GEOGRAPHIC DISTRIBUTION OF WILD POTATO SPECIES

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Abstract: The geographic distribution of wild potatoes (Solanaceae sect. Petota) was analysed using a Geographic Information System software, DIVA-GIS. The wild potatoes are found to occur in 16 countries, such as Argentina, Bolivia, Mexico, Peru and so on. Most of the wild potato species are rare and narrowly endemic based on information obtained from online sources. The geographic locations and the geographic distribution of the wild potato was determined using the DIVA-GIS software. With the help of DIVA, the species richness (number of species in a region) and the number of observations of the wild potatoes was identified. Grids were made to visually view the distribution. Based on the grids produced, it can be determined that the wild potato species has a high number of observation in certain parts of the map, such as in countries like Argentina and USA. The same is described for the species distribution where the wild potatoes are not homogeneously distributed. This could be caused by factors that harms the survival of the species.

Key words: GIS; geographic distribution; potato; number of observation; species richness.

Introduction of DIVA-GIS

DIVA-GIS is a free computer program that is available to all. This free computer program is commonly used for mapping and analysing spatial data. It is used to map and execute geographic data analysis using a geographic information system (GIS). The DIVA-GIS software is able to create maps of the world and small parts of the globe using the data obtained from state boundaries, rivers, satellite images and location of sites where a specific animal species is observed. Since DIVA-GIS software is equipped with the geographic information system, it is very useful in terms of mapping and analysing the biodiversity data of an ecosystem. It has the capacity to identify the distribution of species in point-distribution. The software can be used to make grids or maps of the distribution of the biological diversity of the species that is being studied.

The DIVA-GIS software is able to support the vectors such as points, line and polygon, as well as image and grid data types. Furthermore, it is able to go one step further by allowing its user to improve data quality by accurately identifying the coordinates of the species of study using gazetteers. This can be used and checked with the existing coordinates using overlays (spatial queries) of the collection sites with administrative boundary databases. Analytical functions categories which are the raster images and vector data points. These data are then analyzed by GIS is that are present in the DIVA-GIS software allows mapping of richness and diversity data. There are many other functions that the software is able to execute in regards to the distribution map created. These will be explored in the experiment below.

Introduction of Geographic Information System (GIS)

The DIVA software supports GIS which is Geographic Information System as mentioned above. This geographic information software is a field in information technology and it have different applications. This software is used to create awareness regarding the environment, potential disasters, risks, natural resources and so on. The knowledge obtained from this can also be shared. The system is able to analyze, store and visualize data of an individual or an organization's geographic locations. Most commonly, coordinates such as longitude and latitude is used to provide a visualization. Other methods include data points in a spreadsheet, satellite imaging and so on.

The geographic information system works by based on 5 steps. The first would be Data collection where data of the study subject is collected using various sensors and measurement instruments. It is followed by Strategic planning. Here the collected data will be categorized into two different managers. The third step is Data analysis. Analysts, developers and technicians work to deal with the analysis of the data. During Data visualization, the fourth step, visualization and analysis of the spatial data occurs. The final step is where Data rollout occurs. The final produce is sent to the consumers who have the recent updated mapping and navigation information.

Introduction of species

The organism being studied are the wild potatoes. There are over 100 wild potato species which makes it hard to specifically choose a species to study (Cultivariable, 2021). These wild potatoes relatives have many species which allows certain species to contain useful genes which carries useful traits (Hijmans et al., 2003). These wild potatoes are hypothesized to arise from a group of weedy relatives indigenous to the centre; Ander of central Peru, Bolivia and the northern Argentina (Berg et al., 1998).

The geographic distribution of the wild potatoes can be detected and analysed. This can be achieved by using the data of the wild potato species, (Solanaceae sect. Petota) of 6073 georeferenced observations (Hijmans & Spooner, 2001). As mentioned above the wild potatoes species are hypothesized to be found in several countries, to be specific, these wild potatoes occur in 16 different countries. Majority of the observations, around 88% is from countries such as Argentina, Bolivia, Mexico and Peru. Further analysis is conducted in the study to identify the geographic distribution of the wild potatoes species.

In addition, among the many countries, Bolivia is known to be the center of wild relative diversity for many crops, which also include the wild potato species (Cadima et al., 2014). This is an important factor because the potatoes remain to be one of the important food source in the world and conserving them is crucial. Despite having many species of wild potatoes, the crop wild relatives possess important traits which would improve the conservation efforts. Due to the limited information on the wild potato species, the proper data on each species is unavailable which leads to insufficient data for conservation purposes (Cadima et al., 2014). This data is obtained using the Geographic Information System which provides sufficient information to determine the geographic distribution of the species and to conserve them. As per theory, there are seven cultivated potatoes species and there are 199 wild potato species based on a journal by Spooner and Hijmans [7].

Many studies were conducted on the wild potato species, their taxonomy, the genetic data, germplasms collection, wild potato systematics and so on (Hijmans & Spooner, 2001). This research article studies the geographic area in which these wild potato species occur. This information is computed using the data of the countries or regions and the species-level statistics. The estimated geographic area for each individual species is calculated and mapped in two categories, which are the number of observations and the species richness. The DIVA-GIS software is utilised here to accomplish the estimation and the mapping of the data which is displayed below in the results. The results that are obtained from this software, the geographic distribution can provide a baseline data for the further analysis of the wild potato species such as to explore the factors that causes the distribution among the species and so on (Hijmans & Spooner, 2001).

METHODOLOGY

The geographic data was obtained from a reference journal (Hijmans & Spooner, 2001). The data file obtained was unzipped and was opened with Excel to convert the data in degrees and decimal minutes to decimal degrees. The file was then saved as a file in tab delimited text format. DIVA-GIS software was opened and the text file was used to a shapefile called “wild potatoes” and this was added to the map. The ‘pt_countries’ was added to shapefile to the map. The data by country was summarized by making the potato shapefile active and selecting on Analysis/Point to Polygon. ‘Species’ was selected as the field of interest. The shapefile of countries in the ‘define shape of polygon’ box was added and after an output file was selected, it was applied on the map. The two country layers were selected to change their properties such as style, colour, SPPfiled, legends of the fields and so on. This was done by selecting the layer to be active and right clicking on the layer to open a t5ab where the properties can be found.

Projecting the data

To be able to use a grid with cells of equal area, the data needs to be projected. If the latitude and longitude data were used, cells of 1 square degree would get smaller as it is moved away from the equator. Whereas for small areas, UTM would be a good projection. For this experiment and this data, a projection that can be used for a complete hemisphere was used, such as the Lambert Equal Area Azimuthal projection. Before the data was projected, the map of origin for the data was selected, which is somewhere in the centre of the points, which could be (-80, 0). To continue, all the layers were removed from the software except for the wild potato coordinates and the original country map shapefile. By selecting the Tools/Projection, these files were projected using the Lambert Equal Area Azimutal (equatorial) projection. On the custom tab, the central meridian was changed to 80. The files were saved with different filenames and were applied. With all the layers visible and zoomed in, the projected data will be visible.

Species Richness on a Grid

Determining the distribution of the species richness can be done using grid by using the point-to-polygon option that was used. However, it is more efficient to use the Analysis/Point to grid option. 'Richness' and 'Number of different classes' was selected and 'Species' was selected in the field to create the grid. In the Options window, the X and Y resolution was set to 100,000 (as the projection is in meters this means that the cells will be 100 by 100 km). The default option ('simple') was used for the Point-to-grid procedure. After selecting the output filename, the grid can be applied and created. Another grid based on the number of observations was created. The above grid was in terms of species distribution. In order to define the grid with the exact same grid cell size, number of rows, columns and geographic origin, the option 'Use parameters from another grid' was selected. Both the gird was compared with DIVA's Analysis/Regression option. A graph was produced based on the grids where species richness is at the y-axis and the observations is at the x-axis. The relationship between the number of observations and the species can be determined based on the graph.

There are often gradients of species richness over latitude and altitude. Investigating this, latitudinal gradient in species richness, can be done by making grid of a single column. In the grid options window, in the Point to Grid dialog, the 'adjust with resolution' is selected and the set the number of columns was set to 1. Then by using Grid/Transect, a graph can be produced.

RESULTS AND DISCUSSION

This research conducted in regards to the wild potatoes which are found in America. Wild potatoes (Solanaceae; Solanum sect. Petota) are relatives of the cultivated potato and there are nearly 200 different species that occur in the Americas. This research study studies the groups of closely related wild crop relatives using the Geographic Information System (GIS) software, which provides a systematically analysis (Hijmans & Spooner, 2001). The Geographical Information System is designed to assist the plant's genetic resources and biodiversity communities to map the range of distribution of species (Suma et al., 2019). The regions where diverse accessions of the wild potato species occur can be easily found by analysing the geographical diversity distribution of the species. Using the GIS software, the layout of the country of interest, where the species is generally located, can be layer out to identify as seen in Figure 1.

Figure 1 – Shows the country layout/layer where the wild potato species are commonly found.

Based on information obtained from previous journals and the databases, the data to find the geographic location of the wild potato species was obtained. However, this information alone will not be useful as it doesn't contain the coordinates, the longitude and latitude, that can be recognised by DIVA to correctly located the wild potatoes. The information/data instead had the values to calculated the longitude and latitude of the wild potatoes coordinates. Using the formula stated below, the longitude and the latitude were calculated. The formula is "= -1*(LATD+LATM/60)" for Latitude and "= -1*(LOND+LONM/60)" for Longitude. The calculation that was using Microsoft Excel.

Once the missing information were inserted, the excel file was converted into a text file. The DIVA-GIS software was opened and the shapefile of the country map was opened in a new layer. After adding the new layer, the coordinates of the wild potatoes were added by selecting Data/Import Points to Shapefile. Doing this will provide a visual representation of the locations of the wild potatoes species in the map layout already placed in DIVA. The geographic location and the distribution of the wild potatoes can be seen in Figure 2 below.

The data in each country is also available in DIVA. This can be obtained and viewed. This data represents all the countries with wild potatoes. The table obtained from the country layer is as seen below, in Figure 3.

COUNTRY	PIP ID	OBS	SPP	MARGALEF	MENHINICK	SHANNON	SIMPSON
ARGENTINA	2	1042	26	3598	805	2638	911
BOLIVIA	6	1367	40	5401	1082	3084	936
BRASIL	7	18	3	692	707	1061	680
CHILE	8	115	4	632	373	864	512
COLOMBIA	9	104	13	2584	1275	2086	850
COSTA RICA	10	24	1	0	204	0	0
ECUADOR	14	155	21	3966	1687	2486	888
GUATEMAL	18	58	6	1231	788	1501	753
HONDURAS	22	1	1	-9999	1000	0	1000
MEXICO	25	846	36	5192	1238	3083	935
PANAMA	27	13	2	390	555	690	538
PARAGUAY	28	23	2	319	417	179	87
PERU	29	1052	88	12503	2713	3679	952
UNITED ST	38	157	3	396	239	721	503
URUGUAY	39	3	2	910	1155	637	667
VENEZUEL	40	14	3	758	802	992	648

Figure 3 – Shows the data of the countries in the layer used in DIVA-GIS.

Figure 2 – Shows the geographic locations of the wild potatoes in the countries.

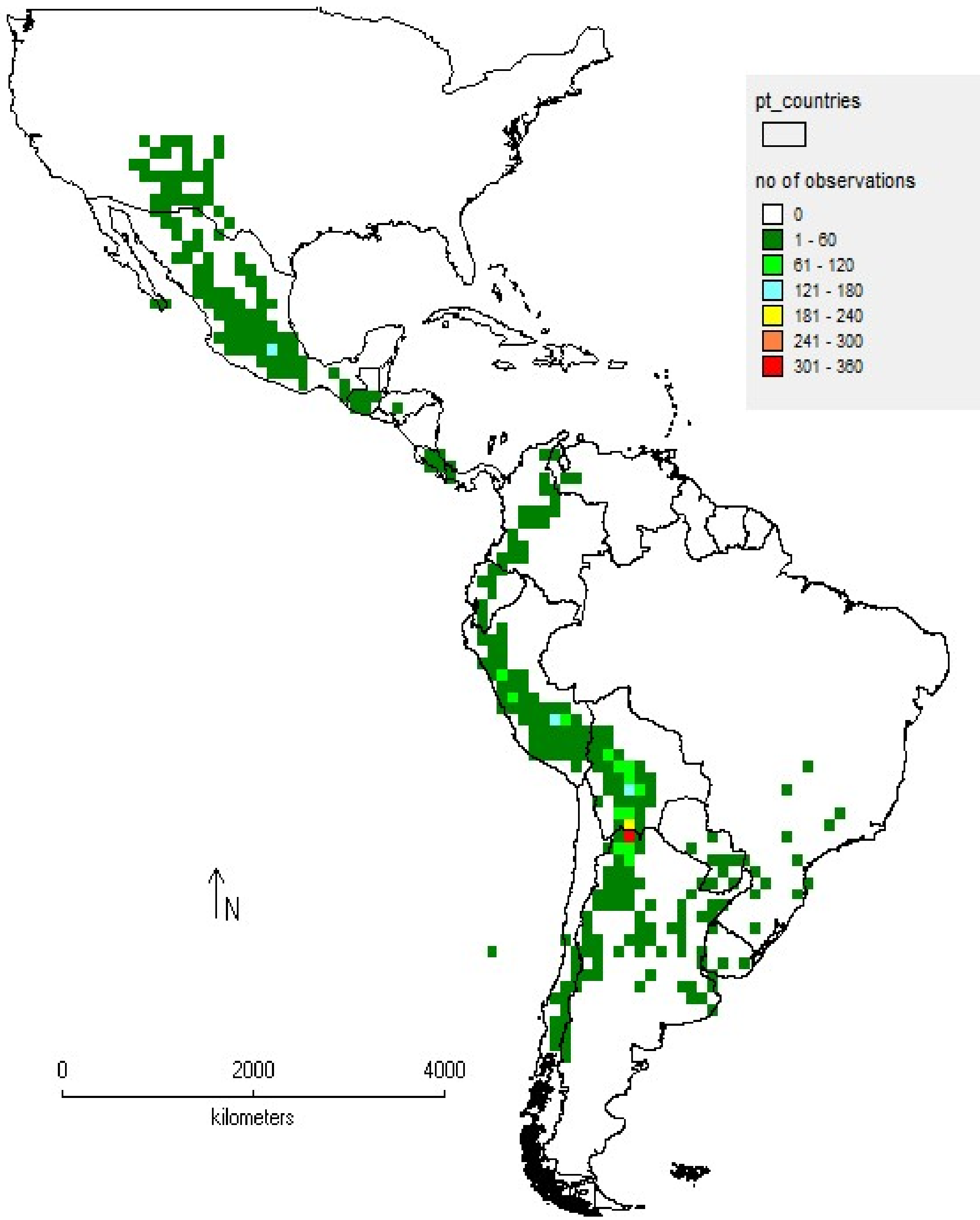

Figure 4 – Shows the number of observations of the wild potato species in grid cells.

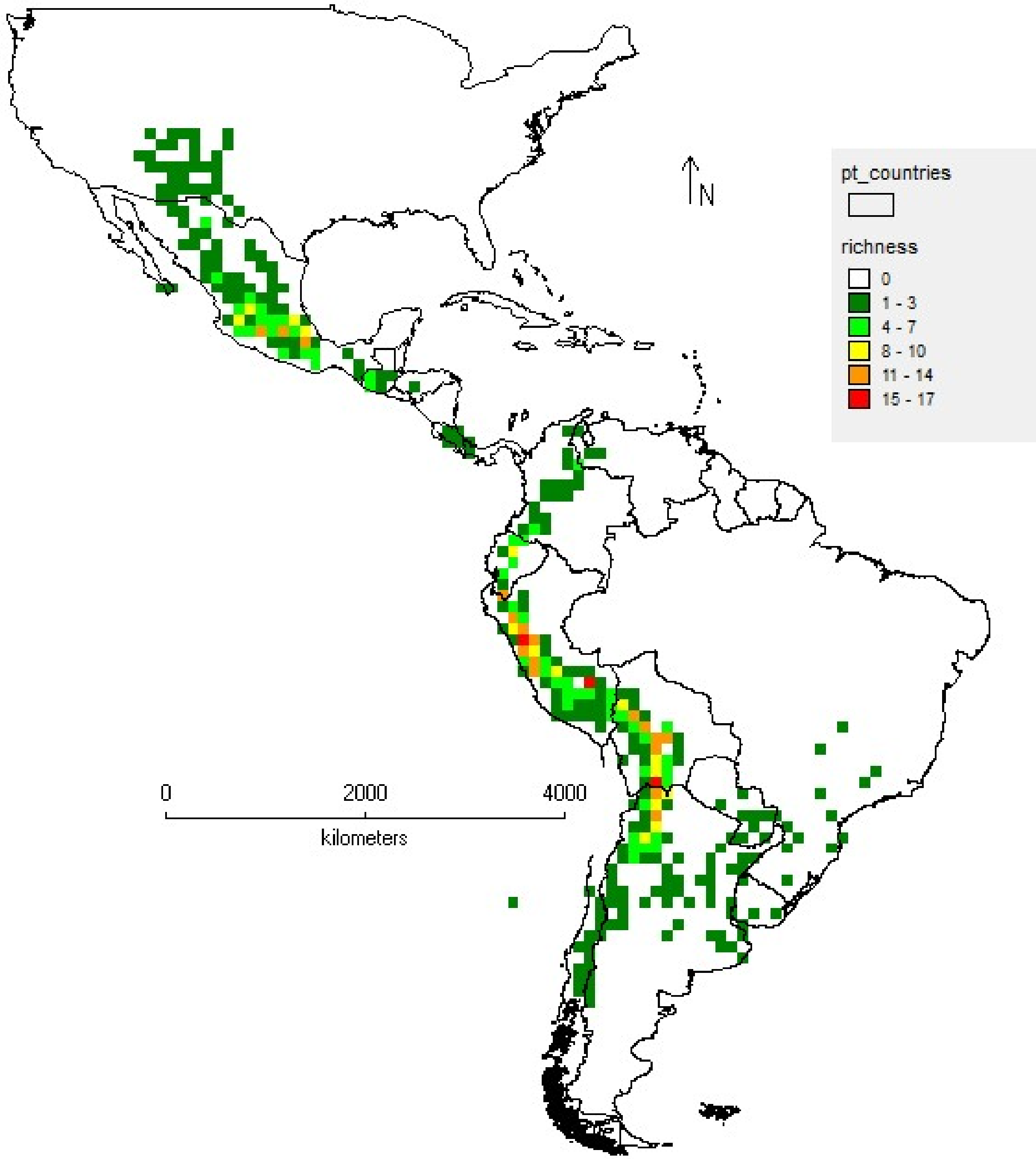

Figure 5 – Shows the Species Richness of the wild potatoes in grid cells.

Based on the data and geographic locations of the wild potato species, the species richness and the number of observations can be easily identified. This was done using the point-to-polygon option that were used before. The Richness and the number of different classes were selected. A new grid formed where the species richness grid can be seen very clearly represented by tiny grid boxes. Just like the richness grid, another grid was made by selecting the number of observations instead of the species richness. The number of species can be observed in Figure 4 whereas the species richness can be seen in Figure 5. The grid cells were used to study the geographic distributions as it is more clear and efficient than the previous studies that were conducted.

Based on the grid in Figure 4, it can be observed that the number of observations of the wild potato species is particularly high in two countries, which are Argentina and Bolivia (Berg et al., 1998). Having a high number of observation of the wild potato species in Argentina would suggest that the country is an area with high diversity. As for countries that has a low number of observation, the survival of the species could be threatened (Cadima et al., 2014). This could be caused due to several factors such as predators, climate, ecological variables and so on. In terms of the species richness as observed in Figure 5, it can be interpreted that the species richness is clearly not homogenously distributed within the countries (Hijmans & Spooner, 2001). There are certain parts of the map that has more species and certain areas have lesser species. Based on Figure 5, it can be said that the species richness of the wild potatoes is high in certain parts of the map such as the southern and central Andes, and in central Mexico (Hijmans & Spooner, 2001). This would mean that those are areas that has a higher number of species in an area. A lower species richness can be observed in the middle of the map, which is around the equator (Hijmans & Spooner, 2001, geo). As mentioned, it could be affected due to factors such as climate that would affect the survival and the growth of the species.

It was hypothesised that there could be a relationship between the species richness and the number of observations of the wild potato species. The data from the number of observation and the species richness grids were taken and a graph was plotted where the species richness (y-axis) against the number of observation (x-axis). The graph, Figure 6, shows a logarithmic curve. It highlights the substantial changes in the trend between the species richness and the number of observations. It can be said that the areas or countries with the higher number of observations has a higher species richness as the areas tends to be a more diverse and conserved area (Cadima et al., 2014).

For further analysis, another graph was also created. This graph was created to investigate the latitudinal gradient in species richness by producing this graph in a single column. The Grid/Transect was selected to create the graph that is shown in Figure 7. The graph shows the distribution of the wild potato species by altitude and latitude. The distribution of the number of species by latitude follows a bimodal distribution (Hijmans & Spooner, 2001). At a latitude of -10 the species richness was at the highest and it also peaked at a latitude of 20. Then, species richness was the lowest at the latitude of 10 to 15. Since the species richness is changing with latitude, then there must be some other factor changing with latitude that is exerting a direct effect on the wild potato communities.

Analysis of the wild potato species based on the climate was not able to be conducted/. This is due to the lack of availability in the data of the wild potatoes. Obtaining the data of altitude required a geological survey which wasn't available to us. However, with that data, a grid can be produced to identify how the wild potatoes are affected by the geological climate of the globe in the different countries. It would further help to identify factors that affects the wild potato species and methods to safely conserve them.

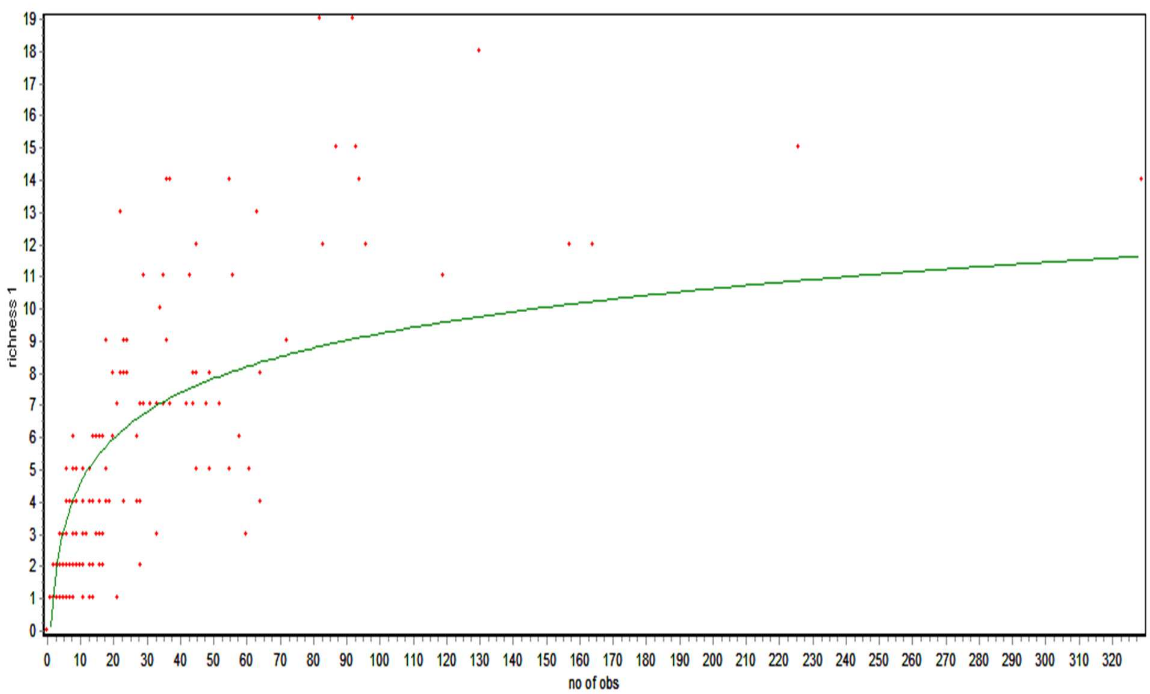

Figure 6 – Shows the graph that describes the relation between the number of observations and species.

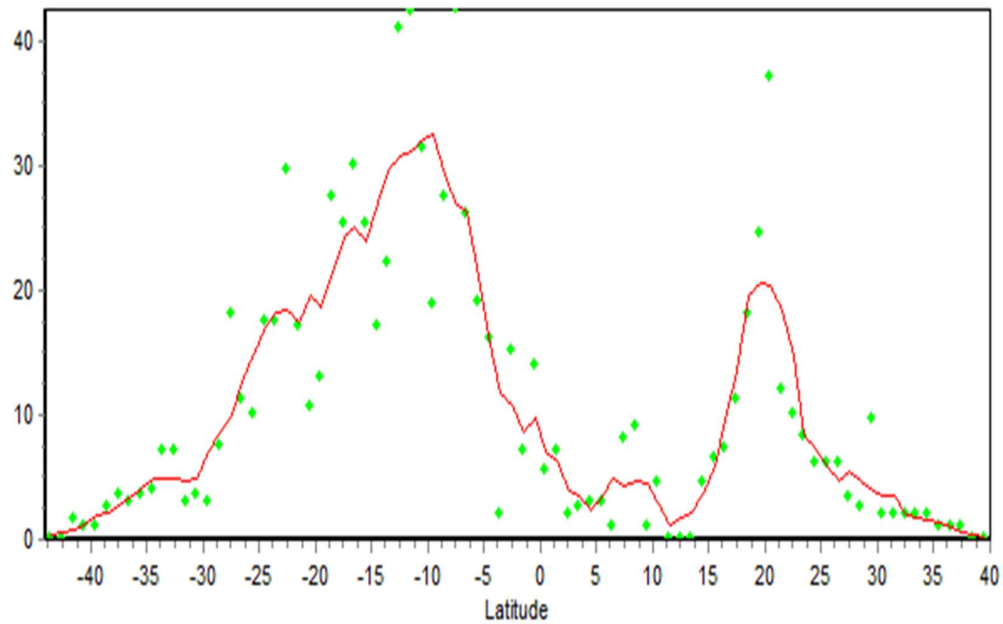

Figure 7 – Shows the wild potato species richness by latitude where each observation represents the number of species found in a 1 degree latitude wide area.

CONCLUSION

The DIVA-GIS software was used to identify the location of the wild potato species. The geographic distribution of wild potatoes (Solanaceae sect. Petota) was analysed using the DIVA-GIS software. The geological locations were determined based on the data obtained from the databases. Grid of species richness and observation count was created to analyse the species of wild potatoes. Most of these species are rare and narrowly endemic. Identifying their geographic distribution aids in planning a conservation plan for the wild potatoes. The location where the potatoes are well grown and have a high species diversity, species richness and number of observations was identified to be countries such as Peru, Bolivia and Argentina. Other locations that have a lower geographic distribution were also determined and identified. These information was produced using the geographic information system and will help to conserve the wild potato species.

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