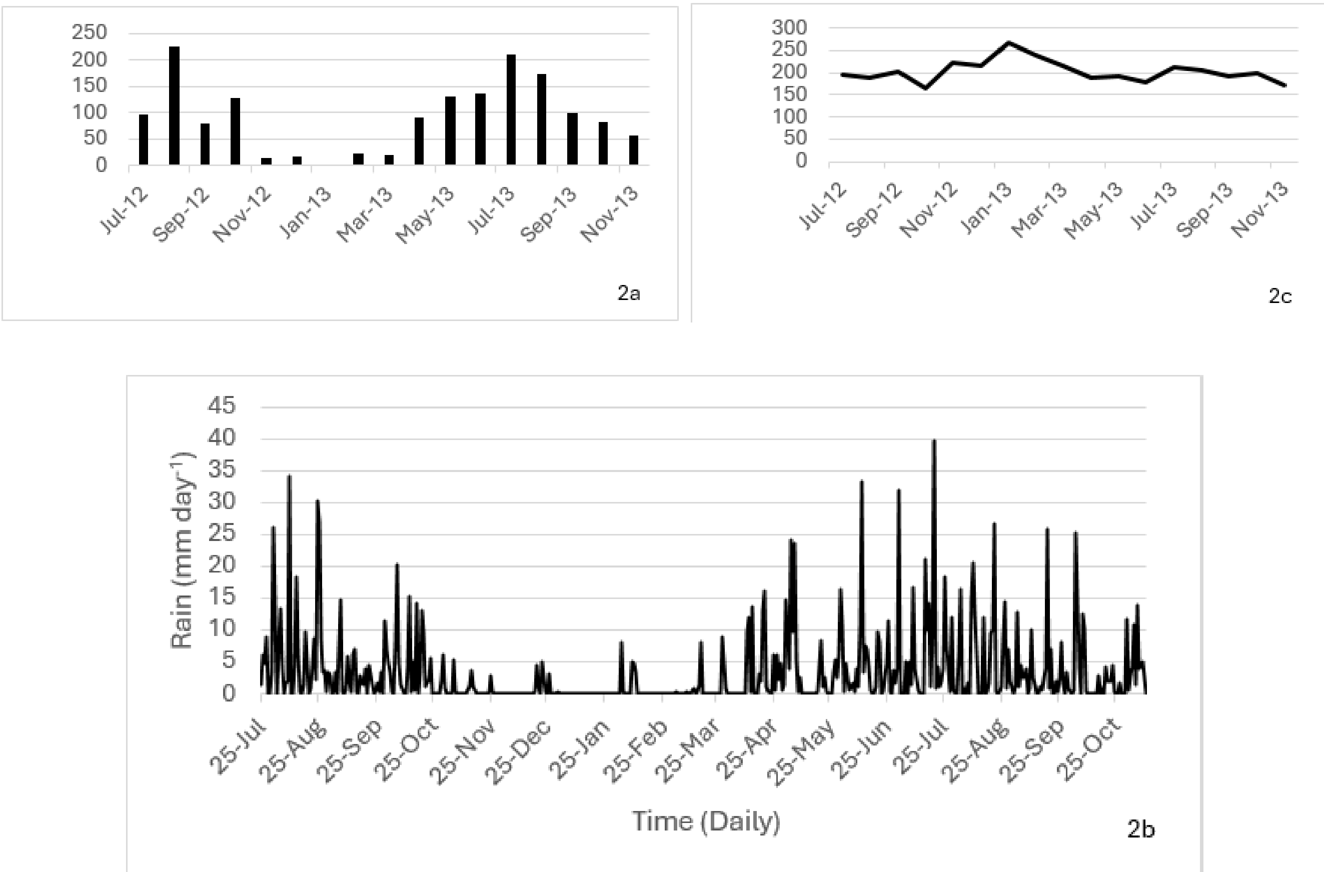

Figure 2a: Monthly rain (mm), *Figure 2b.* Daily rain (mm), and *Figure 2c.* Daily solar radiation mean (W m^{-2}), between July 2012 and November 2013, in the paramo of Mixteque.

Analysis of water soil content

The records of the two TDRs installed in bare soils did not show significant differences (sig=0.675); consequently, their average was used in the analysis.

During the study period, the shrub maintained the highest SWC, whose mean was similar to that of the bare soil but 36% higher than that of the rosette (Figure 3 and Table 1).

In the wet season, the bare soil retained a similar SWC mean to the shrub and was 20% higher than the rosette (Table 1). In contrast, in the dry season, the shrub hold the highest mean, around 30% higher than bare soil and the rosette, whose means were close.

Although the rosette maintained the lowest SWC mean during the study period and the dry season, Figure 4 shows that it maintained a higher and more stable SWC on dry days compared to bare soil.

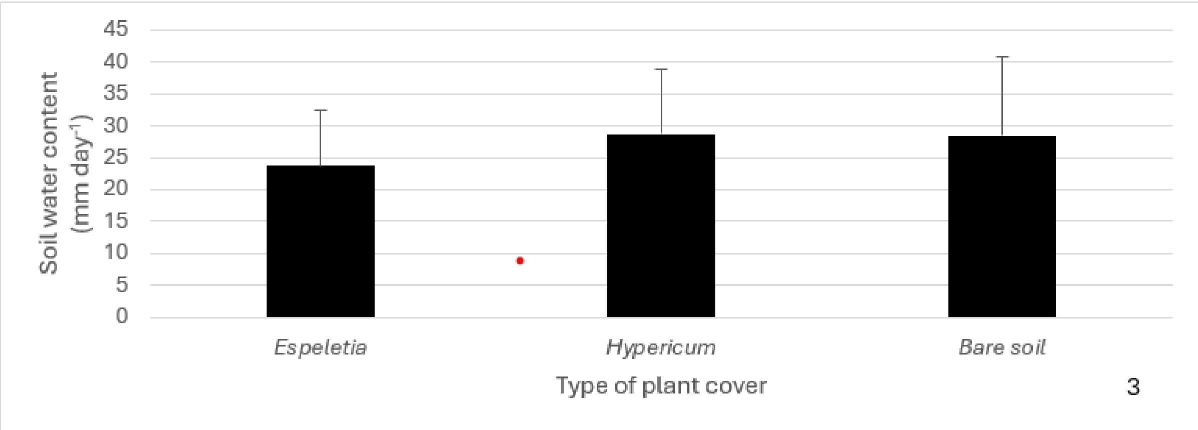

Figure 3: Daily soil water content mean (mm day^{-1}) under a rosetta of *Espeletia schultzii*, below a shrub of *Hypericum laricifolium*, and in soils without plant cover, in the study period from 25th July 2012 to 9th November 2013, in the paramo of Mixteque.

Table 1: Soil water content (mm day^{-1}) means and standard deviations (SD) of the study period and the seasons. Analysis under *Espeletia schultzii*, *Hypericum laricifolium* and bare soils, between 25th July 2012 and 9th November 2013, in the paramo of Mixteque.

	Whole period			Wet season			Dry season		
	Espeletia	*Hypericum*	Bs	*Espeletia*	*Hypericum*	Bs	*Espeletia*	*Hypericum*	Bs
Average	23.2^{a}	28.2^{a}	27.8^{a}	27.9^{b}	33.3^{c}	34.4^{c}	13.2^{d}	17.2^{e}	13.6^{d}
SD	8.8	9.9	12.2	4.5	5.4	5.3	7.4	8.4	10.6

Regardless of the type of cover, the SWC saw a significant decrease at the start of the dry season (Figure 4). The bare soils, in particular, experienced a rapid decline at a rate of 0.84 mm day^{-1} between 1st November and 17th December (Table 2), which was almost twice as fast as the covered soils, reaching values close to zero. In contrast, the rosette and the shrub showed a more gradual decrease of 0.59 mm day^{-1} and 0.56 mm day^{-1}, respectively.

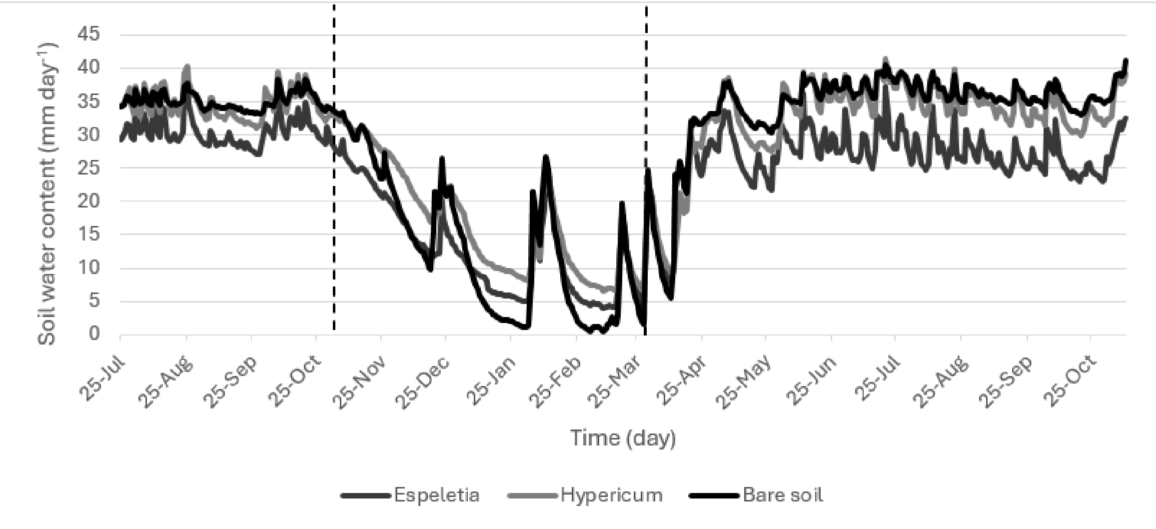

Figure 4: Soil water content (mm day-1) variation. Analysis below a rosette of *Espeletia schultzii*, a shrub of *Hypericum laricifolium* and bare soil, from 25th July 2012 to 9th November 2013, in the paramo of Mixteque. Between dashed lines, the dry season.

The SWC fluctuated according to the rain pattern (Figures 4 and 2b), but the magnitude of this variation is more notable in bare soil during the dry season. The water discharge in bare soils was 0.91 mm day^{-1} after isolated rainy days in the dry season (between 27th December and 2nd February); in contrast, the soil under the rosette showed a slower water discharge of 0.42 mm day^{-1}, and below the shrub, it was 0.63 mm day^{-1} in this same period (Table 2) and maintaining SWC more constant.

Table 2: Slopes of the trend lines of Figure 4, representing the soil discharge rate (mm day^{-1}) in the wet-dry-season transition and after isolated rains in the dry season. Analysis of soils below a rosette of *Espeletia schultzii*, a shrub *Hypericum laricifolium* and bare soil, between 25th July 2012 and 9th November 2013, in the paramo of Mixteque.

Period	Condition	*Espeletia*	*Hypericum*	Bare soil
1ts Nov 2012-17th Dec 2012	Transition wet to dry season	-0.59	-0.56	-0.84
27th Dec 2012-2nd Feb 2013	After isolated rainy days in the dry season	-0.42	-0.63	-0.91
	Average	-0.51	-0.59	-0.88

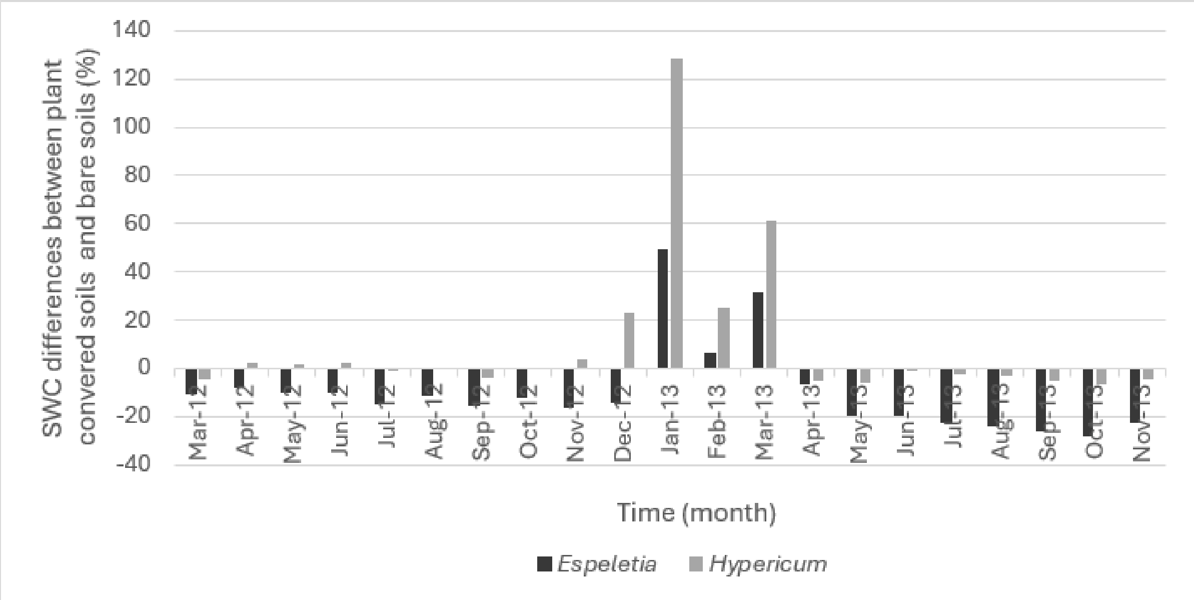

Figure 5: Effect (%) of a rosette and a shrub upon the daily SWC mean. Positive values mean the cover increases the soil water stock. From 8th March 2012 to 9th November 2013, in the paramo of Mixteque.

The rosette reduced the SWC during the wet months (Figure 5) by 30% compared to bare soil. The shrub did not show an effect compared to bare soil. Conversely, in the dry season, plants helped maintain the SWC. During the driest month, the shrub held 120% more water than bare soils. The rosette kept 50% more water than uncovered soils.

Analysis of drainage and superficial runoff

During the wet season, in bare soils, the WSC exceeded the field capacity (FC) in 95% of the 10-minute registers and 96% of the days (Table 3), so drainage was very likely. The shrub followed a similar trend to bare soil, but under the rosette, the SWC reached the FC in 64% of the registers and the wet days. This life form reduced the probability of drainage.

In contrast, during the dry season, the drainage went down noticeably. In bare soils and the shrub, the SWC rose the FC in less than 19% of the 10-minute registers and days. Under the rosette, the drainage was almost improbable during this season (Table 3).

Table 3: Analysis of the drainage. Number of days when the SWC reached the Field Capacity (FC) and their percentage (%). In Italic, the number of 10-minutes-registers when the WSC exceeded FC end its probability (%), below a rosette of *Espeletia schultzii*, a shrub *Hypericum laricifolium* and bare soil, between 25th July 2012 and 9th November 2013, in the paramo of Mixteque.

	Field Capacity			
	Espeletia	*Hypericum*	Bare soil	Total
Wet season	204 (63)	297 (92)	309 (96)	323
Dry season	4 (3)	27 (18)	28 (19)	151
Wet season	*19233 (64)*	*41164 (89)*	*43862 (95)*	*46428*
Dry season	*147 (1)*	*3031 (14)*	*2656 (12)*	*21744*

Under any condition, the measured SWC was higher than the saturation point throughout the study period. As a result, the probability of surface runoff occurrence was extremely low by saturation.

Evapotranspiration

Less than 8% of soil water content variations (ΔSWC) were negative in any cover condition, it means the SWC initial was lower than the SWC final; soil gained water in some days when rain was not registered; these ΔSWC were eliminated from the evapotranspiration analysis.

The plant life forms did not significantly impact on 24h evapotranspiration means (Figure 6, black columns) throughout the period. The rosette EVT was 1.01 mm day-1, the shrub EVT was 0.97 mm day-1, and in bare soil, 0.96 mm day-1 (sig=0.370). The same trend was found in the 12h EVT (Figure 6, grey columns) (sig=0.157).

However, in the wet and dry seasons, the plants clearly influenced the EVT rates, and a marked contrast appeared (Figures 7).

Due the 24h EVT and 12h EVT showed the same trends, the following EVT analysis considered only the 24h EVT estimation.

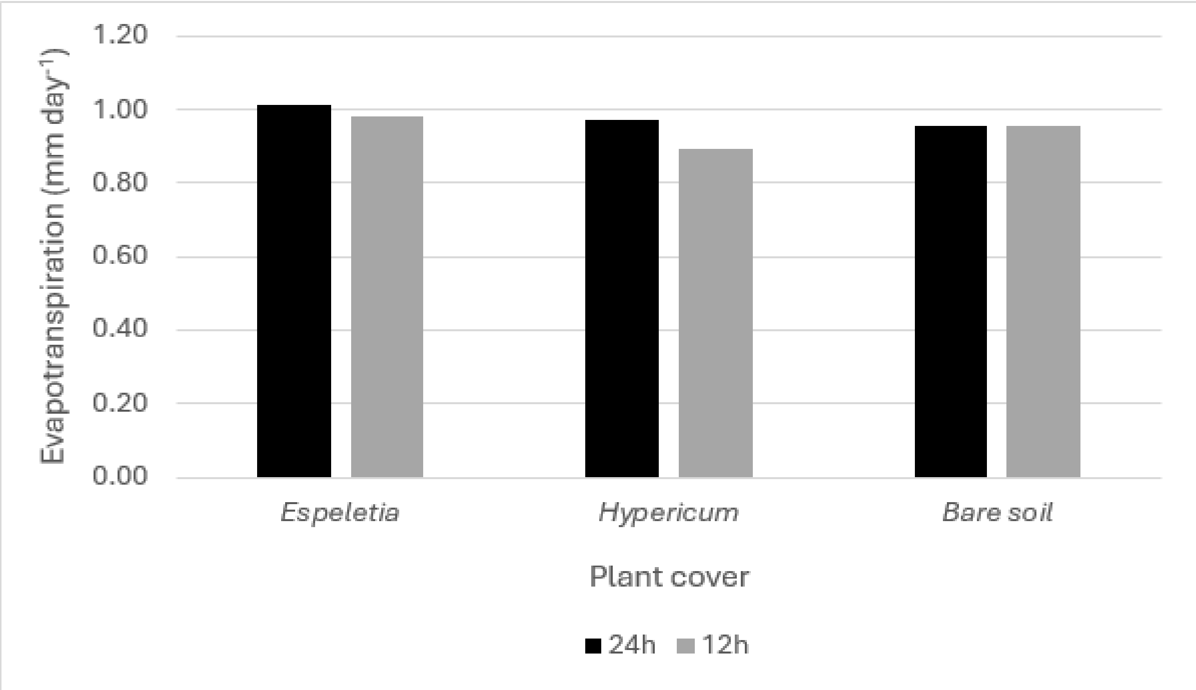

Figure 6: Comparison of daily evapotranspiration means estimated through 24-hours ΔSWC and 12-hours ΔSWC (light hours) in no rain days, in soils below a rosette of *Espeletia schultzii*, a shrub *Hypericum laricifolium* and bare soil, between 24th March 2012 and 9th November 2013, in the paramo of Mixteque.

Wet season Plants had EVT rates 30% higher than bare soil in the rainy months. The EVT under the rosette was 1.32 mm day^{-1}, and beneath the shrub, it was 1.26 mm day^{-1}, contrasting with 0.83 mm day^{-1} in bare soil. In other words, rosette and shrub increased the EVT compared with uncovered soils (Figure 7, black columns).

Dry season

EVT under the rosette and the shrub was almost a half lower than the bare soils (Figure 7, gray columns). EVT in the rosette was 0.70 mm day^{-1}; in the shrub, it was 0.66 mm day^{-1}; and in bare soils, it was 1.09 mm day^{-1}, demonstrating that plants reduce the EVT rates and regulate the EVT outputs.

Comparing the rosette and shrub EVT between the wet and the dry seasons (Figure 7), it was found that plants drastically reduced their own EVT rates; their ETV in the dry season was almost half lower than their ETV in the wet season, this difference was around 0.60 mm day^{-1}. In other words, it was water that was kept in the soils and did not go out from the ecosystem thanks to paramo plants. On the other hand, bare soils showed a 31% EVT increase, and EVT in the dry season was around 0.25 day^{-1} extra than during dry months.

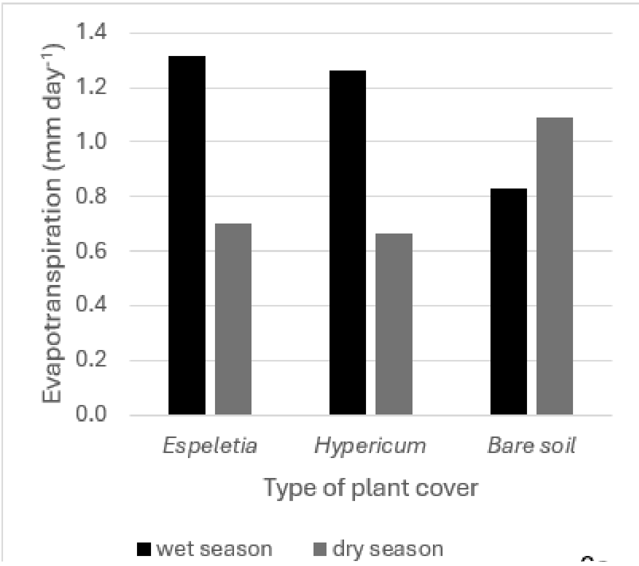

Figure 7: Comparison of the daily evapotranspiration means in the wet and the dry seasons, estimated through the differences of 24h-ΔSWC, in no rain days, in soils below a rosette of *Espeletia schultzii*, a shrub *Hypericum laricifolium* and bare soil, between 24th March 2012 and November 2013, in the paramo of Mixteque.

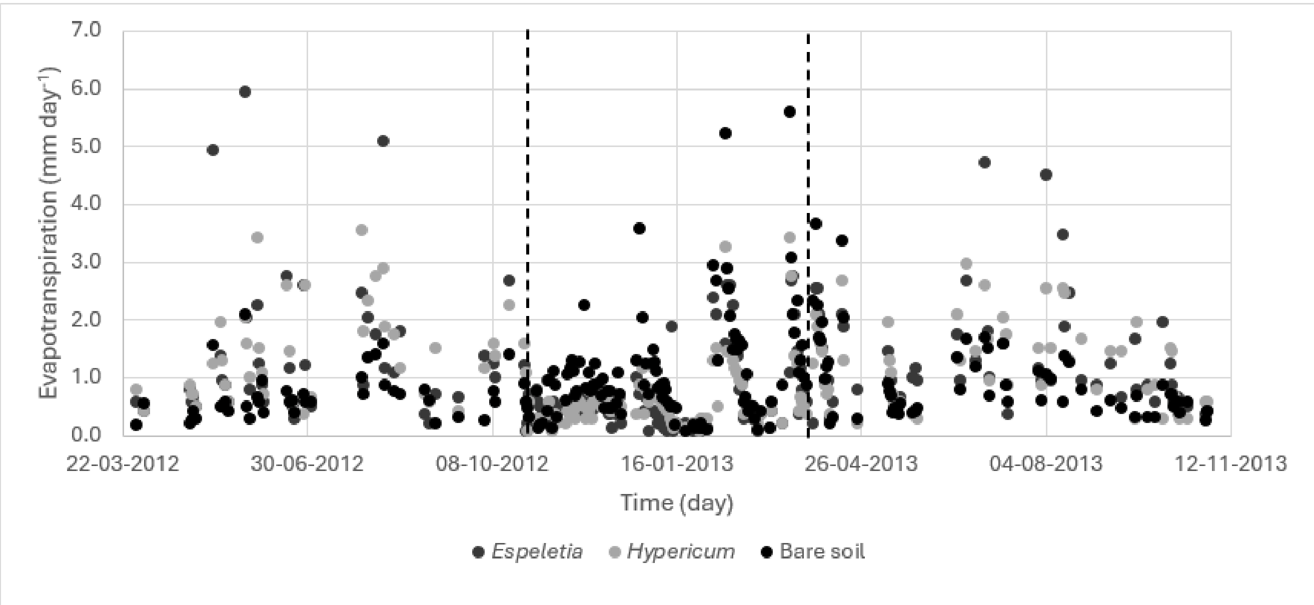

Figure 8: Daily evapotranspiration under different kinds of plant covers, estimated through the difference of soil water content in 24 hours (24h ΔSWC), in no rain days, from 8th March 2012 to 9th November 2013, in the paramo of Mixteque. Between dashed lines, the dry season.

The rosette had the highest daily EVT rates in the wet season (Figure 8), but on many days, the daily EVTs of the shrub were higher than that of the rosette. These few daily ETVs with large amounts below the rosette must considerably increase its wet ETV mean. In contrast, the bare soils had the highest

EVT rates on days without rain, while the shrub had the lower daily EVT rates on most days of the dry season.

III. DISCUSSION

3.1 Soil water content

The rosette had the lowest soil water content (SWC) mean during the whole period, and a similar SWC mean to the bare soils in the dry season. It could be interpreted as the rosettes do not favor water storage in soil. However, considering the rosette SWCs never were as lower as bare soil SWCs (values close to 0 mm) in the dry months, and additionally, the bare soil SWC rose sharply on the rainy days during the dry season, which increased its mean closing it to rosette mean; therefore, rosette might retain more water than it appears.

Wet season

Foliar Interception

In the rainy months, foliar interception (F int) could explain the differences between the SWC in bare soils, the rosette, and the shrub. The lower SWC of covered soil might be due to the F int, which reduces the effective precipitation (Ef Pp) and the water inputs in soils, decreasing the SWC. The canopy characteristic affects the F int, so the plant life forms have different impacts in this flux.

According to this interpretation, bare soil received the total precipitation because no canopy intercepted it, so it had the highest SWC mean. Meanwhile, the shrub slightly modified the total precipitation due its tiny leaves and highly branched canopy. Supporting this supposition, the shrub SWC mean was 1.1 mm day-1 lower than bare soil SWC mean in the wet season. On the contrary, the giant leaves in dense spiral and marcescent leaves around the rosettes' trunk intercepted a considerable portion of the precipitation. The difference between rosette SWC and the bare soil SWC (rosetta F int) was around 5 mm day-1; consequently, the rosetta SWC mean was the lowest compared with the other covers.

In the Ecuador paramos, Ochoa-Sanchez et al., (2018) estimated a canopy storage capacity of tussock grasses of approximability 2 mm day-1, which agrees with the shrub and rosette F int estimation in this research according to their morphological characteristics.

Considering that F int turns in evaporation from the canopy and must be added to the evapotranspiration rate, the rosette's EVT rate was very high. A potential explanation could be the stemflow, which reduces the F int. Unfortunately, it was not measured in this research. This flux is water intercepted by the canopy, which then turns into infiltration through the trunks and roots. This flux contributes to restocking soil. The stemflow probably affected deep soil layers that the TDRs have not monitored. To support this supposition it is necessary to assess this flux through the design of laboratory experiments with rosette individuals, simulating precipitation and collecting the stemflow in the base of these plants.

Drainage

The SWCs were high under the shrub and in bare soil in the wet season; therefore, they overcame the field capacity in 90% of the wet season days. Consequently, drainage is a highly probable flux in these cover conditions, in contrast with the rosette, which had around 60% probability. The difference between shrub and rosette drainage could be attributed to their F int. The high rosetta F int reduced its SWC and its drainage probability.

This high drainage under the shrub and the bare soil must favor hydrological regulation because it contributes to subsurface fluxes supplying and maintaining the stream. Additionally, due the subsurface fluxes are slower than the surface ones, the drainage delays the water moves in the ecosystem and favors that paramo basins release the water slowly.

Surface runoff

Due to the SWCs never overcoming the soil water saturation in any cover conditions, surface runoff was not detected by exceeding the saturation in the study period. This outcome could be supported by Sarmiento (2000), who found that the runoff probability is very scarce, and just 5% of the total precipitation turns into this flux in the paramo of Gavidia, Venezuela.

The low surface runoff in paramos has been attributed to the high sand content of the Venezuelan paramos soils, which increases infiltration rates. For example, in the study area, Rodriguez-Morales et al. (2019) reported a sand content of 72.4%, similar to Gavidia. Buytaert et al. (2006b) reported that soil characteristics favor infiltration in the Ecuador paramos.

In combination with the soil properties, the very low rain intensity of the paramos is a significant factor that makes surface runoff less probable. Perrin et al. (2001) mentioned that the rain events produced Hortonian runoff in just a few days. The low-intensity rainfall is typical of paramos, according to Padron et al. (2015) and as reported by Rodriguez et al. (2014) Sarmiento (2000) and others.

Low surface runoff contributes to the paramos' hydrological regulation because water moves through subsurface fluxes in the ecosystem. It helps to conserve soils, minimizing the erosion process.

Evapotranspiration

In the wet season, the high rain frequency in the paramos (Rodriguez-Morales et al., 2015) favours holding soil water available to plants, so there is no water limitation to transpiration, and plants do not need to regulate the water outputs while they are photosynthesizing. Consequently, the EVT rates were 30% higher in soil covered than in bare soils during this season. Supporting this analysis, Rada (1993) reported that *Hypericum laricifolium* showed a little stomatic limitation in the wet months. Additionally, the plant roots can actively extract water from soils, and they could explore deeper layers, increasing the water enable to the EVT, while the bare soils have a water stock that if it consumed the evaporation stop.

The EVT was 5% higher in *Espeletia schultzii,* which could be explained by their larger leaves, which increase the transpiring surface compared with the tiny leaves of *Hypericum laricufolium*.

Wet season

In contrast with the wet season previously analysed, during the dry months, the evapotranspiration rates should define the SWC under the different covers due to the foliar interception turned cero and the other fluxes.

Evapotranspiration

The slope of the trend in Figure 4 or the soil water discharge is a way to estimate the EVT. These EVTs were similar to the EVT means calculated through the soil water content variations during the dry season.

It was found that the discharge of bare soil was almost two times faster than that of covered soils. Under this cover condition, the lowest registers of SWC were found. The shrub had the slowest slope, keeping the highest soil water amounts.

Analyzing the EVT estimated through the ΔSWC, soils without cover had the highest EVT mean in the dry season. This can be explained by the increase in solar radiation and evapotranspiration demands (ETo) in this season, as described by Rodriguez-Morales et al. (2015) and Rodriguez-Morales (2010).

In dry conditions, the effect of plants upon EVT is more noticeable. The paramo species adaptations against the hydric stress reduce the EVT, conserving the water in this ecosystem (Rada, 1993). For example, the shrub of *Hypericum laricifolium* has tiny leaves with a leather texture leaf, which limits transpiration. While *Espeletia schultzii* has other adaptations against the hydric stress, its large leaves are covered by a dense white pubescent, which reflects the high solar radiation and lessens the leaf temperature and the gasses interchange, minimizing the transpiration flux, despite the fact its medulla stores water and keeps this flux going, making its EVT 5% higher than the shrub. Supporting this discussion, Sandoval et al. 2019, reported that *Hypericum laricifolium* has adaptations more effective against drought. Both growth forms showed strong stomatal control (Rada et al., 2019), especially in the middle of the day when the vapour pressure drops, the evapotranspiration demands rise, avoiding the transpiration increase.

Whereas, in bare soils, the main limitation to EVT is the soil water available to this flux (Callañaupa et al., 2012), due to this ecosystem receiving elevated energy.

Whole period

The similitude in the EVT means under shrub, rosette and bare soils during the study period can be explained through the contrasting influences changes that plants have on the EVT rates in each season; for example, their transpiration goes up, increasing their EVT rates during the wet season. While they limit the transpiration, their EVT decreases during the dry season. Both effects were cancelled out during the whole period. Contrariary, bare soils hold EVT (evaporation) is similar in both seasons.

Despite the imperceptible impact of plants upon the EVT throughout the study period, if climate change prolongs the drought period, the plant effect could be marked.

The positive soil water content differences in no rain days could be explained through inputs through the dew, fog or very low-intensity rain, less than 0,2 mm (rain gauge accuracy) that could not be restricted. Other explanation could be TDR inaccuracy measuring SWC. Deeper analyses are needed to. For example, analysis the relative humidity and temperatures to estimate the probability to dew happens or laboratory assay with TDRs installed in soil under evapotranspiration conditions and without any water input and the analysis of the SWC variation with the aim to verify if is find positive variations.

The method to estimate EVT through ΔSWC has a noticeable limitation, particularly during the wet seasons. The rain frequency is markedly high in the Andean paramos, and there are not sufficient days to estimate it; for example, June and July 2013 had just one day each. However, it represents a low-cost and easy-to-implement method to estimate the EVT; it could be used to calibrate and validate other methods.

3.2 The growth forms effect upon the hydrological fluxes

Summarizing the influence of the rosette (*Espeletia schultzii*), in the wet months, it decreases the SWC, likely due to its high LAI which increases the foliar interception and reduces the effective precipitation. Additionally, the rosette minimizes the drainage fluxes. While, during the dry season, the rosette keeps the minimum SWC higher than uncovered soils and maintains it more stable in the time, thanks to its adaptations which reduce the transpiration and EVT rates.

In the wet season, the shrub (*Hypericum laricifolium*) holds as much water as bare soils due to its low FAI, which affects little the foliar interception, maximizing the effective precipitation, the water inputs in the soil, and keeping the drainage high. In the dry season, the shrub has a more marked effect on reducing the EVT, probably thanks to its tight stomatal control and other adaptations, keeping more water in this ecosystem than rosette and bare soils.

Both life forms have complementary effects on the hydric fluxes. For example, the rosettes, with their high F int, play a crucial role in protecting soil against the rains, thereby reducing erosion. This function becomes even more important with the expected increase in rain intensity due to climate change. Meanwhile, the shrubs promote soil drainage, keeping the subsurface flows and supplying caudal. Finally, both have a significant effect reducing the outputs through EVT in dry environmental conditions, characteristic important to face the increase of temperature and longer drought periods by the global warming, as it is predicted in the Andean ecosystem. Therefore, plants result in a vital ecosystem compartment to maintain the regulation and supplier role of the Andean paramos.

IV. CONCLUSIONS

The effect of life forms on the hydrological fluxes changes marked in the dry and wet seasons; in the wet season, the rosette reduces the soil water content, likely due to its high foliar interception, while the shrub holds as much SWC as the unprotected soils thanks its unimportant foliar interception, while, in the dry season, the WSC was defined by the evapotranspiration rates. The soil water discharge in bs was two times faster than under plant covers. The shrub maintained 120% more water and the rosette a half more than bare soils in the driest month.

The surface runoff was undetectable when comparing the WSC and the saturation point in any plant cover condition. Drainage is an important flux in the paramos, it is few affected by shrubs and slightly reduced by rosettes.

The significant 50% drop in evapotranspiration (EVT) in covered soil and the 31% increase in bare soils during the dry season underscore the crucial role of plants of paramos in regulating their own EVT rates. This regulation effectively reduces the EVT, protecting it against the high demand for evapotranspiration. When both effects are considered, the dominant plants in this ecosystem reduce the output by around 80% through evapotranspiration.

This research presents a preliminary assessment of the effects of plant life forms on hydrological fluxes. However, it is important to note that these findings need to be validated and further explored through other methods to confirm the trends observed. This underscores the need for continued research in this area.

The findings revealed the significant role that each plant species plays in the hydrological function of the Paramo ecosystem. Rosettes and shrubs, in particular, have unique effects on water fluxes, and their biomass and abundance can modify these fluxes, thereby impacting the regulation and water supply of the Paramos. The importance of the Paramos ' function as a water supplier cannot be overstated, underscoring the need to carefully assess and control anthropic activities such as grazing and extractive uses like timber harvest.

Faced with climate change and global warming, plants conform to a crucial and unique ecosystemic compartment, able to adjust to environmental changes and minimize their effects through regulating the EVT, protecting soil, and favouring drainage, among other processes. This reflects the importance of its conservation.

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Darwin's Legacy: The Peacock Paradox

Volker W. Thürey

ABSTRACT

The foundation of this paper is the generation of all life by evolution. By this assumption, 'everything' has to be compatible with Darwin's theory. I discuss some issues that concern animate beings. I ask some rhetorical questions. Answers are provided by speculations. I present arguments for evolution and general thoughts. I show that some properties of animate beings are compatible with an evolution. The arguments except those in the chapter 'Homosexuality' are ideas of mine. All points only are personal views.

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I. INTRODUCTION

I assume that each life on earth is generated by evolution. Of course, this claim is not provable. Some questions about the properties of animate beings are discussed. Basically, I ask how such a thing as 'evolution' can create the properties, for instance, people who have an interest in mathematics.

II. PREJUDICES

In the first question, I talk about prejudices. I believe that the property that people have prejudices is innate. Of course, I cannot prove it.

A funny example is from the German comedian Johann König. In his show, he described the situation: 'Imagine that you return at home, and there is a lion in your flat.' Even if you never had bad experiences with a lion, you see the claws and teeth, and you will be cautious. This is a good decision! The animal could be dangerous. Although there are friendly lions, it is better to be suspicious and to be careful. This prejudice may save your life.

I think that prejudices are inborn, since for millions of years they have been useful, even though it has had consequences for a few wrong decisions. It helps us to act as fast as lightning. Of course, today some prejudices may not be suitable for a modern life.

III. ACORNS AND BEECHNUTS

In this chapter, I discuss the question of why oaks and beeches have relatively big fruits, i.e. acorns, and beechnuts, compared to willows or poplars. Big fruits need a large amount of material. The question is, why do these trees invest material into the production of big fruits? In my opinion, the answer is animals. The Eurasian red squirrel (Sciursus vulgaris) and the jay (Garrulus glandarius) use acorns and beechnuts as a winter store. The German names ('Eichhörnchen' and 'Eichelhäher') advert to this fact. Of course, they prefer big fruits. They stockpile up to 1000 stores in the autumn. The animals remember most of them, but some they forget. From these forgotten buffer stocks new trees grow. In this way, these trees accrete.

Therefore, evolution pressures to produce bigger fruits. In contrast, willows and poplars need the wind to spawn.

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IV. Booze

Everbody knows the effect of alcohol. The production of wine or beer has been a part of human culture for thousands of years. Beer may have been an important food in the past. Also, it was a beverage of high quality, instead of water, which often was polluted. The human liver has the ability to deteriorate the alcohol, but only ethyl alcohol (C_2H_5OH), while the related methyl alcohol (CH_3OH) is toxic. Fortunately, by the fermentation, the fungi produce nearly always ethyl alcohol. From where does come the difference? This means I ask why the liver can deteriorate ethyl alcohol, but not methyl alcohol. The speculated answer is that people have eaten fruits in autumn. The fruits often had fallen down. They often have started the fermentation process already, i.e. they have contained some alcohol. Those who could digest the fermented fruits have survived, the others perhaps died of hunger. This property was handed to the next generation. Thus, people can digest some ethyl alcohol, but not a bottle of vodka each day. Finally, they detected the positive effect of alcohol, and they invented the ability to generate a fermentation.

V. MATHEMATICS

Some people have a talent for mathematics. A part of them likes it, too. For instance, the German mathematician Gauß started in his youth to deal with mathematics. I ask, why evolution has generated people which like mathematics, although the possible application would be in the future. I estimate that less than one percent of the created mathematics is exerted. Hence, people do not know whether their mathematics will be used or not. Anyway, these people can not be deterred from keeping busy with mathematics. Why has evolution done that? The possible answer lies in the past.

Many years ago, the Stone Age people often starved. Some people have begun to make loops as a form of hunt to trap animals. In this way, they perhaps have survived, and their genes were preserved. Those who did not have the ability to do so have died.

Making loops is a very complicated procedure. You have to anticipate what happens if an animal steps in the loop. This requires a lot of abstract considerations. (Apart from that, it was a horrible death for the trapped animal. It may last hours or even days until death has put it out of its misery.)

I have gotten the idea in a hospital. I have lain there in a room with a few television sets without sound, to not disturb the others. To hear the sound, there were two small tannoys. First, you had to put the tannoys with two cables in the plug socket. Sometimes it has happened that the two cables were knotted. At this time, I was not able to unbraid them without the aid of others.

I believe that putting loops was a clever way to hunt, for those who could do so. This was perhaps a decisive way for survival. This would explain the joy of some people about abstract thinking.

VI. SEX

Bacteria spawn by cleavage. For them, one sex is sufficient. Why generally, in highly developed animals, there are two sexes? The answer is, of course, the rearrangement of the genes. When animals accrete, the genes are stirred. Hence, the fact that there are two sexes is clearly superior to only one sex. It makes an evolution possible.

Some people have the opinion that there is a third sex. I believe that this is nonsense since there is no reason for evolution to generate that.

VII. SWEAT

In the times before farming a decisive way for Stone Age people for survival was a successful hunt. I imagine that youngsters early began to exercise the hunt. One requirement was the ability to run. The body overheats easily. The evolution generated perspiratory glands. The hunter could transpire and in this way, he or she could cool down. Therefore, the hunter could run longer, and this resulted in a more successful hunt. Perhaps the evolution of perspiratory glands was a crucial development for survival.

VIII. SUGAR AND SALT

In this chapter, I deal with the fact that generally, people like sweet and salty food. (usually not together, except in ketchup.) The answer to the first is that nearly all sweets are healthy, with one possible exception of honey. Of course not now, but millions of years ago, only in autumn you got sweets in the vegetable form of fruits. In those times without cookies and chocolate, there was nearly only one possibility to eat sweet things. You had to gather ripe fruits in autumn. On some rare occasions, you have found a beehive, and you were able to eat honey. You probably got some painful bee stitches, but this you put up.

When you live near the coast, the supply of salt is no problem. Your food contains enough salt. The difficulties start when you settle afar from the coast. It might be a problem to get enough salt. For a successful hunt you need salt since when you sweat, you lose not only water, but also salt (NaCl). Therefore, evolution has developed an appetite for salty food.

IX. HOMOSEXUALITY

This chapter contains ideas that are not mine. I have read them anywhere.

Here I ask why homosexual people exist, although they do not accrete. The answer is that groups of people are more peaceful if a minority of people is homosexual. For a man, another homosexual man is no threat since he knows that the other man would not try to steal his wife. The same holds for women. Life was so hard in the Stone Age that survival was only possible in a group. This has required some social behaviour since it was important to regard other persons as fellow campaigners and not as rivals. One way was a common dance or to make music together. A book that is responsive to this is [1].

I assume that the genes which make a person homosexual are not only at the homosexual persons, but also at other members of the group

X. PEDOPHILIA

This chapter deals with the phenomenon called 'Pedophilia'. I will only give a justification that it may be genetically determined. I do not consider the difference of power between an adult and a child; what is more, I will not take up any position.

One million years ago a child played anywhere, monitored by two persons (usually the parents). They did their best to protect the child, but they couldn't see everything. Behind every bush could hide a lion, prepared to kill and eat the child. The probability of survival increased significantly when a third person looked after the child. The third person may be an uncle or an aunt. Or it could be a completely foreign person, who fell in love with the child, or it has only a sexual interest in it. The same situation without the lion can happen today, but I believe that the probability of survival would change hardly.

Similar to the previous chaper, I presume that the genes which make a person pedophiliac are not only at the pedophiles, also at other members of the group

XI. NAILS

Probably you are a neat person and cut your nails regularly. This is necessary since the fingernails and toenails grow. In this chapter, I ask why this is necessary. Why do the nails grow faster than they are worn off? The answer is that the speed of growth is just the right one. Of course not now, but in the Stone Age life was so hard that the nails grew as quick as they were worn off. I speculate that the speed of growth was just the right one. Now they grow to fast.

XII. MIGRATORY BIRDS

Some birds are migratory, for instance, the White Stork (Ciconia ciconia). Others are stationary, for instance, the Greenfinch (Chloris chloris). Why has evolution done that? It seems that any migration is a 'disadvantage' since it is a dangeous journey. I believe that in the beginning there were no migratory birds since in the north the weather conditions were as bad as today. But the animals have learned that even in the north during the summer the temperatures are pleasant. Those who could migrate, i.e. some birds, have learned to fly in warmer areas in the summer, to raise their offsprings since in the warmer climate also there was more food. I believe that finally this knowledge has gone into the genes. Some birds have learned to handle the harsh weather conditions in winter, and for them, there was no reason to migrate. They kept to be stationary.

XIII. WITCHES

In the Middle Ages, the Christianity was very intolerant. It was a common practise to burn people on the stake, if they were aspersed to be in league with the devil. Mostly the victims were female. For instance, the mother of Johannes Kepler, the man who have found that in space two celestial bodies move around each other in ellipses, was accused to be a witch. Fortunately, her son managed it to absolve her from the accusation. Burning 'witches' makes happy. Not the witch, of course, which suffered a horrible death, but the others probably felt good. Perhaps mostly they have thought 'God is very fair. The bloody witch gets what she deserves'. Some have felt pity with the 'witch', but they did not show it since this has been dangerous. It was better to hide the emotions, otherwise perhaps they were accused to be in league with the devil, too.

XIV. CHIMPANZEES

It is well-known that chimpanzees are social animals. Furthermore, their children are very cute. Some researches were confused as they detected that also chimpanzees are effective and successful hunters. They hunt and eat smaller apes. Some chimpanzees remain on the ground to cut of any escape way, others go into the treetop to hunt and kill the prey. After a successful hunt they brotherly share the poor victims with those apes who have remained on the bottom. In this way, the chimpanzees get flesh, what normaly is impossible since mainly they eat plants. It only works because the apes cooperate, and they are intelligent animals. The chimpanzees have learnt that cooperation increases their personal abilities enormously. I believe that finally this property has gone into the genes; or, in other words, evolution has taught them this capability since those who did not have the competence to be social died out.

XV. MILK

Some Asian people can not digest the lactose in milk. A great part of the Europian people digests it without problems. The ability to drink milk has been a big advantage when people started livestock breeding. Their survival no more depends on a successful hunt. This means, they could have more children since they had a constant supply of food. Of course, in this day and age, this ability is not of great importance since few people starve, and mostly people do not depend on livestock farming.

XVI. WAR

War is regarded as a big problem among human societies. Many attempts were made by politicians to solve problems between states. Some remain unsuccessful. I believe that to risk one's life is a very social action since life is the most important thing we can give. To sacrifice the own life for other people, maybe the 'crown', or the 'nation' or the believe or something else is a very social act. This distinguishs us from animals. Generally animals do not risk their own life for others.

XVII. MEDICAL SCIENCE

Fortunately, in many human societies there are medical care. For instance, I would not live anymore without it. On the other hand, we are products of an evolution. Medical science is the contrary to evolution. Nature kills someone who has an anomalous behaviour or appearance. It is cruel and merciless. Nearly all creatures suffer a violent death. It is very rare that animate beings die of senile decay. Evolutionary progress comes by death, although it would suffice to exclude them from reproduction.

XVIII. CUCKOOS

The cuckoo (Cuculus canorus) is a well-known migratory bird. It is famous for its call and infamous since the just hatched birds throw eggs and other birds out of the foreign nest. If they survived the fall, they die of undercooling. This policy is a clever way to accrete, so long as the major part of birds pursue a different way. I believe that evolution has created these conditions, although this strategy seems to be 'mean' for a social thinking being.

XIX. ENEMIES

Enemies are important. For a human, the idea of something very evil is helpful. An enemy image makes happy. The imagination of the 'ill' helps to distinguish between the 'good' and the 'bad'. This common belief generates a feeling of togetherness. For instance, Adolf Hitler considered the Jews as 'bad'. Having an enemy image is a general property of human beings, made by evolution.

XX. SPIDERS

Nearly all people find spiders disgusting. Both the slow, hairy ones and the quick ones. I strongly believe that it is innate since animals like butterflies evoke sympathy. Why has evolution done this since in Europe do not live dangerous spiders? This is a hint that people did not develop here (It is only possible to live in Europe when you have a heat source, because of the foul weather), but in a region where dangerous spiders exist, for instance, in Africa.

XXI. THE PEACOCK PARADOX

In this chapter, I mention peacocks (Pavo cristatus), and magpies (Pica pica). Even Darwin wondered about the 'Peacock Paradox'. Male peacocks have a beautiful embellishment, while female peacocks wear an inconspicuous plumage. The solution of the paradox is that female peacocks choose the males to breed. Of course, they prefer the most eye-catching males. Also magpies are conspicuous birds. They are the most beautiful birds in Germany with its salient white and black feathers and a long tail. It is the contrary to a camouflage. Females look similar to males. I don't know why. Perhaps at magpies the appearance is genetically connected with the sex.

XXII. CORRUPTION AND CRIME

In this chapter, I deal with the question why the government can not stop corruption, although it causes heavy damage to a human society. The answer is that corruption is advantageous both for someone who gets money for any service and for somebody who receives anything. Therefore, corruption presents itself more as a social act than a crime. I believe that this behaviour is generated by evolution since it has an advantage for both. Of course, today the government has to continue to fight against it since in a our society it generates more damage than benefit.

Also, delinquency will not disappear since to commit a successful crime has an advantage for the criminal.

XXIII. FASCISM

Two famous dictators have behaved similarly. Both il Duce (the leader) Benito Mussolini and der Führer (the leader) Adolf Hitler stood above and gave speeches, while many others were below and hailed the speaker. I believe that this is more a social act than a wrong behaviour. People unify behind a seemingly wise leader. He (generally the leaders are male) promises to lead them into a bright future. I think that this behaviour is innate and it is generated by evolution. The leader makes all important decisions; some are terrible. Unfortunately the leaders mostly are not 'wise'. They like to have power. It ends in a dictatorship instead of a bright future. I believe that the majority of people are not suitable for democracy.

AFTERWORD

As I have already said in the ABSTRACT, the above notes are my personal opinions. Therefore, I have abstained from giving more references. Further, I always made an effort to write as briefly as possible.

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William H. Calvin: *The River That Flows Uphill* (2001)

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Safeguarding our Atmosphere: Legal Measures and Health

Dr. Ibrahim Badawi

ABSTRACT

The depletion of the ozone layer, a critical shield protecting the Earth from harmful ultraviolet (UV) radiotion, has become a global environ- mental concern. This paper highlights the legal dimensions surrounding Ozone-depleting substances (ODS), their impact on the Ozone layer, and the subsequent risk on human health specially regarding skin cancer and blindness. As countries navigate international agreements, domestic reg- ulations, and enforcement mechanisms, the intricate interplay between legal frameworks and health implication of ozone layer depletion comes to the forefront.

The paper also highlights specific cases of illegal trade in ozone deplet- ing substances provided by parities to the Montreal Protocol, examining statistics provided by parties to the Montreal Protocol. China emerges as a major producer of contraband ODS, while countries such as Bulgaria, Lithuania, Poland, and France report numerous cases. Analyzing these cases provides insights into the effectiveness of legal frameworks and enforcement agencies.

Keywords: ozone-depleting substances, illegal trade, montreal protocol, environ- mental protection, ozone layers, skin cancer, blindness.

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The paper concludes with a set of recommendations designed to spread control and enforcement against the illegal trade of ozone-depleting substances. These recommendations encompass multiple aspects, in- cluding production monitoring, customs collaboration, mutual verifica- tion, cross-border agreements, public-private partnerships, international cooperation, detection equipment, global regulatory standards, resource allocation, public awareness campaigns, alternative substance develop- ment, and controlling the trade at its source. By applying these recom- mendations and enhancing enforcement measures, we aim to protect the ozone layer and create a healthier and safer world for future generations and achieving the sustainable developments goals.

Keywords: ozone-depleting substances, illegal trade, montreal protocol, environ- mental protection, ozone layers, skin cancer, blindness.

I. INTRODUCTION

This story of ozone depleting began in the in 1985 when Joe Farman, Brian Gardiner and Jonathan Shanklin, discovered a hole in the invisible shield that protects us from solar radi- ation, he said “The Discovery had a worldwide impact. It’s still having that impact. Because even the smallest changes in ozone readings can reveal interesting things”.

To understand this issue, the Earth’s atmosphere consists of several layers. The lowest layer, the troposphere, extends from the Earth’s sur- face up to about 6 miles or 10 kilometers. The next layer, the stratosphere, goes from 6 miles to around 31 miles in altitude. Most commercial air- planes fly in the lower stratosphere [1].

In the stratosphere, between 9 to 18 miles (15 to 30 km) above the Earth's surface, you find a significant concentration of ozone, a molecule with three oxygen atoms. According to the U.N The ozone layer is a thin shield of gas in the Earth's atmosphere that protects the planet, absorbing the sun's ultraviolet (UV) rays and helping to preserve all life on the planet [2]. However, the emergence and widespread use of ODS, such as chlorofluorocarbons (CFCs) and other synthetic compounds, have catalyzed the thinning of this crucial layer [3].

As UV radiation due to ozone layer depletion, the impact on human health becomes increasingly clear. A major concern is the heightened risk of skin cancer, directly associated with prolonged exposure to increased UV radiation. Additionally, the risk of blindness is a significant health consideration. According to the World Cancer Research Fund Interna- tional, over-exposure to certain types of light, such as ultraviolet rays from the sun or tanning devices, is the primary cause of both melanoma and non-melanoma skin cancers [4].

On the other hand, cataracts and blindness are prevalent eye condi- tions related to progressive ozone layer depletion and increased UV-B radiation reaching the Earth's surface. These UV-B radiation effects di- rectly to the cornea, lens, and retina [5].

The anticipated increase in UV radiation due to ozone depletion is expected to raise the incidence of cataracts among the population. A mere 1% reduction in stratospheric ozone levels may contribute to an estimated 100,000 to 150,000 additional cases of blindness attributed to cataracts globally [6].

The increased incidence of the skin cancer, blindness, and the broader health risks associated with elevated UV radiation, have prompted in- ternational cooperation to address the cause of this global crisis.

The Montreal Protocol comes to the forefront of these efforts, a land- mark international agreement crafted to safeguard the ozone layer by applying strict rules and implementation, curbing the production and consumption of ozone-depleting substances (ODS). The protocol serves as a pivotal instrument, embodying the collective commitment of nations to address the complex interplay between environmental preservation, human health, and the regulation of harmful substances.

The Montreal Protocol, initiated in 1987, has evolved into a corner- stone of global environmental governance. Its provisions encompass phased reductions in the production and use of ODS, aiming for a sub-stantial decline to mitigate the risks associated with ozone layer de- pletion. By prioritizing international cooperation and regulatory mea- sures, the protocol seeks to strike a delicate balance between industrial practices, economic considerations, and the imperative to protect the well-being of populations worldwide. the Montreal Protocol not only addresses the immediate health risks posed by increased UV radiation but also strives to achieve sustainable, long-term solutions.

Ozone-depleting substances (ODS), a group of synthetic greenhouse gases, which include chlorofluorocarbons commonly present in everyday items like air conditioners, refrigerators, and aerosol cans, have been causing harm to the ozone layer [7].

The Kigali Amendment to the Montreal Protocol, addressing the sub- stance that deplete the Ozone layer, signifies a crucial milestone on our efforts to control Ozone deleting substances. it calls for leadership coun- tries to accelerate their responsibilities to phasing down faster these sub- stances. under this Amendment all parties are required to cut their production and consumption of HFCs by more than 80% over next years to avoid the equivalent of more than 70 billion metric tonnes of CO_2 emissions by 2050 [8].

It is crucial to rapidly reduce CO2 emission, as well as emission of HFCs and the other climate super pollutants as fast as possible. one effective strategy, among many, is the regulation and control the illegal trade of ozone depleting substances.

Illegal trade poses a significant challenge for governments world- wide, in their efforts to combat ozone depleting substances, giving rise to various risks and complexities. These risks include economic distortions, tax revenue losses, increased criminal activities, especially along borders, threats to public health and safety, environmental hazards, and develop- ments goals. Addressing and understanding these risks and challenges requires the involvement of law enforcement agencies, international co- operation, regulatory measures, public awareness campaigns, and in- creasing people's awareness. The illegal trade not only undermines environmental conservation but also has far-reaching consequences on public health, safety, and broader development goals.

Illegal trade, which has various definitions, both common and spe- cific, is often referred to as black market or underground economy, refers to the exchange of goods, services, or commodities that violates the laws and regulations of a particular country or jurisdiction [9].This trade hap- pens outside the formal, government-regulated market named channels such as smuggling, counterfeiting, tax evasion, and the sale of prohibited or controlled substances. The impacts of this illegal trade extend beyond environmental concerns and directly affect human health, particularly in the context of increased risks of skin cancer and blindness. The sub-stances involved in illegal trade contribute to the thinning of the ozone layer, intensifying the penetration of harmful ultraviolet (UV) radiation. The major faced by the parties under Montreal Protocol is that the illegal trade doesn't have a specific definition and it required further clarification. In recent times, countries worldwide have been grappling with the depletion of the ozone layer, a process that began several decades ago. Governments must work collaboratively to curb illegal trade, not only to protect the environment but also to safeguard public health and
safety on a global scale.

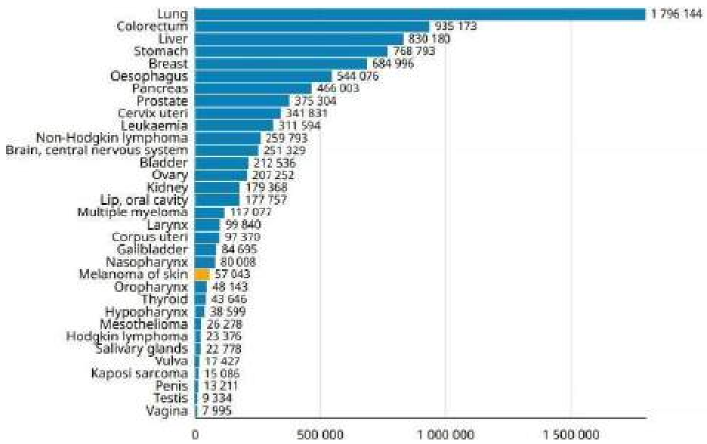
II. HOW DO THE OZONE-DEPLETING EFFECTS IMPACT OUR PLANET AND OUR HEALTH?

This in simple terms, when ozone levels decrease, it leads to intensified sunlight and greater exposure to UVB radiation at the earth's surface. This result in reduced protection from the sun's harmful effects. For example, consider the Antarctic, where the amount of the UVB radiation at the surface can double during annual ozone hole [10].

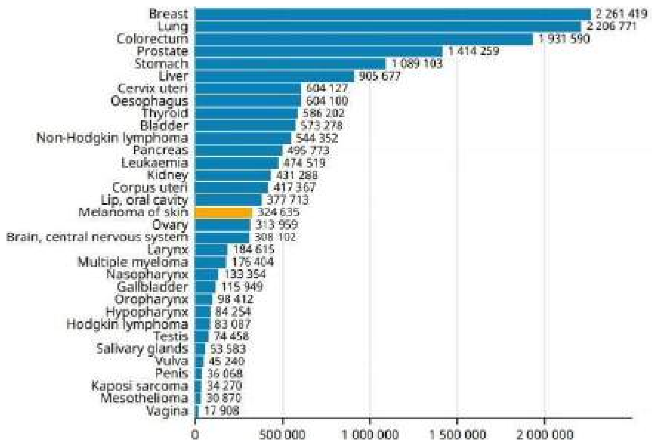
The increased UVB radiation has various adverse effects on human health, the environment, and marine life. Firstly, it can elevate the risk of skin cancer and impact the production of essential vitamin D in the skin, crucial for overall health. UVB exposure is also linked to conditions re- sponsible for approximately half of the world's blindness cases, affecting around 20 million people in 2010 [11].

Notably, UV radiation is responsible for approximately 95 percent of the skin cancer in populations with lighter skin tones, leading to an annual worldwide mortality rate around 60,000 individuals due to melanoma [12]. According to the following charts, they illustrate the global spread of melanoma skin cancer affecting both female and male populations. it is evident that the number of new cases in 2020, reached 324,635 cases. Additionally, the number of deaths in 2020, considering both sexes all ages, amounted to 75,043 persons. This situtions has be- come a significant concern worldwide, prompting serious considerations on how to address this alarming trend.

In response to this crisis, the Montreal Protocol has emerged as the umbrella initiative, combining global efforts to combat the spread of Skin cancer. The Protocol has implemented numerous regulations and strin- gent rules for countries involved in the production of ozone-depleting substances (ODS). Moreover, it focuses on controlling and minimizing il- legal trade of ozone-depleting substances. The Montreal Protocol stands as a pivotal framework, unifying nations in the collective efforts to miti- gate the impacts of this health crisis.



Clip 1: Number of deaths in 2020, both sexes, all ages



Source: Globocan 2020

Clip 2: Number of new cases in 2020, both sexes, all ages

Secondly, in terms of the environment, diseases linked to climate change are significantly influenced by ozone depletion. Unchecked ozone depletion puts plants, animals, and microbes in natural ecosys- tems in risk in addition to food production. Essential services that these ecosystems offer include clean water, clean air, and the removal of carbon dioxide from the atmosphere.

Moreover, in terms of marine life, ozone depletion can have a direct and several harms impact on crustaceans, fish eggs, and corals. Con- sequently, uncontrolled ozone depletion would pose a threat to fishes and other aquatic resources that play a substantial role in global food supply [13].

III. THE MONTREAL PROTOCOL: A LANDMARK IN GLOBAL ENVIRON- MENTAL PROTECTION

In 1987, the Montreal Protocol marked a critical moment in global endeav- ors to shield the ozone-depleting layers. This international agreement garnered signatures from 197 countries, distinguishing it as one of the inaugural treaties in United Nations history to attain universal ratification. The Protocol not only symbolized a collective commitment but also served as the vanguard for consolidating global efforts to preserve the ozone-depleting layers, underscoring the imperative of international collaboration in environmental protection.

The Montreal Protocol has implemented several measures and pro- cedures to control and phase out the production and consumption of ozone-depleting substances (ODS).. Here's what the Protocol has done to protect Ozone Layer:

Phasing Out ODS Production: The Protocol establishes specific phase-out schedules for different ODS, leading to a gradual reduc- tion in their production and consumption. substances.

The Montreal Protocol established an essential quota system to oversee the production and use of ozone-depleting substances (ODS) by participating nations, particularly during the HCFC Phase-out Management Plan (HPMP) implementation. The quota system's core objective is to prevent countries from exceeding their allo- cated limits for importing and exporting specific substances, in accordance with their national legislation and the Protocol's con- straints.

Controlled Substances Lists: The Protocol identifies and lists spe- cific ODS, such as chlorofluorocarbons (CFCs), halons, carbon tetra- chloride, methyl chloroform, and others, that are subject to strin- gent controls and restrictions. These substances are regulated to prevent their harmful effects on the ozone layer.

Regulation of Trade: The Protocol controlled the import and export of new, used, recycled substances ODS through the establishment of licensing systems. Importers and exporters of ODS must obtain licenses, ensuring that their movements are tracked and controlled.

data Reporting: This aspect plays a pivotal role by providing es- sential statistics for analyzing the efforts of the parties. Parties to the Protocol are mandated to furnish data regarding the pro- duction, consumption, trade, and illegal trade of ozone-depletingsubstances (ODS). This data serves as a crucial tool for monitoring compliance with the Protocol's provisions.

Enforcement Measures and Control of Illegal Trade: Parties are urged to take action to identify and sanction illegal activities associ- ated with ozone-depleting substances (ODS), including smuggling and unauthorized production. These actions may encompass the imposition of penalties for breaches and the initiation of investiga- tive processes.

International Cooperation: The Protocol fosters international coop- eration, information exchange, and capacity-building initiatives to support the efforts of developing countries in controlling ODS and complying with the Protocol.

IV. HOW THE MONTREAL PROTOCOL AFFECTS THE MINIMIZATION AND CONTROL OF SKIN CANCER AND BLINDNESS

The Assessment and Review Committee (ARC) divides benefits from substituting ozone-depleting substances (ODS) into two groups: health and non-health effects. The health effects are classified into four categories -non-melanoma skin cancer, melanoma skin cancer, skin can- cer deaths, and eye injuries (cataracts)- a illustrated in the following tables.

Health Benefit	Number
Avoided cases of non-melanoma skin cancer	19,100,000
Avoided cases of melanoma skin cancer	1,500,000
Avoided skin cancer deaths	1,300,000
Avoided case of cataracts	129,000,000

The estimated health benefits resulting from the reduction of ODS Pro- duction and consumption, according to the Montreal Protocol and Kigali Amendment, are outlined in preceding table. Sourced from ARC in 1997, the data includes a reduction in the number of cases for non-melanoma skin cancer (19,100,000 cases), melanoma skin cancer (1,500,000 cases), skin cancer deaths cases (1,300,000), and cataracts (129,00,000 cases). These estimates are based on a model assessing the impact of increased UV radiation, comparing scenarios under the Montreal Protocol with a non-regulation scenario.

The table below provides a detailed breakdown of the non-health benefits specific to agriculture, forest, and fisheries, amounting to US$ 429 billion, as well as benefits related to the built environment, totaling US$ 30 billion. These benefits result from the reduction in the production and consumption of ODS in accordance with the Montreal Protocol from 1987 to 2060.

Environmental Benefit	Amount (US$)
Avoided agriculture, forest, and fisheries to the built environment	429,000,000,000 Avoided damage 235,000,000,000

The following table shows the estimated global benefits and costs resulting from reduction of ODS production and consumption: Global Dollar benefits - US$ 459 billion, Global Dollar Costs - US$ 235 billion, resulting in a Net Global Benefits of US$ 224 billion. According to data sourced from ARC in 1997, this implies that each dollar spent on costs related to reducing ODS production and consumption yields a return of US$1.95 [14]. The previous data shows how the Montreal Protocol is the focal point of global efforts, leading to the minimization and control of skin cancer and cataracts.

Category	Amount (US$)
Total Monetized Benefits	459,000,000,000
Cost of Montreal Protocol Implementation	235,000,000,000
Net Benefits + Health Benefits	224,000,000,000

V. THE HUMAN HEALTH IMPLICATIONS OF ILLEGAL TRADE IN THE OZONE-DEPLETING SUBSTANCES

The connection between Illegal trade of substances and ozone layer de- pletion, in addition to human health, is complex and attached. As illegal trade escalates, there is a corresponding increase in ozone layer depletion, exacerbating its effects on human health. Conversely, as illegal trade di- minishes, there is a reduction in ozone layer depletion, and its associated health effects. Understanding this positive relationship is of paramount significance in comprehending the measure required to regulate ozone depleting substance.

Understanding this positive relationship is of paramount significance in comprehending the measure required to regulate ozone depleting sub- stance. Ozone-depleting substances (ODS) comprise a category of syn- thetic chemicals. Among the most renowned examples are chlorofluoro- carbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrobromofluoro- carbons (HBFCs), methyl bromide, carbon tetrachloride, methyl chloro-form, and a range of others [15]. These substances find widespread appli- cation in various sectors, including home and air conditioning systems, commercial refrigerants, and refrigerators. Furthermore, they serve as constituents in foam blowing agents, aerosol spray propellants, certain components of electrical equipment, industrial solvents, cleaning agents (including those utilized in dry cleaning), fumigants, and fire extinguish- ing materials.

The problems resulting from illegal trade in ozone depleting sub- stances are divided into two categories; short-term and long-term health effects.

For the first short-term effects, it is caused by the processes of transfer, handing, storage, and disposed of ozone-depleting substances. This cat- egory results in direct health impact from exposure to ozone-depleting substances, especially in the events of accidental leaks, affecting individ- uals. This may include respiratory, problems, skin irritation and other acute heaths issues [16].

For the long-term Health effects, the most prevalent illness caused by ozone depleting substances include skin cancer and eye disease. UV radiation resulting from stratospheric ozone depletion can led to more severe sunburn and large increases in skin cancer incidence. There are two types of skin cancer, Melanoma and Non-melanoma. Melanoma is most serious form of cancer and is often fatal, while non-melanoma is most common type and less fatal [17]. Eye diseases, such as 'snow blindness,' which is the ocular equivalent of sunburn, are also associated with UV radiation, uncontrolled ozone depletion depleting substance lead to an increase ozone depleting layers, ultimately significant increases rises in cataracts and skin cancer cases [18].

It is important to realize the impacts of the illegal trade in ozone depleting substances; their negatives effects are wide-ranging and in- clude different aspects beyond health, such as economic and criminal perspectives.

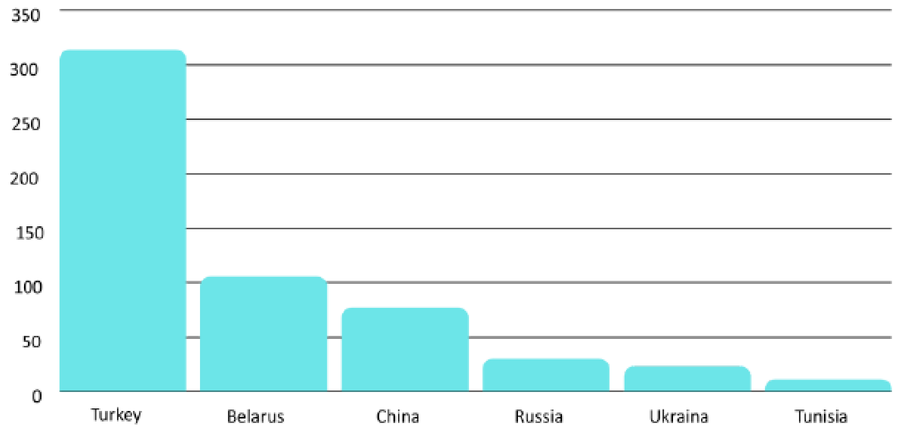
The economic consequences of this illegal trade are significant. Sometimes referred to as the underground economy, can undermine the legal market for more environmentally friendly alternatives to ozone- depleting sub- stances. This not only affects the environment but also has direct impact on the tax revenue. It counteracts stand against the eco- nomic and environmental benefits associated with transitioning to safer and more sustainable technologies especially the shift toward a circular economy.

In addition to economic impacts, the criminal implications are profound. Transnational organized crime groups are often involved in the il- legal trade of ozone-depleting substances, which are banned or regulated by international agreements like the Montreal Protocol, aimed at protecting the ozone layer. Criminal organizations engage in this trade to profit from the high demand for these substances especially from the developing countries, often driven by the avail- ability of cheaper but harmful alternatives.

VI. HOW THIS ILLEGAL TRADE IS TRAFFICKING?

To determine how the illegal trade of ozone-depleting substances traffick- ing, that need to know first who is the most producer for these materials. China is the largest single source of contraband ozone-depleting sub- stances (ODS). At its peak in 1998, China was producing approximately 55,000 tones of CFCs annually. However, through an accelerated pro- duction phase-out by 2007, only one CFC plant remained operational, producing a mere 550 tones per year. Despite the decline in CFC produc- tion, China's production of HCFCs has significantly increased [19].

According to reports submitted by the parties to the Montreal Protocol as shown in clip 3, it has been demonstrated that most ozone-depleting substances originate from Turkey, Belarus, and China. These countries have emerged as significant sources of contraband ozone-depleting sub- stances, contributing to the global challenge of ozone layer depletion. Understanding the primary suppliers is crucial in addressing the illegal trade and implementing effective control measures [20].



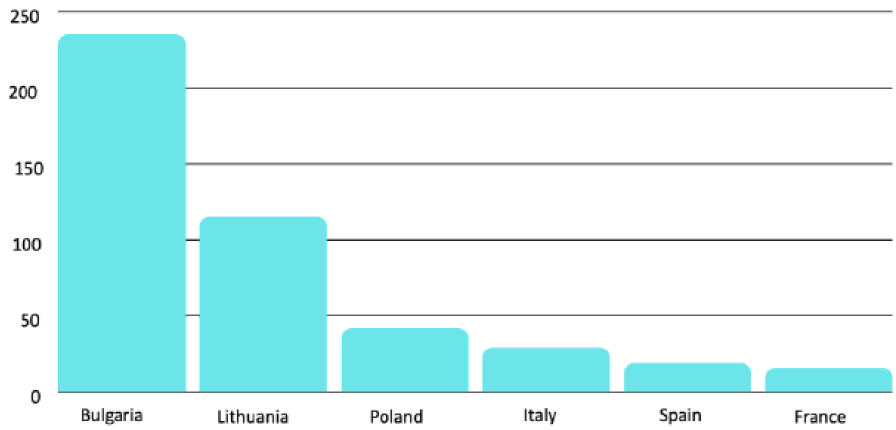
Clip 3: Major Sources of Illegal Trade in Ozone-Depleting Substances.

VII. THE CASES OF ILLEGAL TRADE IN SUBSTANCES CONTROLLED UNDER THE MONTREAL PROTOCOL.

According to reports submitted by the parties to the Montreal Protocol as shown in clip 4, Bulgaria stands out as a country with a significant number of reported cases related to illegal imports of ozone-depleting substances. This trend began in 2007, and most of these cases fall under the category of attempted illegal imports of ozone-depleting substances. Bulgarian customs authorities successfully intercepted and halted these attempts at the Bulgarian border. The cylinders containing these sub- stances were seized and subsequently directed for destruction in facilities recommended by the law.

In the case of Lithuania, which ranks second in terms of the highest number of cases provided by Montreal Parties, these incidents are pri- marily attributed to smuggling non-refillable cylinders detected during roadside inspection, importing ozone depleting substances (ODS) out- side the quote system specified in the Montreal protocol, and some of them are related to goods being mis-declared with the wrong Hs code. In response, the government-imposed fines, and the goods were seized. Similarly, Poland has reported numerous cases related to illegal ozone- depleting substances. These cases encompass a wide range of infractions, including smuggling, goods not declared for customs clearance, use of non-refillable cylinders, violations of regulations 517/2014, false labeling, and imports outside the quota system.

France, too has reported several cases, also starting in 2007. These cases encompass various categories, including the illegal packaging of refrigerants in non-refillable cylinders, which is prohibited within the European Union. Additionally, cases involve the illegal import and ex- port of air conditioning units, which were detected by French customs authorities. [21].



Clip 4: Illegal Trade Cases Reported by Montreal Protocol Parties.

VIII. ANALYSIS OF THE CASES OF ILLEGAL TRADE IN SUBSTANCES CON- TROLLED UNDER THE MONTREAL PROTOCOL

These figures pertain to specific instances of illegal imports of substances that deplete the ozone layers, with many of these cases coming from China, aligning with its status as one of the world's primary suppliers of such substances. It is important to acknowledge that these statistics reflect varying perspectives, shedding light on the effectiveness of legal systems and law enforcement agencies across international borders.

On one hand, a high number of cases may indicate that numerous countries lack strict and effective laws or regulations to combat and con- trol the illegal import of these substances. This underscores the necessity for more robust legal measure and enhanced international cooperation to comprehensively address the issue. It may also highlight the challenges associated with enforcing and regulating such matters across borders.

Conversely, a high number of cases can signify a country's implemen- tation strong enforcement agencies capable of effectively monitoring, seizing, and apprehending those involved in such criminal activities. This underscores the necessity of law enforcement efforts and interna- tional collaborations in curbing illegal trade.

On the other hand, countries with few or no recorded cases may indict two distinct scenarios. They might have relatively weak enforcement agencies or regulatory frameworks, leading to an inability to effectively combat such criminal activity. In such cases, strengthening enforcement and regulations becomes imperative.

Conversely, countries with minimal recorded cases could have highly effective enforcement agencies successfully preventing such occurrences, in these instances, their strict measure act as a strong deterrent against illegal imports of ozone- depleting substances.

In summary, the numbers of recorded cases serve as valuable indica- tors of the global landscape of illegal ozone-depleting substances trade. Analyzing these figures can inform efforts to develop and enforce regu- lations, enhance international cooperation, and strengthen enforcement agencies to protect the ozone layer and mitigate environmental harm.

IX. CHALLENGES IN COMBATING ILLEGAL TRADE OF OZONE-DEPLETING SUBSTANCES (ODS)

This section is exploring the challenges and difficulties associated with controlling illegal trade in ozone-depleting substances. These challenges encompass a wide range of factors, each contributing to the complexity of the issue. To provide a comprehensive understanding, we will give highlight the struggles and obstacles faced in regulating and combating illegal trade, through on the following 13 key points:

1. Global Nature of the Trade: Illegal trade often crosses international borders, making it challenging to coordinate efforts and enforce regulations effectively.
2. Complex Supply Chains: Ozone-Depleting Substances (ODS) may pass through multiple intermediaries, making it difficult to trace the origins and destinations of these substances. Additionally, ODS come in various forms, including liquids and gases, which lack distinct odors, making it challenging for customs officers to detect them.
3. Diverse Range of Substances: ODS encompass various chemicals, each with unique characteristics, posing challenges in regulating and monitoring them. The diverse physical states of these substances, from liquids to gases, further complicate detection and seizure.
4. Inadequate Regulatory Frameworks: Some countries may lack ro- bust legal frameworks to control ODS trade or may have weak enforcement mechanisms. The effectiveness of regulations often depends on the economic and developmental status of individual countries, as well as the awareness of people.
5. Limited Resources: Insufficient funding and manpower for enforce- ment agencies can hinder their ability to combat illegal trade effec- tively. Both funding and manpower are crucial elements that work together to address this issue.
6. Lack of Adequate Inspection Equipment: most countries lack ad- vanced equipment to detect and confirm the presence of ODS, which should be highly developed to check these distinctive materials, making it difficult to seize them.
7. Evolution of New Substances: Criminals may continually seek new substances that are not yet regulated, requiring updated regula- tions and monitoring mechanisms to keep pace with these distinct materials.
8. corruption and Bribery: Inadequate government oversight can lead to corruption and bribery, undermining efforts to combat illegal trade.
9. Lack of Awareness: Some individuals and businesses may not be aware of the environmental and legal implications of ODS trade.
10. Limited Availability of Alternative Substances: Developing coun- tries with economic constraints often struggle to transition to al- ternative substances due to limited technological advancements. Support in discovering and adopting alternatives is crucial in over- coming this challenge.
11. Support for Developing Countries: Providing subsidies, additional funds, and incentives can facilitate the development of regulations and laws to control illegal trade.
12. Enhanced International Cooperation: Effective control of illegal trade necessitates strong international collaboration. Differing pri- orities among nations can present obstacles to these efforts, high- lighting the need for effective coordination on a global scale.

X. RECOMMENDATIONS TO STRENGTHEN CONTROL AND ENFORCEMENT AGAINST ILLEGAL TRADE OF OZONE-DEPLETING SUBSTANCES

After conducting a comprehensive analysis of the challenges and com- plexities surrounding the illegal trade of ozone-depleting substances (ODS) and its detrimental effects on human health, as well as under- standing the environmental impact of ozone depletion on our plant and its effects on various sectors of our lives, it is essential to propose a set of recommendation aimed at strengthening control, minimizing, and enforcing measure against this illegal trade. These following recommendations address the various aspects of ODS trade and aim to enhance international efforts to protect the ozone layer, as well as safeguard hu- man health comprehensively.

Production monitoring and transparency are crucial. Encourage major ozone- depleting substance-producing countries to establish transparent and accountable systems for monitoring and reporting their pro- duction levels under Montreal Protocol, involving regular reporting to international body responsible for ozone layer protection.

Enhance customs collaboration and joint Training is vital. Collaborate more effectively between customs agencies across nations, enabling the sharing of intelligence and best practices in detecting illegal trade. Organize joint operations and training exercises to strengthen enforcement capabilities, ultimately leading to the establishment of international customs units to oversee the illegal trade of ozone- depleting sub- stances.

Cross border agreements for control should be established. Create bilateral or regional agreements aimed at fostering collaboration in regulating the pro- duction and trade of ozone-depleting substances. These agree- ments would encompass the sharing of information, coordinated inspections, and mutual enforcement support, ultimately reducing the processes of transfer, handling, and storage of ODS. This aims not only to enhance environmental protection but also to mitigate and control the direct human health impacts associated with ODS exposure.

Stringent Penalties and Deterrents must be implemented. Review, develop, and strengthen legal frameworks to impose and apply strict penalties for engaging in the illegal trade of OSD, including substantial fines and impris- onment, for involvement in the illegal trade of ozone-depleting substances (ODS) within the ambit of the Montreal Protocol. Em- phasize within each country's legislative system a direct link be- tween illegal ODS trade and its adverse impacts on human health, aligning with both domestic legislation and international agree- ments like the Montreal Protocol to underscore the severity of the offense.

Allocation resources for enforcement: Provide financial and techni- cal support to developing and resource-limited countries enabling them to strengthen their enforcement agencies and enhance their capabilities to combat illegal trade and develop regulations and laws and transitioning to alternative substances.

Standardized Detection Equipment. Promote the development and distribution of standardized, and user-friendly detection equip- ment to help customs officers in identifying ozone-depleting substances effectively.

Establish global regulatory standards: Encourage uniform global regula- tory standards for controlling ODS trade, aiding countries with inadequate regulatory frameworks in adopting best practices on how control and minimize the ODS trade.

Encourage cooperation between public and private partnership for self-regulation. Engage the private sectors in self-regulation to as-sume responsibility and propose effective solutions for controlling the illegal trade for ozone-depleting substances by providing them subsidies and incentives.

Through these methods, they will play important role to addressing this issue.

Launch public awareness Campaigns. Launch campaigns to communities about the health risks associated with ODS and the consequence of the illegal trade. Educate individual and businesse about the health impacts and environmental and legal implications of ozone- depleting substance trade, thus reducing demand and involvement in illegal activities.

Promote alternative Substance Development. E nhance research and devel- opment efforts to discover and promote environmentally friendly alternatives to ODS with no side effects on human health, especially in developing countries with limited technological advancements.

Minimizing and controlling the trade of Ozone-Depleting Substance at the source. This requires international collaborative efforts. The focus should be on identifying major (ODS) producing countries and establishing new mechanism aimed at reducing and closing Il- legal trade of (ODS) from the source, rather than allowing it to cross borders. This proactive approach entails close collaboration to limit production and ensure compliance with international agreements like Montreal Protocol, ultimately safeguarding the ozone layer and the environmental.

XI. CONCLUSION

In conclusion, the depleting of the ozone layer, a crucial shield protecting our Earth from harmful ultraviolet (UV) radiation, has become as a global environmental concern. This paper outlined the legal dimensions sur- rounding ozone-depleting substances (ODS), their impacts on the ozone layer, and the consequential risks to human health, specifically regarding skin cancer and blindness.

Furthermore, the paper focuses on severe issue related to illegal trade in Ozone-depleting substances, which disrupt economic stability, dimin- ishes tax revenues, fuels criminal enterprise, threaten public and health safety, and poses a sever threat to the environment. As well as it contra- venes the goals of sustainable development.

Moreover,, effective international cooperation to regulate and penal- ize illegal trade significantly influence human health. In the first short- term, immediate health impacts arise from transfer, handing, storage, and disposed of ozone-depleting substances, leading to issues like respi- ratory problems, skin irritation and other acute heaths issues. Over the long-term, the primary linked to ozone-depleting substances encompass skin cancer and eye disease.

The Montreal protocol stands as a landmark, representing significant international cooperation in global environmental protection. This pro- tocol plays a vital role in controlling and phasing out ozone-depletin substances, safeguarding human health from the adverse consequences arising from the depletion of the ozone layer. It signifies a vital step in international collaboration to preserving and protecting the ozone layer from further depleting.

The positive impacts of the Montreal Protocol on human health are apparent in the estimated benefits resulting from the reduction of ODS production and consumption. These benefits include the avoidance of millions of cases of non-melanoma and melanoma skin cancer, skin can- cer deaths, and cataracts.

The crucial role of the ozone layer in safeguarding life on Earth is evident, with profound effects on human health, the environment, and marine life. Its significance lies in maintaining the delicate balance es- sential for life. The consequences of ozone depletion extend widely, impacting human health, ecosystems, and climate. .

To address the challenges outlined earlier, a set of recommendations is required. These suggestions center around maintaining a global grip on the illegal trade of ozone depleting substances. They encompass aspects such as production monitoring, customs collaboration, cross- border agreements, stringent penalties and deterrents, resource alloca- tion for enforcement, standardized detection equipment, global regu- latory standards, cooperation between public and private partnership for self-regulation, increasing public awareness campaigns, enhance re- search and development efforts, and curbing ozone-depleting substances trade at the sources. By implementing these recommendations and strengthening enforcement measures, governments can strive for future scenario where the ozone layer remains intact, ensuring a healthier and safer world for next generation.

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Phytochemical Study of Cuba's Endemic Solanum: Nº 2 *Solanum Boldoense* Dunal & A. Dc. Family Solanaceae

Anselmo Enrique Ferrer Hernández, Raquel Laura Montiel Castro Francisco Coll Manchado, Nicasio Joaquin Borrego Maria Eunice Aiardes Ferrer, Pedro Ramón Ortiz del Toro & Victor Ramon Fuentes Fiallo

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ABSTRACT

Introduction: The Solanum boldoense Dunal & A.DC, is endemic to Cuba, where it is found in forests and forest edges at low to medium elevations. It has two synonymous species, Solanum cardiophyllum Dunal and Solanum scandens Sessé & Moc. . In Cuba it is used as an ornamental because of the color of the blue flowers. In the form of a vine, the fruit is a globular berry, 1-1.2 cm in diameter, red when ripe. It is occasionally confused with the Mexican and Central American Species S. dulcamaroides Dunal, to which it is probably closely related. *Objectives:* For not having previous studies Phytochemistry it was decided to study trying to know the steroidal compounds of the species. *Materials And Methods.* The plant was collected in the Serra da Grande Pedra, in Santiago de Cuba, by Dr. Victor Ramón Fuentes Fiallo, who in addition identified it and made the desiccant, which was deposited at the Experimental Plant of Medicinal Plants, Dr. Don. Tomás Roig, Minsap, Cuba. The plant was transferred to the Organic Chemistry laboratory of the Faculty of Chemistry, where the organs were separated, and placed to dry in the shade and then in an oven with air flow at 40-50 ºC, for 48 hours. After drying, the material was ground to a homogeneous powder. For the extraction, the decoction method was used for 4 hours, which was repeated 4 times.

Keywords: solanaceae, *solanum boldoense* dunal & a.dc, steroidal compounds.

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Introduction: The Solanum boldoense Dunal & A. DC, is endemic to Cuba, where it is found in forests and forest edges at low to medium elevations. It has two synonymous species, Solanum cardiophyllum Dunal and Solanum scandens Sessé & Moc. In Cuba it is used as an ornamental because of the color of the blue flowers. In the form of a vine, the fruit is a globular berry, 1-1.2 cm in diameter, red when ripe. It is occasionally confused with the Mexican and Central American Species S. dulcamaroides Dunal, to which it is probably closely related. Objectives: For not having previous studies Phytochemistry it was decided to study trying to know the steroidal compounds of the species. Materials And Methods. The plant was collected in the Serra da Grande Pedra, in Santiago de Cuba, by Dr. Victor Ramón Fuentes Fiallo, who in addition identified it and made the desiccant, which was deposited at the Experimental Plant of Medicinal Plants, Dr. Don. Tomás Roig, Minsap, Cuba. The plant was transferred to the Organic Chemistry laboratory of the Faculty of Chemistry, where the organs were separated, and placed to dry in the shade and then in an oven with air flow at 40-50 ºC, for 48 hours. After drying, the material was ground to a homogeneous powder. For the extraction, the decoction method was used for 4 hours, which was repeated 4 times. The extracts were concentrated in vacuum to syrup. From the column layer chromatographic study, it was possible to purify three steroidal compounds, which were soon identified through the layer chromatographic study, using isolated and identified steroid patterns from other Solanum species. RESULTS: From our phytochemical study, the isolation and identification of three steroidal compounds was obtained, such as Solasodine, Solasodieno and Diosgenina. Conclusions: Solanum boldoense Dunal & A. DC, has steroidal compounds such as Solasodine, Solasodiene and Diosgenin.

Keywords: solanaceae, *solanum boldoense* dunal & a.dc, steroidal compounds.

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I. INTRODUCTION

The Antilles (Bahamas, Greater Antilles and Lesser Antilles) are an area with great floristic wealth and, most importantly, with a high level of endemicity in many groups. The West Indies are generally defined as the islands of the Caribbean comprising the Greater Antilles (Cuba, Hispaniola, Jamaica, Puerto Rico), the Bahamas and the Lesser Antilles (Windward and Sotavento Islands), but excluding the islands of Trinidad and Tobago, which are continental origin. [1] Solanum (Solanaceae) is a very diverse genus in the region, which has 25 endemic species. Nineteen of these taxa are endemic to a single island, and some have not been collected since the early 20th century. A synopsis is now presented of the endemic species of the Antilles, with all the synonyms and their distribution and with the citation of a representative specimen of each species. All accepted names and synonyms are to have lectotyped when necessary; many of these taxa were described from collections that were preserved in Berlin (B), but have disappeared. The Lectotypes designated here are illustrated [1].

In Cuba there are six species of the genus Solanum that are endemic and that have not yet been studied phytochemically, among them the *Solanum boldoense* Dunal & A. DC. A species that grows mainly in the eastern region of the country, specifically in the Serra da Grande Pedra, in Santiago de Cuba. According to Knapp 2009, the other endemic species are; *Solanum chamaeacanthum* Griseb; *Solanum gundlachi* Urb.; *Solanum maestrense* Urb. & Ekman; *Solanum moense* Britton & Wilson.; *Solanum pachyneurum* O.E. Schulz. and *Solanum pachyneuroides* Amshoff. [1]. These species must be located and updated in our inventories of endemic plants, as they have been located and identified for many years, not being able to find them in the regions indicated in the current inventories.

The Solanum boldoense Dunal & A.DC, is endemic to Cuba, where it is found in forests and forest edges at low to medium elevations.

It presents two synonymous species, Solanum cardiophyllum Dunal and Solanum scandens Sessé & Moc. [two].

This interesting Cuban woody vine has a very wide local distribution in this region widely separated actions; ex: In Matanzas this grows especially in the famous gorge of the Yumury or Rio Yumury. This gorge is one of the scenic attractions on the north coast of Cuba. In Pinar del Rio in San Diego de los Banhos. Specimen 381 by C. Wright was collected in Oriente. [3]. A species that grows mainly in the eastern region of the country, specifically in the Serra da Grande Pedra, in Santiago de Cuba, where it was collected for our study.

In Cuba it is used as an ornamental because of the color of the blue flowers. It is occasionally confused with the Mexican and Central American species Solanum dulcamaroides Dunal, to which it is probably closely related. It is also somewhat morphologically similar to Cuba's Solanum boldoense. The filaments of Solanum dulcamaroides and Solanum boldoense are the same. The tube, while the pedicels of *Solanum dulcamaroides* and *Solanum seaforthianum* are articulated at the base by a small sleeve. [2] Belongs to the Subgenus Solanum, Section: Dulcamaroides [6].

Solanum boldoense Dunal & A. DC has no previous phytochemical studies carried out and that is why its study was interesting, to evaluate the presence or absence of steroidal alkaloids and sapogenins.

II. MATERIALS AND METHODS

2.1 Collection of plant material and its preparation

The collection was carried out in the Grande Pedra area, in Santiago de Cuba, by Dr. Victor Ramón Fuente Fiallo, who made his taxonomic identification. A branch was used to obtain his exsiccate, which was deposited in the Herbarium of the Experimental Plant of Medicinal Plants Dr. Don Tomás Roig.

To obtain the extracts, the plant was taken to the Organic Chemistry Laboratory of the Faculty of Chemistry, University of Havana, Cuba. The organs were separated (leaves and stems) and allowed to dry at room temperature in the shade and then in an oven with forced air ventilation at 48-50 ºC, for 48 hours. Soon the dry plant material was ground to a homogeneous powder, in a mill with water recirculation

Figure. 1: Solanum boldoense Dunal & A. DC plant. Showing your flowers. (Photo. [3].)

III. BOTANICAL DESCRIPTION OF SOLANUM BOLDOENSE DUNAL & ADC [2]

Woody vine bush or liana; flexuous rods, glabrous; minutely pubescent new growth, trichomes ca. 0.4 mm, simple, unified, then glabrous; bark of older dark reddish-brown stems.

3.1 Plurifoliated sympodial units.

Simple leaves, 4.5-7 x 3-5 cm, ovate to strings or narrowly strands, glabrous on both surfaces or with a few simple uniseriate simple trichomes along the central rib above; primary veins 5-7 pairs, drying reddish; corded or truncated and oblique base; entire margins; apex acuminate; petioles 2.3-3.5 cm, glabrous, twisted to assist in climbing the supports.

Opposite or terminal leaf inflorescences, 10-30 cm, ovoid to ellipsoid in general, branching 5 times, with 50-100 flowers, glabrous; peduncle 1.5-9 cm, glabrous; thin pedicels, 1.2-1.7 cm, ca. 0.5 mm diameter at the base, ca. 1 mm in diameter at the apex, inclined, glabrous, articulated in the distal room just below the calyx tube, leaving an elongated nail, occasionally articulated in the ½ basal of the pedicel, but always leaving a distinct nail; well-spaced pedicle scars ca. 1 cm apart, a series of pins elongated due to the point of articulation. Globular and somewhat inflated buds, the corolla is strongly exerted from the calyx tube.

Perfect flowers; calyx tube 3.5-4 mm (for the joint), the upper part 2-2.5 mm on a comical structure similar to a receptacle, the lobes absent or mere undulations on the edge of the tube, glabrous; corolla 2-2.3 cm in diameter, purple or violet, starry, lobed ca. ¾ from the path to the base, the lobes 0.8-1 x 0.4-0.6 cm, flat (or slightly shell-shaped?) In anthesis, the margins and tips of densely papulous cucumbers; anthers 4-4.5 x 2-2.5 mm, robust, poricidal at the tips, pores widening for cracks with age;

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free portion of the filaments ca. 0.75 mm, the filament tube <0.1 mm, glabrous; conical, glabrous ovary; style 0.8-0.9 cm, glabrous, the stigma capitate, the surface minutely papillary.

The fruit is a globose berry, 1-1.2 cm in diameter, red when ripe, the pericarp thin and shiny; fruiting pedicels 1.1-1.3 cm, ca. 0.5 mm diameter at the base, ca. 1 mm in diameter at the apex, not particularly woody, reflected, the basal portion of the goblet tube expanding in fruit to be clearly differentiated above the point of articulation, looking somewhat swollen.

Seeds ca. 10 per berry, 3-3.5 x 1.5-2 mm, flattened reniform, light brown, meticulously punctuated surfaces, sinuous test cells in contour.

3.2 Extraction method.

The extraction method used was by Decoction, using 95% Ethanol as solvent. The process is carried out for 4 hours at boiling point and then the solvent is filtered and the process is repeated four times, until the plant material is exhausted. All extracts are concentrated under reduced pressure in rotate evaporator, up to a syrup. Then the concentrated extract is studied by column chromatography and thin layer chromatography, to purify and isolate the steroidal compounds.

3.3 Chromatographic study in column and thin layer

To determine the compounds, present in the crude ethanolic extract of the stem and leaves, a chromatographic analysis was performed, using column chromatography. The column was prepared wet, with Silicagel as a stationary phase and as a chloroform/methanol solvent in varying concentrations. After the column was prepared, the extract was added with the aid of a 10 ml pipette, the elution of the mobile phase was adjusted to 60 drops per minute and the eluates were collected in small flasks in a volume of 20 ml each. Each eluate was chromatographed using thin layer chromatography, using 5 X 10 cm chromate plates. With Silicagel G 60, as a stationary phase and as a mobile phase with a mixture of solvent (chloroform/methanol (95: 5) v/v. Rf was calculated for all spots, to identify possible steroidal compounds, with the aid of standards of alkaloids and sapogenins isolated and identified from other Solanum species.

IV. RESULTS AND DISCUSSION

4.1 Results obtained from the study of extraction of the active ingredients.

The result obtained from the plant material was 565 grams of stems and 475 grams of leaves. After the extraction, a syrup of leaves of 50 grams was obtained, for a 10% yield and for the stems of 48 grams, for an 8% yield.

4.2 Result of the column chromatographic study

From the column chromatographic study of the extracts of the Stems and Leaves, we were able to isolate and purify three steroidal compounds and their calculated Rf, to be compared with isolated steroid patterns from other species of the genus Solanum. [7]. Table 1 shows the results obtained.

Table No. 1: Result of the thin layer chromatographic study of the compounds isolated from the Leaves and Stems of *Solanum boldoense* Dunal & A. DC.

Extracts / Standards	Rf-1	Rf-2	Rf-3	Rf-4
Stems	0,45	0,64	0,74	0,81
Leaves	0,42	0,63	0,73	0,83

Solasodine	0,43			
Solasodiene	0,73		0,73	
Diosgenin	0,65	0,65		
Tigogenin	0,68			
Yucagenin	0,55			

Eluent: Chloroform / Methanol (95: 5) (v / v).

In order to corroborate the identified structures, studies were carried out with steroid patterns, which confirmed the presence of Solasodine, Solasodiene and Diosgenin. Melting points were performed mixed with the standards, without any change in the results. In addition, mixed co-chromatographies were performed without any deviation observed in the study.

Isolated and identified compounds

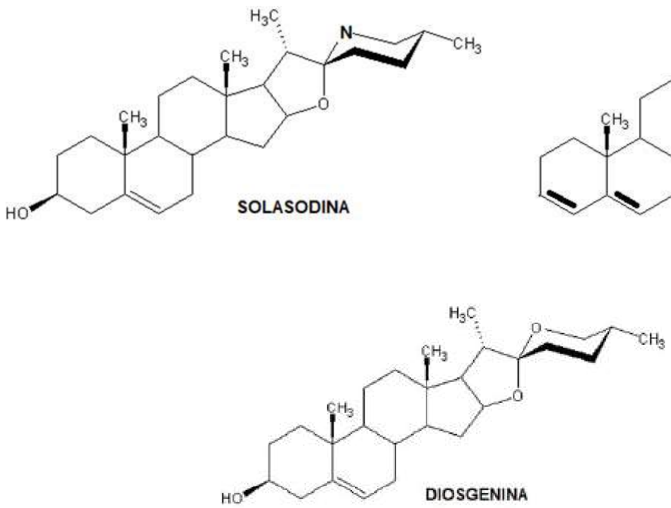

Figure. N° 2: Isolated and identified steroidal structures of the stalks and leaves of *Solanum boldoense* Dunal & A. DC.

The samples identified as Solasodine and Diosgenin were sent for resonance study. In order to corroborate the identified structures, studies were carried out with steroid patterns, which confirmed the presence of Solasodine, Solasodiene and Diosgenin. Melting points were performed mixed with the standards, without any change in the results. In addition, mixed co- chromatography's were performed without any deviation observed in the study.

Isolated and identified compounds C^{13} Nuclear Magnetic Resonance, managing to confirm the structures of these two compounds. Solasodiene is an artifact formed by acid hydrolysis of Solasodine, in the extraction process [5]. Table No. 2 shows the chemical discharge of the studied compounds and their comparison ith data from the specialized literature.

Table N° 2: Chemical discharge of the compounds isolated and identified through the C^{13} NMR of the stems and leaves of *Solanum boldoense* Dunal & A. DC. ($DCCl_3$) / TMS / ppm.

RMN, C^{13}, $CDCl_3$ – TMS (ppm): **SOLASODINE**					
C-1 (37,3)	C-2 (31,6)	C-3 (71,6)	C-4 (39,6)	C-5 (141,1)	C-6 (121,4)
C-7 (32,4)	C-8 (31,9)	C-9 (50,3)	C-10 (36,65)	C-11 (21,4)	C-12 (39,9)
C-13 (41,6)	C-14 (56,4)	C-15 (32,5)	C-16 (83,6)	C-17 (62,0)	C-18 (16,6)
C-19 (19,0)	C-20(42,1)	C-21 (15,2)	C-22 (99,0)	C-23 (32,8)	C-24 (30,5)
C-25 (31,9)	C-26 (46,0)	C-27 (19.8)	X	X	X

RMN C^{13}, $CDCl_3$ / TMS (ppm): **DIOSGENIN.**					
C-1 (39.81)	C-2 (33-08)	C-3, (71.74)	C-4 (44.84)	C-5 (139.20)	C-6(121.39)
C-7 (32.07)	C-8 (32.07)	C-9 (50.08)	C-10 (37.23)	C-11 (19.44)	C-12(40.29)
C-13(41.62)	C-14(56.54)	C-15 (31.27)	C-16 (80.83)	C-17 (62.11)	C-18(17.15)
C-19(20.89)	C-20 (42.29)	C-21 (14.53)	C-22 (109.28)	C-23 (32.07)	C-24(28.82)
C-25(31.47)	C-26 (66.86)	C-27 (17.1)	X	X	X

Solasodiene

This compound is an artifact that is formed in the process of hydrolysis of glycoalkaloids and its abundance depends on the conditions of hydrolysis. [5].

It was recrystallized from acetone, obtaining a TF 176-177 ºC solid. Thin layer chromatography using Silicagel 60 F254 (0.25 mm) and as a mobile phase $CHCl_3$ / MeOH (95: 5) showed a Rf = 0.71. A mixed melting point of the compound and a sample of Solasodieno isolated from *Solanum guanicense* Urb., Showed no depression. [7]

V. DISCUSSION

The *Solanum boldoense* Dunal & A.DC, is endemic to Cuba, where it is found in forests and forest edges at low to medium elevations, had no previous phytochemical studies. According to our study, satisfactory results were obtained, managing to isolate and identify three steroidal compounds such as Solasodine, Solasodiene and Diosgenin. The main steroidal compounds were identified using chromatographic techniques and C^{13} NMR spectroscopic studies. Thus, the structures of Solasodina, Solasodieno and Diosgenina were confirmed. This result is in line with the result developed by Raquel in 1987, in which she reported the isolation and identification of Solasodine, Tomatidenol and Diosgenin of this species. [8].

VI. CONCLUSIONS.

The study of the aerial part stem and leaves of Solanum boldoense Dunal & A. DC, allowed the isolation and identification of three steroidal compounds, which were identifying chromatographic and spectroscopic studies of C^{13} NMR, such as Solasodine, Solasodiene and Diosgenin.

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