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# Identification, Mapping and Ethnobotany of Plant Species in the Peruvian High Andean Wetlands: Stimulating Biodiversity Conservation Efforts towards Sustainability

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**Abstract**

The high Andean wetlands of Peru provide not only the well-known ecosystem services such as water storage, flood mitigation, erosion control, and purification of water, but are also a source of income for local economies (as fodder), have medicinal properties, are a source of food, contribute to the development of ecotourism among many other uses. Economic and population growth have already damaged many parts of the high Andean wetlands including their rich flora. In order to promote the conservation of its diversity and unique flora, this study conducted extensive botanical explorations to identify and map the floristic composition of the high Andean wetlands of La Libertad, Peru, as well as their influence on local communities. The authors conducted explorations taking taxonomic, biogeographic and ethno biological data of the flora species as well as their therapeutic and economic botany. The study identified 64 species of flora distributed in 46 genera and 27 families including Asteraceae (with 8 species), Juncaceae (with 7 species), Poaceae (with 6 species), Cyperaceae (with 5 species), Licopodiaceae and Rosaceae (with 4 species each), Apiaceae, Gentianaceae, Orobanchaceae and Sphagnaceae (with 3 species each) and Poligonaceae (with 2 species). With reference to economic botany, it was found that 32.8% of species constitute resources with a very good economic benefit. The study concludes that it is imperative to take actions to protect the high Andean wetlands as they are ecosystems with great biodiversity. This study contribution expects to raise concerns regarding the increasing impact of economic and population growth on the loss of not only natural habitats but species as well. Conservation efforts will help protect the heritage of the Andes wetlands for future generations.

**Keywords:** plant diversity, flora, ecosystem, high Andean wetlands, Peru

## 1. Introduction

Peru is among the countries that hosts the greatest biodiversity on earth accounting for the world's 10% species of flora (World Bank, 2014). The country has a variety of ecosystems with great importance both from the biological and social point of view. These ecosystems are the source of sustenance for the population and industry that have gradually increased their impact on natural resources and often in a disorganized and unplanned way (Kahn *et al*, 1993; Mostacero *et al*., 2007).

A wetland is an ecosystem flooded by water either seasonally or permanently (Keddy, 2010). A wetland is a zone generally flat or with a moderate slope, in which the surface is permanently or intermittently flooded, giving rise to a hybrid ecosystem aquatic and terrestrial, as occurs in the high Andean areas of Peru (Squeo *et al*., 2006; Ramsar, 2010). The benefits of wetlands can be grouped into seven basic categories: water importance; source of resources and energy; sediment retention and protection; transportation; recreation; ecotourism; and ecological importance (Tabilo, 1999). Regarding water importance, wetlands act as natural liquid retention, regulating their flow and avoiding floods. Wetlands also provide food and medicine to human populations (Tabilo, 1999; Mostacero *et al*., 2009; Mostacero *et al*., 2011).

Due to the different types of vegetation that are usually found, wetlands contribute to the removal of nutrients by encouraging sedimentation. On the other hand, they show a recognized importance in the protection of the coastline, avoiding the erosion of estuaries and rivers. From a social and cultural point of view, wetlands are an excellent resource for recreation and tourism, due to their extraordinary landscape importance and their wide biodiversity (Dugan, 1992; Tabilo, 1999). From the ecological point of view, wetlands serve as a refuge for animals that use their environments to reproduce or feed (Kahn *et al*., 1993; Arana, 1998; Tabilo, 1999; Mostacero *et al*., 2007).

In Peru there are 16 coastal wetlands of which only four are protected within any of the categories of the National System of Protected Natural Areas (Valdivieso et al, 2016). These wetlands are located in the southern and central region of the country. The High Andean wetlands are located in the high plateaus of Ecuador, Peru, Bolivia, Argentina and Chile. While there are some conservation efforts in the region, these are limited to migratory species and wild animals (Rosetti and Stiles, 2012). In Peru there is yet to be a high Andean conservation area, despite the fact that this zone has a significant outcrop of biological richness (Arana, 1998; Kahn *et al*., 1993).

While the conservation of these wetlands is of great importance, the government has not given special attention to this issue. Some studies have addressed the importance of Peruvian wetlands in general. ProNaturaleza (2010) made a historic analysis of coastal wetlands in Peru and highlighted their importance and identified the main causes of their degradation including population growth, expansion of agricultural land and desertification. Ubilluz et al (2011) made a general description of a few wetlands in the central coast of Peru and identified agriculture and livestock as the main causes of their degradation. Maldonado (2014) identified the main threats to the conservation of Peruvian Andes wetlands as overgrazing, peat extraction, mining and development of infrastructure.

To the best of our knowledge there is no comprehensive plant inventory of the wetlands located in the Peruvian Andean Northern region. Moreover, the government so far hasn't introduced or implemented specific measures to protect these ecosystems. This study aims to fill this gap by identifying and safeguarding the biodiversity present in such wetlands as well as their impact on local communities. In some cases, these wetlands could constitute the only remaining habitat for some plant species and their identification is essential. The paper is organized as follows. Section 2 describes the materials and methods used during the botanical explorations, section 3 highlights the results of the explorations and discusses the results and finally, section 4 summarizes the most important findings of this study.

## 2. Materials and Methods

The present investigation was oriented to inventory the flora of the wetlands of the department of La Libertad, located between 2500 and 4500 meters above sea level (m.a.s.l.) as shown in Fig. 1. The data collection was carried out during the decade of 2008 and 2017. The botanical explorations were conducted at a rate of 4 explorations per year (summer, autumn, winter and spring); encompassing altitudinal and latitudinal transects. During the explorations, the collected botanical material and data allowed us to identify the taxonomy, habit, habitat, altitudinal distribution, form of propagation and time of flowering and fruiting. The process of herborization and taxonomic determination of the botanical material was carried out in the Herbarium Truxillense of the National University of Trujillo (HUT).

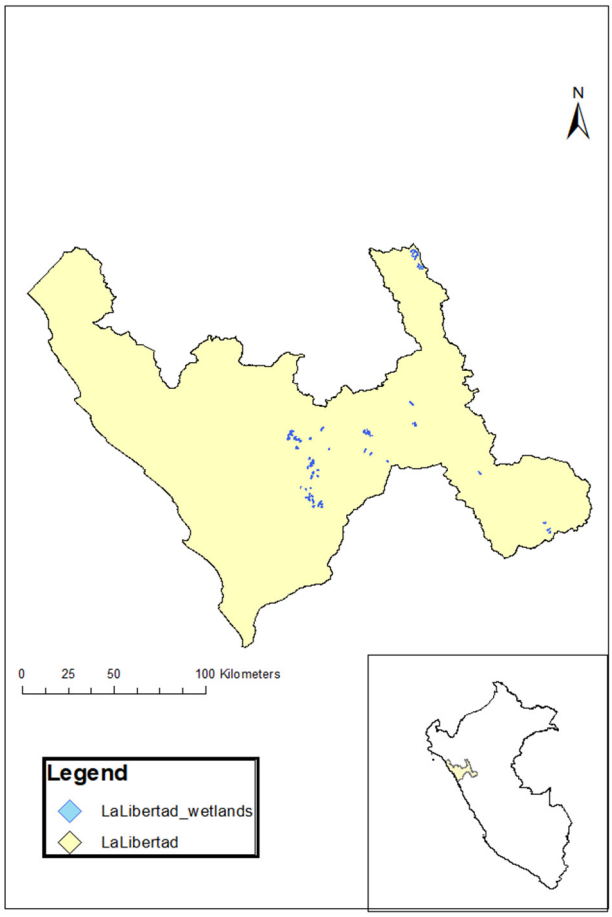


Figure 1. Map of the high Andean wetlands of La Libertad, 2017

Note: the wetlands located in La Libertad region are shown in blue. The box shows the La Libertad region location in Peru

In order to evaluate the potential benefits of the wetland species to the local people, the authors conducted a survey during the last expedition in 2017. We interviewed 384 locals (this value corresponds to the maximum sample size for a 95% confidence level and 5% margin of error) and asked about the value of each of the species from the following options: medicinal, dyeing, soil protector, and fodder. The results of the survey were recorded during the exploration according to the labels attached to the species registered in the HUT.

## 3. Results and Discussion

Table 1 shows the taxonomic characteristics of the flora of the high Andean wetlands. The table highlights scientific name / family, common names, habit, habitat, altitudinal distribution, propagation form, flowering time and period of fructification.

Table 1. Characteristics of the flora of the high Andean wetlands of the Department of La Libertad, Peru

| N | SCIENTIFIC NAME / FAMILY | COMMON NAMES | HABIT | HABITAT (*) | ALTITUDE (m.a.s.l.) (*) | PROPAGATION FORM | FLOWERING TIME | TIME OF FRUCTIFICATION |
|---|---|---|---|---|---|---|---|---|
| 1 | ***Acaena torilicarpa*** Bitter (ROSACEAE) | - | marsh plant 40 cm tall | Disturbed areas. It grows in wetlands, preferably with soil rich in organic matter. | 2000-4500 | Seeds and stolons. | April-June | June-August |
| 2 | ***Adiantum raddianum*** C. Presl (PTERIDACEAE) | "culantrillo" | Small herb riparian | Own of flat places, caespitose and wet. | 3000-4000 | Spores and rhizomes. | All year | All year |
| 3 | ***Agrostis breviculmis*** Hitchc. (POACEAE) | "grass". | Prostrate and marsh grass | Disturbed areas. It grows in wetlands, preferably with soil rich in organic matter. | 2000 - 4500 | Seeds. | All year | All year |
| 4 | ***Alchemilla orbiculata*** R. & P. (ROSACEAE) | - | Prostrate and marsh herb | Ambient with fog and humid soils rich in organic matter. | 2000- 4500 | Seeds and stolons. | April-June | June-August |
| 5 | ***Alchemilla pinnata*** R. & P. (ROSACEAE) | - | Prostrate and marsh herb | Marsh and muddy slopes, disturbed areas. It grows in wetlands, preferably with soil rich in organic matter. | 2000- 4500 | Seeds and stolons. | April-June | June-August |
| 6 | ***Alchemilla procumbrens*** ROSE (ROSACEAE) | - | Prostrate and marsh herb | Marsh and muddy slopes, disturbed areas. It grows in wetlands, preferably with soil rich in organic matter. | 2000 - 4500 | Seeds and stolons. | April-June | June-August |
| 7 | ***Baccharis genistelloides*** (Lam.) Pers. (ASTERACEAE) | "carqueja" | Herb with winged stems | Sub shrub of marshy and rocky areas. | 500-4500 | Seeds. | May -July | July -August |
| 8 | ***Bartsia bartsioides*** (Hook.) Edwin (OROBANCHACEAE) | - | Small, glutinous herb | Of places Palustres, flooded, humid and | 2000-4500 | Seeds. | May -July | July August |

| N | SCIENTIFIC NAME / FAMILY | COMMON NAMES | HABIT | HABITAT (*) | ALTITUDE (m.a.s.l.) (*) | PROPAGATION FORM | FLOWERING TIME | TIME OF FRUCTIFICATION |
|---|---|---|---|---|---|---|---|---|
| | | | | flat. | | | | |
| **9** | ***Bartsia tomentosa*** Molau (OROBANCHACEAE) | - | Small, glutinous herb | Endemic to the north of Peru of flat, swampy and waterlogged places. | 3000-4800 | Seeds. | May -July | July-August |
| **10** | ***Bidens andicola*** Kunth (ASTERACEAE) | " love dry " | Small herb | Marsh and swampy slopes. | 3000-4500 | Seeds. | May -July | July- October |
| **11** | ***Bidens squarrosa*** Kunth (ASTERACEAE) | "love dry" | Small herb | Marsh and swampy slopes | 500-3000 | Seeds. | May -July | July- October |
| **12** | ***Calamagrostis ligulata****(Kunth) Hitchc.* (POACEAE) | "pajonal". | Cespitose grass | Flooded areas and edge of lagoons with acid drainages. | 3000- 4600 | Seeds. | All year | All year |
| **13** | ***Calamagrostis rigescens*** (J. Presl) Scribn. (POACEAE) | "pajonal". | Cespitose grass | Wet and sub-humid soils, edges of rivers. | 3500- 4500 | Seeds. | All year | All year |
| **14** | ***Carex lemanniana*** W**.** Boott (CYPERACEAE) | - | Herb of stems trines | Herb of regular slope , humid, marshy and aquatic. | 2500- 4000 | Seeds and rhizome | May -July | July -August |
| **15** | ***Castilleja arvensis*** Schltdl. & Cham. (OROBANCHACEAE) | " bull blood ". | Herb with red flower | Of flat lands to moderate slopes humid to aquatic. | 0-3800 | Seeds. | May -July | July -August |
| **16** | ***Ceratophyllum demersum*** L. (CERATOPHYLLACEAE) | "ceratofilo", " fox's tail ". | Herb | Aquatic and submerged. | 10- 500 | Seeds and stolons. | All year | All year |
| **17** | ***Cortaderia jubata*** (Lem.) Stapf (POACEAE) | "cortadera" | Grass with rigid and cutting blades | Riparian grass of shrub, waterlogged and aquatic places. | 2000-4300 | Seeds. | April -June | June -August |
| **18** | ***Distichia muscoides*** Nees & Meyen (JUNCACEAE) | "champa" | Grass | Aquatic, submerged in marshy and waterlogged soils. | 3500- 4800 | Seeds and stolons. | All year | All year |
| **19** | ***Epilobium denticulatum*** R. & P**.***(ONAGRACEAE)* | - | Cespitose herb | Herb of medium slope to plains, humid, marshy and even aquatic. | 3000-4500 | Seeds. | May -July | July -August |
| **20** | ***Equisetum bogotense*** Kunth | " horse tail " | Cespitose | Form | 3500 -4500 | Sorus and | All the year | All the year |

| N | SCIENTIFIC NAME / FAMILY | COMMON NAMES | HABIT | HABITAT (*) | ALTITUDE (m.a.s.l.) (*) | PROPAGATION FORM | FLOWERING TIME | TIME OF FRUCTIFICATION |
|---|---|---|---|---|---|---|---|---|
| | (EQUISETACEAE) | | herb | pajonales, humid soil. | | rhizomes. | | |
| **21** | ***Festuca breviaristata*** Pilg. (POACEAE) | "pajonal". | Cespitose grass | Semi-humid ambient associated | 4100 -4500 | Seeds. | All the year | All the year |
| **22** | ***Festuca rigidifolia*** Tovar (POACEAE) | "pajonal". | Pubescent grass | River grass and marsh. It grows in wetlands, preferably with soil rich in organic matter. | 1000-4000 | Seeds. | All the year | All the year |
| **23** | ***Gentianella bicolor*** (Wedd.) Fabris ex J.S. Pringl***e*** (GENTIANACEAE) | "corpus huay". | Pubescent herb | Disturbed areas. It grows in wetlands, preferably with soil rich in organic matter. | 1000-3000 | Seeds. | May -July | July- September |
| **24** | ***Gentianella chamuchui*** (Reimers) Fabri***s*** (GENTIANACEAE) | "chamuchui" | Small herb with yellow flowers | Own of places plans or of slope of little slope, humid, swampy and flooded. | 3000-3500 | Seeds. | May -July | July- September |
| **25** | ***Halenia vincetoxicoides*** Gilg (GENTIANACEAE) | - | Herb | Of slopes, swamps and flooded. | 2500- 4000 | Seeds. | May -July | July- September |
| **26** | ***Huperzia crassa*** (Humb. & Bonpl. ex Willd.) Rothm. (LYCOPODIACEAE) | "trencilla". | Creeping herbs - ascendant | Creeping herbs from places of plans or slopes of ponca pending, wet, marshy and flooded. | 2500-4000 | Sorus. | All the year | All the year |
| **27** | ***Huperzia saururus*** (Lam.) Trevis. (LYCOPODIACEAE) | "trencilla". | Water herb | Aquatic grass grows in swampy and marshy places. | 0-3500 | Sorus. | All the year | All the year |
| **28** | ***Huperzia tetragona*** (Hook. & Grev.) Trevis. (LYCOPODIACAEAE) | "órnamo" | Water herb | Aquatic grass grows in swampy and marshy places. | 1500-3500 | Sorus. | All the year | All the year |
| **29** | ***Hydrocotyle humboldtii*** A. Richard (APIACEAE) | " Abad's hat " | Flowering bush of yellow flowers | Of cloudy and marshy slopes or very humid. | 2000-4500 | Seeds and stolons. | May -July | July -August |

| N | SCIENTIFIC NAME / FAMILY | COMMON NAMES | HABIT | HABITAT (*) | ALTITUDE (m.a.s.l.) (*) | PROPAGATION FORM | FLOWERING TIME | TIME OF FRUCTIFICATION |
|---|---|---|---|---|---|---|---|---|
| **30** | ***Hydrocotyle umbellata*** L. (APIACEAE) | " Abad's hat " | Cespitose herb with yellow capitulos | Herb of flat, marshy or very humid places of the Jalca. | 3000-3500 | Seeds and stolons. | May -July | July -August |
| **31** | ***Hypericum laricifolium Juss.*** (HYPERICACEAE) | "chinchango" | Cespitose herb with yellow capitulos | Herb of flat, marshy or very humid places of the Jalca. | 1500 -4800 | Seeds. | April-June | June -August |
| **32** | ***Hypochaeris schizoglossa*** Cabrera (ASTERACEAE) | - | Marsh herb | Grass of flat, marshy or very humid places of the Jalca. | 2500-4000 | Seeds. | April -June | June- August |
| **33** | ***Hypochaeris taraxacoides*** (Walpers) Bentham & Hokker f. (ASTERACEAE) | - | Marsh herb | Herb of flat, marshy or very humid places of the Jalca. | 0-4000 | Seeds. | April- June | June- August |
| **34** | ***Juncus arcticus*** Willd. (JUNCACEAE) | "junco" | Marsh grass | Grass of flat, marshy or very humid places of the Jalca. | 3500-4500 | Seeds and stolons. | April -June | June- August |
| **35** | ***Juncus bufonius*** L. (JUNCACEAE) | "junco" | Marsh grass | Grass of flat, marshy or very humid places of the Jalca. | 2000-4000 | Seeds and stolons. | April -June | June- August |
| **36** | ***Juncus imbricatus*** Laharpe (JUNCACEAE) | "junco" | Marsh grass | Grass of flat, marshy or very humid places of the Jalca. | 1500-4000 | Seeds and rhizomes. | April -June | June- August |
| **37** | ***Juncus pallescens*** Lamarck (JUNCACEAE) | "junco" | Grass | Floating aquatic grass | 2000-2500 | Seeds and rhizomes. | April -June | June- August |
| **38** | ***Lemna minuta*** Kunth.(ARACEAE) | " duckweed " | Small herb with blue flowers | From flat to low slope, wet, swampy and waterlogged. | 2500-3500 | Seeds and stolons. | May -June | June- August |
| **39** | ***Lobelia tenera*** Kunth (CAMPANULACEAE) | - | Marsh and riparian grass | Own of flat places or slopes of little slope, very humid riverside and marshes. | 3000-4500 | Seeds. | May -June | July -August |
| **40** | ***Lophosoria quadripinnata*** (J.F. Gmel.) C. Chr. (DICKSONIACEAE) | " fern ". | Herb | River herb, rizomatosa, lacustrine plains. | 3000- 4000 | Sorus and rhizomes. | All the year | All the year |
| **41** | ***Loricaria ferruginea*** (Ruiz & Pav.) Wedd. (ASTERACEAE) | " foot of hen ". | Herb | Poscuda Decumbent edge of ditches, lagoons and wetlands. | 3500- 4500 | Seeds. | April- June | June -August |

| N | SCIENTIFIC NAME / FAMILY | COMMON NAMES | HABIT | HABITAT (*) | ALTITUDE (m.a.s.l.) (*) | PROPAGATION FORM | FLOWERING TIME | TIME OF FRUCTIFICATION |
|---|---|---|---|---|---|---|---|---|
| **42** | ***Luzula gigantea*** Desvaux (JUNCACEAE) | "luzula" | Grass | Riparian wetlands, lagoons and streams. | 2800-3800. | Seeds. | May -July | July -August |
| **43** | ***Lycopodium clavatum*** L. (LICOPODEACEAE) | "licopodio" | Floating aquatic herb | Emerging in shallow bodies of water and on the banks of springs or ditches. | 2500- 4500 | Sorus and rhizomes. | All the year | All the year |
| **44** | ***Mimulus glabratus*** *Kunth.* (PHRYMACEAE) | "berro yellow". | Herb | Aquatic from emerged to floating. | 3000- 3500 | Seeds. | May-June | July- August |
| **45** | ***Myriophyllum quitense*** Kunth (HALORAGACEAE) | " fox's tail ". | Marsh herb and cespitose | Plain places with a little slope, humid, marshy and flooded. | 3000-4500 | Seeds. | May -June | July -August |
| **46** | ***Oxychloe andina*** Phil. (JUNCACEAE) | - | Herb | Own grass of flat places, cespitose, humid, marshy and waterlogged. | 3000-4500 | Seeds. | May -June | July -August |
| **47** | ***Paranephelius uniflorus*** Poeppig (ASTERACEAE) | - | Herb | Aquatic herb, riparian, emerging. | 2000-4000 | Seeds. | April- June | June -August |
| **48** | ***Phyllactis rigida (Ruiz & Pav.)*** Pers. (CAPRIFOLIACEAE) | "valeriana star". | Herb | Water herb, submerged and emerging. | 200-3000 | Seeds. | May -June | June -August |
| **49** | ***Polygonum aviculare*** L. (POLYGONACEAE) | "water pepper". | Herb | Water herb, submerged and emerging. | 2000-4500 | Seeds and stolons. | All the year | All the year |
| **50** | ***Polygonum hydropiperoides*** Michx. (POLYGONACEAE) | "water pepper". | Marsh herb | Of flat places, humid riparian and marshy. | 0-4000 | Seeds and stolons. | All the year | All the year |
| **51** | ***Polytrichum commune*** Hedw. (POLYTRICHACEAE) | "moss". | Herb | Aquatic, Emerging in wetlands. | 50-4000 | Spores. | April -July | July- September |
| **52** | ***Potamogeton pectinatus*** L. (POTAMOGETONACEAE) | "potamogeton". | Herb | Aquatic, Emergent and submerged. | 2000- 4000. | Seeds and stolons. | May- June | June -August |
| **53** | ***Ranunculus praemorsus*** Kunth ex DC. (RANUNCULACEAE) | "centella". | Rigid, marsh and aquatic herbs. | Riparian, marsh, aquatic and flooded soil. | 2500- 3500 | Seeds. | May -July | June- August |

| N | SCIENTIFIC NAME / FAMILY | COMMON NAMES | HABIT | HABITAT (*) | ALTITUDE (m.a.s.l.) (*) | PROPAGATION FORM | FLOWERING TIME | TIME OF FRUCTIFICATION |
|---|---|---|---|---|---|---|---|---|
| **54** | ***Rorippa nasturtiumaquaticum*** (L.) Hayek (BRASICACEAE) | "berro". | Rigid, marsh and aquatic herbs. | Humid ambient, and when mature the stems harden. | 50 - 4200 | Seeds. | May -June | July -August |
| **55** | ***Scirpus pungens*** M. Vahl (CYPERACEAE) | "totora". | Grass | Marsh plant, aquatic and emergent. | 3000- 3500 | Seeds and stolons. | April- June | June -August |
| **56** | ***Scirpus californicus*** (C.A. Mey.) Steud. (CYPERACEAE) | "totora". | Grass | Marsh plant, aquatic and emergent. | 3000- 3500 | Seeds and stolons. | April- June | June -August |
| **57** | ***Scirpus rigidus*** Boeckeler (CYPERACEAE) | "totora". | Grass | Marsh plant, aquatic and emergent. | 3000- 3500 | Seeds and stolons. | April- June | June -August |
| **58** | ***Solanum americanum*** Mill. (SOLANACEAE) | " nightshade ". | Aquatic herbs | Biotype of wetlands of the Jalca or Puna. | 3500-4801 | Seeds | April -July | June- September |
| **59** | ***Sphagnum magellanicum*** Brid. (SPHAGNACEAE) | "esfagno". | Herb | Flat, marshy and flooded lands of the jalca or puna. | 2500-4000 | Spores. | All the year | All the year |
| **60** | ***Sphagnum mossmannianum*** Müll. Hal. (SPHAGNACEAE) | "esfagno". | Herb | Flat, marshy and flooded lands of the jalca or puna. | 3000-4800 | Spores. | All the year | All the year |
| **61** | ***Sphagnum subbalticum*** Warnst. (SPHAGNACEAE) | "esfagno". | Herb | Flat, marshy and flooded lands of the jalca or puna. | 3000-4800 | Spores. | All the year | All the year |
| **62** | ***Torulinium odoratum*** (L.) Hooper (CYPERACEAE) | - | Herb | Riverside, swampy, waterlogged and aquatic. | 3000- 3500 | Seeds. | May -June | July -August |
| **63** | ***Verónica peregrina*** *L.* (PLANTAGINACEAE) | "verónica". | Herb | Marsh plant , riverside and aquatic | 2800- 3501 | Seeds. | May -June | July -August |
| **64** | ***Werneria nubigena*** Kunth (ASTERACEAE) | " onion of the buzzard " | Herb | Marsh plant , riverside and aquatic | 3500- 4500 | Seeds. | May -June | July -August |

Legend: The (*) identifies the author that the given information refers to (Brako & Zarucchi, 1993).

Figure 2 illustrates the most representative species of flora in the study area namely A) *Loricaria ferruginea*, B) *Werneria nubigena*, and C) *Distichia muscoide.*


Figure 2. Representative species of flora of the high Andean wetlands of the Department of La Libertad, Peru 2008-2017

A) *Loricaria ferruginea*, B) *Werneria nubigena*, C) *Distichia muscoides*.

On the other hand, Figure 3, illustrates the distribution of the 64 plant species in 27 families.

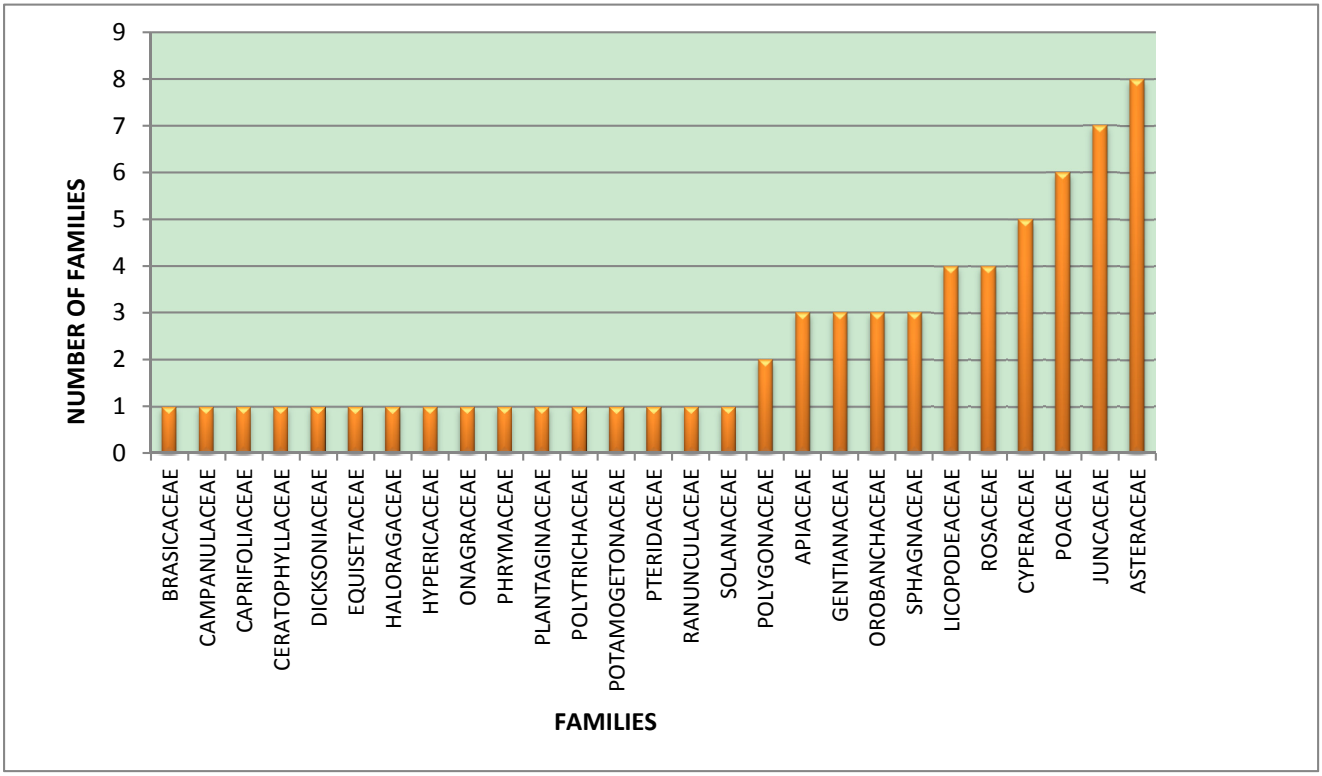


Figure 3. Distribution of the 64 species among 27 families

Table 2 and 3 present the plant species with their respective use and qualitative qualification of their benefits. From the analysis of the species we identified 13 (20.3%) of the 64 species have fodder use, 25 (39.1%) medicinal use, 40 (62.5%) potential phytoremediation, 53 (82.8%) protection of soils and 1 (1.6%) dye.

Table 2. Benefits or uses of the high Andean wetland species from the La Libertad Department, Peru 2008- 2017

| N° | Species | Socioeconomic/ Environmental Benefits | | | | |
|---|---|---|---|---|---|---|
| | | Fodder | Medicinal | Phytoremediation Potential | Soil Protection | Dye |
| 1 | ***Acaena torilicarpa*** Bitter (ROSACEAE) | • | | • | • | |
| 2 | ***Adiantum raddianum*** C. Presl (PTERIDACEAE) | | • | • | • | |
| 3 | ***Agrostis breviculmis*** Hitchc. (POACEAE) | • | | • | • | |
| 4 | ***Alchemilla orbiculata*** R. & P. (ROSACEAE) | • | | • | • | |
| 5 | ***Alchemilla pinnata*** R. & P. (ROSACEAE) | • | | • | • | |
| 6 | ***Alchemilla procumbrens*** ROSE (ROSACEAE) | • | | • | • | |
| 7 | ***Baccharis genistelloides*** (Lam.) Pers. (ASTERACEAE) | • | • | | | |
| 8 | ***Bartsia bartsioides*** (Hook.) Edwin (OROBANCHACEAE) | • | • | | | |
| 9 | ***Bartsia tomentosa*** Molau (OROBANCHACEAE) | • | • | | | |
| 10 | ***Bidens andicola*** Kunth (ASTERACEAE) | | • | | | |
| 11 | ***Bidens squarrosa*** Kunth (ASTERACEAE) | | • | | | |
| 12 | ***Calamagrostis ligulata****(Kunth) Hitchc.* (POACEAE) | • | | • | • | |
| 13 | ***Calamagrostis rigescens*** (J. Presl) Scribn. (POACEAE) | • | | • | • | |
| 14 | ***Carex lemanniana*** W. Boott (CYPERACEAE) | | | • | • | |

| N° | Species | Socioeconomic/ Environmental Benefits | | | | |
|---|---|---|---|---|---|---|
| | | Fodder | Medicinal | Phytoremediation Potential | Soil Protection | Dye |
| 15 | ***Castilleja arvensis*** Schltdl. & Cham. (OROBANCHACEAE) | | ● | | ● | |
| 16 | ***Cortaderia jubata*** (Lem.) Stapf (POACEAE) | | | | ● | |
| 17 | ***Distichia muscoides*** Nees & Meyen (JUNCACEAE) | | | ● | ● | |
| 18 | ***Epilobium denticulatum*** R. & P.*(ONAGRACEAE)* | | | | ● | |
| 19 | ***Equisetum bogotense*** Kunth (EQUISETACEAE) | | ● | | ● | |
| 20 | ***Festuca breviaristata*** Pilg. (POACEAE) | ● | | ● | ● | |
| 21 | ***Festuca rigidifolia*** Tovar (POACEAE) | ● | | ● | ● | |
| 22 | ***Gentianella bicolor*** (Wedd.) Fabris ex J.S. Pringl***e*** (GENTIANACEAE) | | ● | ● | | |
| 23 | ***Gentianella chamuchui*** (Reimers) Fabri***s*** (GENTIANACEAE) | | ● | ● | | |
| 24 | ***Halenia vincetoxicoides*** Gilg (GENTIANACEAE) | | ● | | ● | |
| 25 | ***Huperzia crassa*** (Humb. & Bonpl. ex Willd.) Rothm. (LYCOPODIACEAE) | | ● | ● | | |
| 26 | ***Huperzia saururus*** (Lam.) Trevis. (LYCOPODIACEAE) | | ● | ● | | |
| 27 | ***Huperzia tetragona*** (Hook. & Grev.) Trevis. (LYCOPODIACAEAE) | | ● | ● | | |
| 28 | ***Hydrocotyle humboldtii*** A. Richard (APIACEAE) | | ● | ● | ● | |
| 29 | ***Hydrocotyle umbellata*** L. (APIACEAE) | | ● | ● | ● | |
| 30 | ***Hypericum laricifolium Juss.*** (HYPERICACEAE) | | | | | ● |
| 31 | ***Hypochaeris schizoglossa*** Cabrera (ASTERACEAE) | | | ● | ● | |
| 32 | ***Hypochaeris taraxacoides*** (Walpers) Bentham & Hokker f. (ASTERACEAE) | | | ● | ● | |
| 33 | ***Juncus arcticus*** Willd. (JUNCACEAE) | | | ● | ● | |
| 34 | ***Juncus bufonius*** L. (JUNCACEAE) | | | ● | ● | |
| 35 | ***Juncus imbricatus*** Laharpe (JUNCACEAE) | | | ● | ● | |
| 36 | ***Juncus microcephalus*** H.B.K. (JUNCACEAE) | | | ● | ● | |
| 37 | ***Juncus pallescens*** Lamarck (JUNCACEAE) | | | ● | ● | |
| 38 | ***Lemna minuta*** Kunth**.** (ARACEAE) | ● | | ● | ● | |
| 39 | ***Lobelia tenera*** Kunth (CAMPANULACEAE) | | ● | | ● | |
| 40 | ***Lophosoria quadripinnata*** (J.F. Gmel.) C. Chr. (DICKSONIACEAE) | | | ● | ● | |
| 41 | ***Loricaria ferruginea*** (Ruiz & Pav.) Wedd. (ASTERACEAE) | | ● | ● | ● | |
| 42 | ***Luzula gigantea*** Desvaux (JUNCACEAE) | | | ● | ● | |
| 43 | ***Lycopodium clavatum*** L. (LICOPODEACEAE) | | ● | | ● | |
| 44 | ***Mimulus glabratus*** *Kunth.* (PHRYMACEAE) | | | ● | ● | |
| 45 | ***Myriophyllum quitense*** Kunth (HALORAGACEAE) | | | | ● | |
| 46 | ***Oxychloe andina*** Phil. (JUNCACEAE) | | | | ● | |

| N° | Species | Socioeconomic/ Environmental Benefits | | | | |
|---|---|---|---|---|---|---|
| | | Fodder | Medicinal | Phytoremediation Potential | Soil Protection | Dye |
| 47 | ***Paranephelius uniflorus*** Poeppig (ASTERACEAE) | | | | • | |
| 48 | ***Phyllactis rigida*** (Ruiz & Pav.) Pers. (CAPRIFOLIACEAE) | | • | • | • | |
| 49 | ***Polygonum aviculare*** L. (POLYGONACEAE) | | | | • | |
| 50 | ***Polygonum hydropiperoides*** Michx. (POLYGONACEAE) | | | | • | |
| 51 | ***Polytrichum commune*** Hedw. (POLYTRICHACEAE) | | | | • | |
| 52 | ***Potamogeton pectinatus*** L. (POTAMOGETONACEAE) | | | | • | |
| 53 | ***Ranunculus praemorsus*** Kunth ex DC. (RANUNCULACEAE) | | • | • | • | |
| 54 | ***Rorippa nasturtiumaquaticum*** (L.) Hayek (BRASICACEAE) | | • | • | • | |
| 55 | ***Scirpus pungens*** M. Vahl (CYPERACEAE) | | | • | • | |
| 56 | ***Scirpus californicus*** (C.A. Mey.) Steud. (CYPERACEAE) | | | • | • | |
| 57 | ***Scirpus rigidus*** Boeckeler (CYPERACEAE) | | | • | • | |
| 58 | ***Solanum americanum*** Mill. (SOLANACEAE) | | • | | • | |
| 59 | ***Sphagnum magellanicum*** Brid. (SPHAGNACEAE) | | | • | • | |
| 60 | ***Sphagnum mossmannianum*** Müll. Hal. (SPHAGNACEAE) | | | • | • | |
| 61 | ***Sphagnum subbalticum*** Warnst. (SPHAGNACEAE) | | | • | • | |
| 62 | ***Torulinium odoratum*** (L.) Hooper (CYPERACEAE) | | | | • | |
| 63 | ***Verónica peregrina L.*** (PLANTAGINACEAE) | | • | | • | |
| 64 | ***Werneria nubigena*** Kunth (ASTERACEAE) | | • | | • | |

Table 3. Main uses of the flora of the high Andean wetlands of the Department of La Libertad, Peru 2008-2017

| Total | Fodder | Medicinal | Phytoremediation Potential | Soil Protection | Dye |
|---|---|---|---|---|---|
| **Total** | 12 | 25 | 40 | 53 | 1 |
| **%** | 18.8 | 39.1 | 62.5 | 82.8 | 1.6 |

In the High Andean wetlands of La Libertad it is reported the presence of 64 species of flora. The number of species in La Libertad wetlands exceeds to the Pantanos de Villa, Lima, where 47 species were reported (Ramirez and Cano, 2010) and the wetlands of Puerto Viejo, Cañete, where 32 species were reported (La Torre and Aponte, 2009). On the other hand, regarding the families with the highest number of species in the high Andean wetlands of La Libertad, were: Asteraceae (8), Juncaceae (7), Poaceae (6). Researches corroborate this information about the predominance of species of families: Poaceae and Asteraceae (Ramírez and Cano, 2010; La Torre and Aponte, 2009). By comparing the data obtained with similar works in other wetlands, we can consider the importance of these ecosystems to house an important wealth of flora.

From the analysis in Table 2, it is clear that most of the high Andean wetland species have fodder use, medicinal, and phytoremediation use, among others. Of all of them, medicinal use (39.1%), soil protection function (82.8%) and phytoremediation potential (62.5%) predominate. These results are in accordance with another study that states that wetlands are sources of medicinal, forage resources, avoiding the erosion (Aponte & Cano, 2013). On the other hand, Tables 3 highlights that 32.8% of the species can have a very good use. Studies on economic botany affirm that these ecosystems contribute economically with the surrounding communities to be a source of natural

resources and ecotourism. On the other hand, it is important to consider that they constitute reservoirs of biological diversity, regulating and maintaining the microclimate by contributing to carbon capture (Dugan, 1990; Kahn, *et al*., 1993; Tabilo, 1999; Arana, 1998).

## 4. Conclusions

The high Andean wetlands of La Libertad comply with 75% of the world's environmental services (Table 4). Studies have shown that wetlands perform many vital functions, such as: water storage, flood mitigation, erosion control, purification of water by retaining sediment and pollutants and stabilization of local climatic conditions, particularly precipitation and the temperature (Tabilo, 1999; Mostacero *et al*., 2009; Mostacero *et al*., 2011). According to Barry & Salt (2012), environmental variation and anthropogenic disturbances can influence this ecosystem. Although wetlands have a complex structure and particles, activities such as agricultural expansion and livestock are its main threats (Aponte & Ramírez, 2011).

Table 4. Comparison of the environmental services of the wetlands of the world with those of La Libertad, Peru

| Wetlands | Environmental services | | | | | | | | Consideration | |
|---|---|---|---|---|---|---|---|---|---|---|
| | L | NR | EI | WI | RA | R&EC | SR & P | MB | N° | % |
| **Of the world** | X | X | X | X | X | X | X | X | 8 | 100 |
| **High Andean of La Libertad** | X | X | X | X | X | - | X | - | 6 | 75 |

Legend: EI = ecological importance; R&EC = recreation and ecotourism; L = Livestock; WS= water storage; SR & P = sediment retention and protection; NR= natural resources; RA = reservoir-agriculture; MB = Migration of birds.

At present these ecosystems are undergoing significant changes caused by the rapid economic and population growth as reported in other cases (Arana, 1998; Ramirez & Cano, 2010). As Peru doesn´t have a national wetland plant inventory there is an urgent need to generate more information and develop conservation programs (Dugan, 1990; Tabilo, 1999).

In order to promote the conservation of plant diversity it is very important to have a comprehensive inventory first. The lack of a comprehensive study on the wetlands located in the Andean region of Peru coupled with the absence of specific measures to protect these ecosystems were the main drivers of this research. The study concluded that the high Andean wetlands of La Libertad, Peru, are ecosystems with great biodiversity that contribute to the conservation of at least 64 species of flora. By determining the floristic composition of the high Andean wetlands of La Libertad, Peru, as well as their impact on local communities this study aimed to raise awareness on the importance of their preservation for present and future generations.

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