Geographic Distribution of *Lilium Philippinense* Baker (Liliaceae) in the Cordillera Central Range, Luzon Island, Philippines

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ABSTRACT: The geographical distribution of *Lilium philippinense* Baker in the Cordillera Central Range (CCR), Luzon Island, Philippines has not been accurately recorded in previously published literature. The need for this type of study for *L. philippinense* becomes more immediate due to the decline of its population. The output of this paper is the identification, establishment and description of the geographic distribution of *L. philippinense,* an endemic species in the region through extensive survey of the entire CCR. Mapping the 118 natural populations of *L. philippinense* in the entire study area using Geographical Information System (ArcMap of ArcGIS 9) shows a narrow and fragmented distribution pattern, specifically on the southwestern slopes of the CCR. Descriptive analyses reveals that the populations are distributed at an altitudinal range of 754 and 2,155 m and geographically located between 16º27’90” and 17º15’55” latitude and 120º51’86” and 121º09’22” longitude. In addition, results of hierarchical cluster analyses and analysis of variance also show that elevation plays a major role in the distribution of this species. Moreover, threats to this species are also determined. Information derived from this study can be of aid to biologists and conservationists in developing strategies to protect this endemic and threatened species.

KEY WORDS: Cordillera Central Range, distribution, fragmented, geographic location, GIS.

INTRODUCTION

Lilium philippinense Baker is one among three bulbous species of the genus *Lilium* found in the Cordillera Central Range (CCR) and mostly used for horticultural purposes. It is one of the spectacular displays found in nature with its pure white, tubular flowers, sometimes tinge with a reddish color at the base of the corolla. The anthers emit an enthralling fragrance at anthesis which occurs only once a year, usually from late May until late July, after which their capsules mature and start dehiscing their seeds from August to September (Balangcod, 2009). Benguet lilies, as the species is popularly known, grow half-concealed among closely associated Gramineae species such as *Themeda triandra*, *Imperata cylindrica* and *Miscanthus sinensis*, making them difficult to locate during their vegetative phase (Fig. 1). This plant receives various local names which suggest the characteristics of this lily. For example, *us-usdong* (*Kankanai*) means “*to bow*” because the flowers apparently bow when in bloom; while *kanyon* (*Ilocan*o) illustrates the shape and dehiscence of the matured capsule. Some local residents refer to this species as “*sabong ti bantay*” which literally means “*flowers of the mountains*” because it grows only on mountain slopes.

Lilium philippinense was first discovered growing on the mountain slopes of Benguet province along Halsema Highway in 1871 by Wallis, a well known plant collector and horticulturist. It was first described by Baker in Gardener’s Chronicle, 1873, p.1141 and was also published in the Journal of Linnean Society Botany XIV, 1874, p. 228 (Elwes, 1880). In 1880, Elwes reported that populations of this species occur in hundreds; however, recent observations show that a cluster is composed only of approximately 10 to 50 individuals or less. Supportively, Madulid (2002) reported that the populations are declining.

This *Lilium* species is endemic to the CCR (Elwes, 1880) but its geographic distribution in the CCR has not been completely elucidated to date. Moreover, its population is declining due to habitat loss hence is a candidate for species conservation.

In the previous decades, the rapid degradation of our environment had prompted researchers to channel efforts on biodiversity studies and conservation; most of these studies were conducted in tropical countries where biodiversity hotspots have been identified. Parthasarathy (1999) demonstrates that the primary forests of Asia, particularly those of the Western and Eastern Ghats of peninsular India and other countries in the tropics, are disappearing at an alarming rate due to anthropogenic activities and are replaced by forests comprising inferior species or a change in land use pattern. Unfortunately, the disappearance of tropical forests comes at a time when our knowledge on their structure and dynamics is

Fig. 1. A photograph showing *Lilium philippinense* in its natural habitat and associated species. The inset picture shows the floral characteristics of *L. philippinense*, the yellow anthers emit a fragrant smell at anthesis.

woefully inadequate (Hubbell and Foster, 1992). Similarly, Parthasarathy and Karthikeyan (1997) showed that many of the quantitative plant biodiversity inventories have been focused on species-rich forests; however, inventory data on species-poor forests are inadequate. In the Philippines, relatively few biodiversity studies especially on high elevations have been conducted (Merrill 1904 and 1923; Dickerson, 1928; Jacobs, 1972; Payawal, 1981; Pancho, 1983; Buot and Okitsu, 1998). With this present state of our environment, the need for more research on inventory with the aim of establishing conservation efforts and strategies escalates.

Of late, a specific area of research on biodiversity is analyzing patterns of distribution and elucidating the factors that influence the pattern of distribution in plants. Earlier works on Philippine biogeography, although relatively few (Merrill, 1904 and 1923; Merrill and Merritt, 1910; Dickerson, 1928; Tan, 1984; Ashton, 1993) provided the baseline data inspiring recent studies in this field. These works described the distribution of plants in the Philippines as they relate to the geologic formation of the region. In the Cordillera Central Range, notable works on plant distribution include those of Jacobs (1972), who from a survey, presented a comprehensive list of plant species in Mt. Pulog, while Buot and Okitsu (1998) and Buot (1999) studied the vertical distribution and structure of the tree vegetation as well as the forest architecture along altitudinal gradients in Mt. Pulog respectively.

In conservation of plants, documenting the spatial distribution is essential. With recent technology, the use of Geographic Information System (GIS) has been valuable in mapping and predicting spatial and temporal distribution of species (Stibig et al., 2002). Recently, the uses of GIS in various purposes have also been elucidated. Of note, Collins and Bolstad (1996) compared different spatial interpolation techniques in temperature estimation; Elorza et al. (2003) demonstrated the changes in the high mountain vegetation of Central Iberian Peninsula as a probable sign of global warming; Schaetsl et al. (2005) described modeling soil temperatures in central Great Lakes using GIS as a technique; and Hijmans and Spooner (2001) demonstrated the use of GIS in interpolating climate surfaces for global land areas. These important works, using GIS as a tool not only in mapping species distribution, have simultaneously or successively generated important findings.

The aim of this study is to establish the natural populations and map the geographic distribution of *L. philippinense*, in the CCR using GIS. With the declining *L. philippinense* populations, the basic information derived from this study is useful in developing conservation strategies of this endemic species.

MATERIALS AND METHODS

Study area

The Cordillera Central Range (CCR), where populations of *L. philippinense* are found, is the largest and youngest among three mountain ranges in northern Luzon, Philippines. It consists of Mt. Polis, Central and Malayan ranges (Villa, 1999). The geographical boundaries of the CCR is represented by its political boundaries hence the six provinces namely Abra, Apayao, Benguet, Ifugao, Kalinga, and Mountain Province encompass the CCR. The famous mountains in the CCR are Mount Sto. Tomas, having an elevation of 2,258 m and Mount Pulag, which is considered the second highest mountain in the Philippines and has an elevation of 2,924 m. Other high-peaked mountains with an altitude of over 2300 m such as Mt. Amuyao, Mt. Pauai, Mt. Ugu and Mount Data can be found in this region. According to Villa (1999), the mountain ranges have a maximum length of 320 km and a maximum width of 60 km covering an area of about 23,000 km^2.

The highest points of the Cordillera ranges are geologically young and steep, with altitudes between 2,000-3,000 m. This observation was supported by Lawrence (1951) and Dickerson (1928) who affirmed that these mountain ranges are relatively of recent geologic origin because of their uniformly great heights. Moreover, the CCR displays a unique diversity of plant assemblages. It is one of the 15 identified biogeographic zones in the Philippines (ONG et al., 2002).

The CCR exhibits two types of climate, types I and III based on Corona's system of climate classification (PAG-ASA n.d). Type 1 has two pronounced seasons, dry from November to April and wet during the rest of the year while Type III has no pronounced seasons, however it is relatively dry from November to April. The eastern part of the CCR has Type III and the western area exhibits Type I climate. This distinctive climate, combined with variations in altitude makes the CCR a refuge to a rich flora and fauna, of which some of the species are endemic to the area. The different vegetation assemblages found in the CCR can be distinguished by its dominant species namely; mossy, pine and dipterocarp forests. According to Villa (1999), the elevation brackets of these forests are distinctly classified where dipterocarps, and associated plants, grow between 400-900 m. Pine forests occupy an elevation range from 900 to 1,400 m, sometimes extending to 2,700 m and oak and mossy mist forests are found above 1,400 m.

Geographic survey

Extensive field surveys in the entire CCR were accomplished to identify, locate and establish the natural population sites of *L. philippinense*. A global positioning system (GPS) receiver was used to geo-reference the geographic location and elevation of each natural population. The field surveys were conducted on several occasions from 2007 to 2009. Most of the field trips were accomplished from late May to September, when the flowers of the lilies were in bloom as it is difficult to locate them in their habitats during their vegetative phase due to their morphological similarity with their associated plants. Since there is meager published works on *L. philippinese*, photographs of this species were reproduced and were brought with us during the field surveys. These photographs were shown to local residents in order to facilitate the location of the natural populations. Interviews with the locals were also conducted to determine the threats to its declining population.

Mapping the populations of *L. philippinense*

Two maps were needed for the ArcMap. A Digital Elevation Map (DEM), showing altitudinal gradients, was downloaded from GTOPO3 serving as the base map of the Philippines. The second map was the CCR regional map which was overlaid on the DEM. Plotting of the 118 sites on both the base map and CCR map required a database file of the 118 sites including the latitude, longitude and elevation. This database file was based on a table of the geographic locations and elevations of the 118 population sites which was created in MS Excel and then was converted to a database file. The database file was used as an input to the ArcMap of ArcGIS 9 software to plot the location of these sites on the CCR map.

Statistical analyses

Descriptive statistics using mean, standard deviation and coefficient of variation were used to describe and characterize the 118 population sites based on elevation, latitude and longitude. Hierarchical Cluster analysis was used to establish if there are similarities among the populations. Analysis of variance (ANOVA) was used to determine relationships among the populations based on the three parameters measured. Post hoc test was used to determine which among the clusters are significantly different.

RESULTS

Geographic Distribution of *L. philippinense*

During the extensive survey, there were 118 natural populations of *L. philippinense* established and geo-referenced. Most of the populations were found on very steep, grassy slopes, and on rocky open areas. The population sites, elevation, latitude, and longitude of these populations are summarized in Table 1. Plotting the 118 populations of *L. philippinense* shows a narrow and fragmented pattern of distribution specifically in Benguet and the southern part of Mountain Provinces (Fig. 2).

Statistical analyses

Descriptive analysis shows that the 118 *L. philippinense* population sites are found at an elevation range of 754 m and 2,155 m. The population sites are stretched between 16º27'90" and 17º15'55" latitude and 120º51'86" and 121º09'22" longitude. Conversely, coefficient of variation for latitude and longitude yielded relatively low values, which suggest that there is little variation among the population sites in terms of longitude and latitude. However, the coefficient of variation (CV) of the populations based on elevation showed a 29.36% suggesting that the populations have variable elevation ranges (Table 2).

Hierarchical cluster analysis, using Ward's method and squared Euclidean distance showed four clusters

Table 1. Geographic locations and elevation of the 118 *Lilium philippinense* population sites in the Cordillera Central Range.

Population Sites	Elevation (m)	Latitude *ºN*	Longitude *ºE*	Population Sites	Elevation (m)	Latitude *ºN*	Longitude *ºE*
Ambuklao1, Inidian	1,042	16º47’28”	120º76’22”	Bontoc, Km.388 Bontoc-Banaue Rd.2	928	17º08’88”	120º95’31”
Ambuklao2, Inidian	1,081	16º47’48”	120º76’07”	Bontoc, Km.388	908	17º08’73”	120º95’43”
Atok, Balangabang1 (Km46 Halsema Rd.)	1,927	16º57’96”	120º75’00”	Bontoc, Poblacion1	882	17º09’69”	120º99’94”
Atok, Balangabang2 (Km.46 -waiting shed)	1,959	16º58’93”	120º75’86”	Bontoc, Poblacion2 (After Latang Brdge)	889	17º10’56”	121º00’15”
Atok, Balangabang3 (Km.46 Halsema Rd)	1,953	16º58’18”	120º75’35”	Bontoc, Poblacion3 (Latang Bridge)	909	17º10’37”	120º99’41”
Atok, Caliking	1,598	16º52’59”	120º70’26”	Bontoc, Talubin1 (Km. 378 Bon-Banaue)	1,039	17º05’65”	121º00’63”
Atok, Guiweng	1,849	16º57’59”	120º74’75”	Bontoc, Talubin2	1,160	17º04’83”	121º00’45”
Atok, Km 26, Halsema Rd.1	1,594	16º52’63”	120º70’41”	Bontoc, Tocucan1	869	17º11’69”	121º01’60”
Atok, Km. 26 Halsema Rd.2	1,780	16º27’90”	120º70’27”	Bontoc, Tocucan2	886	17º11’90”	121º02’21”
Atok, Topdak (Km.32 Halsema Rd.)	1,792	16º54’47”	120º71’32”	Bontoc, Tocucan3	866	17º12’55”	121º02’80”
Atok,Near Half Tunnel, Halsema Rd.1	2,091	16º60’17”	120º76’40”	Buguias, Amlimay	1,545	16º68’93”	120º83’63”
Atok,Near Half Tunnel, Halsema Rd.2	2,089	16º60’27”	120º76’39”	Buguias, Man-asok	1,443	16º75’13”	120º83’56”
Baguio City, Kennon Rd.1	1,203	16º37’51”	120º60’70”	Itogon, Ampucao1	1,516	16º31’46”	120º65’12”
Baguio City, Kennon Rd.2	987	16º36’91”	120º60’44”	Itogon, Ampucao2	1,476	16º30’42”	120º65’32”
Bakun, Ampusongan	1,513	16º76’66”	120º74’38”	Itogon, Ampucao3	1,353	16º28’44”	120º64’49”
Bakun, Goldstar, Bagtangan	2,058	16º74’76”	120º76’82”	Itogon, Ampucao4	1,311	16º28’85”	120º64’19”
Bauko, Abatan	1,377	16º98’72”	120º84’04”	Kabayan, Apunan, Near Boundary	1,443	16º55’81”	120º81’88”
Bauko, Bulayok, Sadsadan	1,930	16º90’14”	120º88’01”	Kabayan, Caleng, Bashoy	1,085	16º57’12”	120º83’60”
Bauko, Hanging Bridge, Mt. Data	2,155	16º86’80”	120º87’28”	Kabayan, Duacan	1,232	16º61’40”	120º83’90”
Bauko, Maba-ay	1,868	16º90’76”	120º88’31”	Kabayan, Duacan	1,232	16º61’40”	120º83’90”
Bauko, Lagawa	1,731	16º92’18”	120º88’68”	Kapangan, Bolinsac	798	16º60’24”	120º61’83”
Bauko, Otucan	1,192	16º99’75”	120º88’64”	Kapangan, Cattay	837	16º59’29”	120º61’79”
Bauko, Upper Buga1,Bauko	2,089	16º86’99”	120º87’49”	Kapangan, Dakiwagan, Mt. Beling Belis	1,089	16º65’11”	120º62’77”
Bauko, Upper Buga2	2,110	16º87’00”	120º87’18”	Kayapa, Central. Nueva Vizcaya	1,103	16º35’76”	120º88’80”
Bauko1, Lower Buga3	2,074	17º02’77”	121º09’22”	Kibungan, Leseb, Sagpat	1,324	16º66’95”	120º65’26”
Bauko2, Lower Buga4	2,094	16º86’84”	120º87’63”	Kibungan, Napsung	1,291	16º73’32”	120º67’28”
Bessang Pass1	1,243	16º97’30”	120º67’52”	Kibungan, Tabbak	1,734	16º75’41”	120º69’71”
Bessang Pass2	1,353	16º96’85”	120º67’25”	Mankayan, Taneg	1,622	16º80’75”	120º79’34”
Bessang Pass3	1,292	16º97’28”	120º67’13”	Sabangan, Namatek	1,516	16º93’96”	120º91’00”
Bessang Pass4	1,496	16º96’10”	120º65’86”	Sabangan, Palingaw	1,020	17º01’52”	120º93’25”
Bessang Pass5	1,051	16º97’28”	120º68’22”	Sabangan, Pingad	1,482	16º97’52”	120º90’74”
Bessang Pass6	1,047	16º97’29”	120º68’21”	Sabangan, Supang	1,091	17º10’42”	120º90’23”
Bokod, Akbot, Bobok	1,524	16º43’36”	120º85’41”	Sabangan1	1,817	16º92’05”	120º89’08”
Bokod, Bila	1,481	16º55’31”	120º82’14”	Sabangan2	1,794	16º92’02”	120º89’28”
Bokod, Bolo, Poblacion	1,055	16º46’24”	120º82’43”	Sabangan3	1,750	16º92’17”	120º89’32”
Bokod, Daclan	1,220	16º50’46”	120º82’88”	Sabangan4	1,686	16º92’50”	120º89’75”
Bokod, Inidian, Ambuklao	1,052	16º47’08”	120º76’14”	Sabangan5	1,605	16º93’19”	120º89’91”
Bokod, Lower Adonot	754	16º45’66”	120º73’53”	Sabangan6	1,171	17º00’38”	120º92’07”
Bokod, Lower Bobok, Sawmill	1,514	16º43’32”	120º85’51”	Sabangan7	1,601	16º92’95”	120º89’79”
Bokod, Moatong1, Poblacion	851	16º47’40”	120º81’98”	Sadanga (before Barangay Anabel)	867	17º12’61”	121º03’46”
Bokod, Moatong2, Poblacion	915	16º48’28”	120º82’83”	Sadanga, Belwang	773	17º15’55”	121º04’61”
Bokod, Moatong3	873	16º47’55”	120º81’96”	Sadanga, Betwagan	859	17º14’40”	121º05’75”
Bokod, Moatong4	851	16º47’70”	120º81’98”	Sagada, Danom	1,728	17º09’41”	120º88’56”
Bokod, Pito1	1,321	16º40’60”	120º86’49”	Sagada,After Danom	1,685	17º09’50”	120º87’73”
Bokod, Pito2	1,353	16º40’80”	120º86’44”	Sagada, Madongo1	1,556	17º10’45”	120º91’30”
Bokod, Pito3	1,276	16º40’04”	120º86’19”	Sagada, Madongo2	1,541	17º10’61”	120º89’90”
Bokod, Upper Adonot	899	16º44’51”	120º72’99”	Samoki (Km.380 Bontoc-Banaue Rd.)1	995	17º06’10”	120º98’54”
Bokod, Upper Ambuklao	928	16º46’17”	120º74’95”	Samoki (Km.380 Bontoc-Banaue Rd.)2	899	17º08’49”	120º98’07”
Bontoc, Alab	959	17º05’25”	120º93’64”	Samoki (Km.380 Bontoc-Banaue Rd.)3	895	17º07’53”	120º98’53”
Bontoc, Bayyo1	1,276	17º01’58”	121º01’57”	Samoki (Km.380 Bontoc-Banaue Rd.)4	985	17º06’09”	121º00’03”
Bontoc, Bayyo2	1,294	17º01’30”	121º01’64”	Tadian1	1,354	16º98’74”	120º84’17”
Bontoc, Dantay1	922	17º07’77”	120º94’59”	Tadian2	1,348	16º98’91”	120º83’79”
Bontoc, Dantay2	913	17º07’85”	120º94’80”	Tadian3, Poblacion	1,286	16º99’70”	120º83’28”
Bontoc, Dantay3	961	17º07’81”	120º94’48”	Tadian4, Poblacion boundary	1,292	16º99’81”	120º83’46”
Bontoc, Dantay4	985	17º07’98”	120º94’39”	Tuba, Badiwan, Marcos Highway1	1,198	16º37’57”	120º55’45”
Bontoc, Gonogon1	951	17º04’59”	120º93’71”	Tuba, Marcos Highway2	1,144	16º38’68”	120º51’86”
Bontoc, Gonogon2	986	17º03’56”	120º93’81”	Tuba, Marcos Highway3	1,145	16º38’48”	120º52’93”
Bontoc, Maliteb, Gonogon3	961	17º04’55”	120º93’66”	Tuba, Sto. Tomas1	1,961	16º35’36”	120º55’88”
Bontoc, Km.388 Bontoc-Banaue Rd.1	911	17º08’74”	120º95’44”	Tuba, Sto. Tomas2	1,988	16º35’15”	120º55’46”

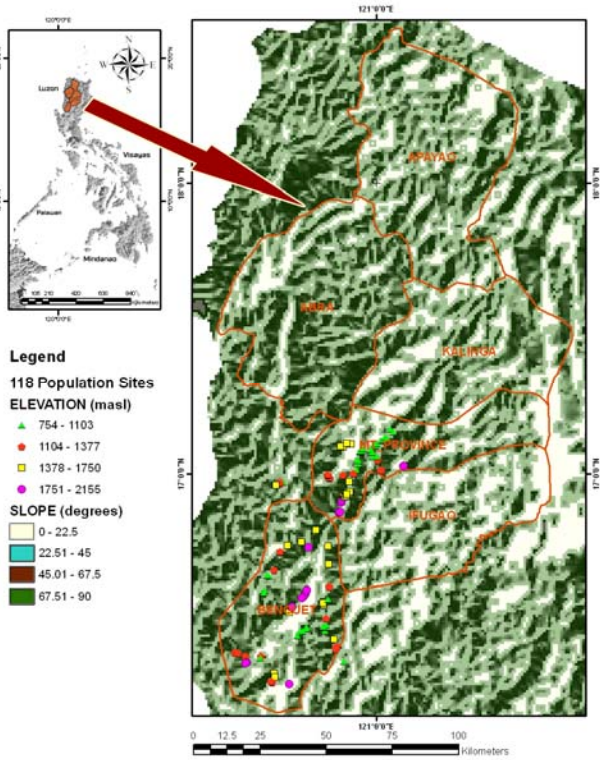

Fig. 2. Map of the Cordillera Central Range showing the spatial distribution and elevation range of *L. philippinense* populations

which are summarized in Table 3. Cluster 1 is characterized by 52 populations with an elevation range from 754 m to 1,243 m; cluster 2 is composed of 21 populations with an elevation range between 1,160 m to 1,377 m; cluster 3 is composed of 31 populations with an altitudinal distribution of 1,443 m to 1,868 m, and cluster 4 is composed of 14 populations distributed between 1,927 m and 2,155 m elevation. Cluster 4 demonstrates the highest elevation bracket while the highest number of populations (43%) occurs between 754 m to 1,243 m.

From among the three variables used to characterize the 118 populations, analysis of variance shows that elevation plays a major role in the distribution of the different populations of *L. philippinense*. Latitude and longitude are not significantly different among the 118 populations. Tukey's test using elevation as dependent variable reveals that all four clusters are significantly different from each other (Table 3).

DISCUSSION

The patterns of distribution of plants are influenced by various factors as revealed in various studies (Magcale-Macandog and Whalley, 1994; Buot and Okitsu, 1998; Hijmans and Spooner, 2001; Schnitzer, 2006); and rarely does a factor work in isolation. Climate, which is characterized by temperature and rainfall, is generally accepted as the dominant factors that influence plant distribution. The influence of climate to plant distribution was established by Orlandi et al. (2005) who studied the bioclimatic requirements for olive flowering in two Mediterranean regions located at the same latitude. Olive flowering is affected by climatic factors such as temperature and photoperiod which vary geographically in latitude and altitude. In liana, climate was negatively correlated with mean annual precipitation and positively with seasonality (Schnitzer, 2006). Conversely, Werff and Consiglio (2004) revealed that factors thought to influence endemism and plant distribution include variation in climatic and edaphic conditions within short distances in montane areas.

The present study shows that the distribution of the natural populations of *L. philippinense* is not evenly distributed in the entire CCR. Mapping the geographic locations of the 118 sites, using ArcMap of ArcGIS 9, illustrates that these populations follow a narrow distribution pattern within the southern slopes of the CCR, particularly in Benguet and Mountain Provinces. A similar pattern of distribution was demonstrated by Hiramatsu et al. (2001) in *L. longiflorum* and *L. formosanum*, two closely related species of *L. philippinense.* These species, including *L. philippinense* are found on very steep south-facing slopes, where the sun falls directly especially on hot days and these species are perched on rocky, well-drained soil.

Climate plays a role in plant distribution as presented earlier and a historical account of the distinct climate in the CCR has been elaborated by Dickerson (1928). The relict-temperate climate of the CCR and the presence of high elevation mountains create a suitable environment for establishment of lilies, which are temperate plants. In fact, the temperate climate of Baguio plateau and Benguet province and the origin of its flora puzzled the first Americans who visited the area. In 1904, Merrill noted that the Benguet-Bontoc region, located at the southern part of CCR has a unique type of vegetation, and the plant species found in this area is not found in other parts of the Philippines. The narrow and fragmented populations of *L. philippinense* are somehow affected by a distinct climatic regime which is characteristic of the southwest part of the CCR.

Consequently, the distinct assemblage of *L. philippinense* populations are strongly aggregated by geographic location and elevation as revealed in cluster analysis. Among the three variables, elevation seems to play a key role in the distribution of the populations. Findings of this study show that the highest number of the populations (43%) is aggregated at an elevation range between 754 m to 1,243 m. The mid-elevation range

Table 2. Descriptive analysis of the *L. philippinense* populations based on the three variables.

Variables	N	Minimum	Maximum	Mean	Std. Deviation	Coefficient of Variation
Latitude °*N*	118	16º27'90"	17º15'55"	16º78'19"	0.2782	0.0166
Longitude °*E*	118	120º51'86"	121º09'22"	120º82'90"	0.1330	0.0010
Elevation (m)	118	754	2,155	1,324.07	388.748	0.2936

Table 3. Comparisons of environmental factors among different population clusters. The a, b, c, d represents Tukey's test for multiple comparison.

		Mean (± Standard Deviation)			Range (min. - max.)		
Cluster	N	Latitude °*N*	Longitude °*E*	Elevation (m)	Latitude °*N*	Longitude °*E*	Elevation (m)
1	52	16º82'11"±0º30'58"[a]	120º84'75"±0º15'69"[a]	969.35±111.91[d]	16º35'76" - 17º15'55"	120º51'86" - 121º05'75"	754 – 1,243
2	21	16º77'55"±0º25'32"[a]	120º82'12"±0º12'02"[a]	1,289.33± 62.79[c]	16º28'44" - 17º04'83"	120º64'19" - 121º01'64"	1,160 – 1,377
3	31	16º75'71"±0º28'31"[a]	120º81'68"±0º09'03"[a]	1,621.94±130.25[b]	16º27'90" - 17º10'61"	120º65'12" - 120º91'30"	1,443 – 1,868
4	14	16º70'09"±0º20'86"[a]	120º79'57"±0º13'63"[a]	2,034.14± 77.16[a]	16º35'15" - 17º15'55"	120º55'46' - 121º09'22"	1,927 – 2,155

between 1,443 m to 1,868 m is occupied by 31 populations, which is 26% of the total populations, only about 12% occupies higher elevations. This result parallels the findings of Werff and Consiglio (2004) who elucidated the distribution of species along elevational gradient. The study showed that densities for all life forms peaked at 1,500 to 3,000 m in Andean slopes. In *L. philippinense,* the distribution of populations extends to lower altitudes.

The populations of *L. philippinense* are nestled within a distinct phytogeographic zone that is characterized by high mountains and the dominance of *Pinus kesiya* (Merrill, 1904). This region, owing to extreme altitudinal variation, and a temperate temperature within a tropical realm, supports a wide range of unique vegetation assemblages. Many species, including *L. philippinense,* are of Asiatic types.

Conversely, man's activities also help shape the formation of vegetation assemblages (Miller and Knoufi, 2006; Dickerson, 1928). Anthropogenic activities can influence the geographic distribution of plants through displacement resulting from habitat destruction (Sharma et al., 2000). Most of the present patches of vegetation along mountain ranges are a result of human intervention. Dickerson (1928) assumed that the original vegetation of the Philippine Islands before man reached the Archipelago was continuous forest of one type or another. However, the presence of vast areas of open grassland characterized by the dominance of cogon grass (*Imperata*), talahib (*Saccharum*), *Themeda* and other coarse grasses are probably due to the activities of man. This could probably explain the close association of *L. philipinense* with *Imperata cylindrica, Themeda triandra* and *Miscanthus sinensis.*

According to Elwes (1880), the climatic conditions which seem to favor the growth of *Lilium* are a moderately cold winter of short duration and a warm spring and summer with considerable moisture. There are three general conditions under which lilies grow in their native countries: (1) a considerable degree of summer heat is requisite; (2) a good amount of moisture is necessary during the growing season, either in the form of rain or mist; and, (3) the partial shade afforded by grass and weeds, or overhanging shrubs, is a necessary condition for their health. It prefers a well-drained soil and inhabits primarily rock surfaces at high elevations although some populations are found in slightly shaded hillsides. All of these requirements are offered by the phytogeographic region of the southern part of the CCR where the *L. philippinense* populations are also narrowly distributed. In addition, the pattern of distribution of *L. philippinense* as shown in this study is similar to *L. longiflorum* and *L. formosanum*, both endemic species in Japan and Taiwan respectively (Hiramatsu et al., 2001). Alternatively, the distribution of *L. philippinense* may also reflect historical processes not accounted for by hypotheses based on species-environment interactions.

In the Philippines, Dickerson (1928) and Ashton (1993) reported that endemism in primary forests exceeds 80% of the total species that are found in these areas. Like in other parts of the country, the CCR harbors endemic and diverse species of plants and animals. Merrill (1923) reported that about 500 species of plants in the higher groups are known in the Philippines only from the Benguet-Bontoc region. Seventeen families are endemic to the region, of which Liliaceae is included (Dickerson, 1928). This indicates a specialized flora and the families essentially characteristic of the temperate regions are relatively strongly developed in this area. *Lilium philippinense* is an endemic species that is found on high elevations in the CCR. Consequently, mountain tops act as islands where populations that live here are isolated and evolved independently. Conversely, endemism are also affected by several factors which include habitat fragmentation and variation in climatic and edaphic conditions leading to isolation of small populations (Kruckeberg and Rabinowitz, 1985, Gentry, 1986). These small populations are vulnerable to extinction. According to Myers et al. (2000) and Knapp (2002), the degree of endemism of an area is often cited as a measure of the uniqueness of the flora and consequently is important for prioritizing sites for conservation.

In order to establish regional conservation goals and develop strategies to achieve these goals, an understanding of the diversity and composition of mountain communities such as the Cordillera Central Range (CCR) is critical for prioritizing conservation efforts. The CCR is home to a number of important and endemic species, among which is *L. philippinense*, that apparently need to be conserved or assessed of their conservation status. According to Madulid (2001) and Olarte (2001) the populations of this species are declining due to over collection. Hence, the former author considered it is a threatened species.

To date, the lack of information about *L. philippinense* specifically its distribution, ecology, reproductive biology and adaptability to changing environmental conditions makes it difficult to predict its long term vulnerability. According to Gibson (2002) conservation of rare plants requires a thorough knowledge of their ecology and distribution. This study therefore, can provide essential information for the development of conservation strategies. In support, Fiedler (1986) demonstrated that studying the distribution of species can contribute to an understanding of the possible reasons for its rarity.

In conservation strategies, species with limited distribution are of greater importance than species with a wide distribution (Werff and Consiglio, 2004). *Lilium philippinense* populations are distributed narrowly at the southern part of the Cordillera Central Range. With the increasing threats on this species and its narrow distribution, conservation strategies are indispensable.

CONCLUSIONS

The distribution of any species of organism is limited by the presence of suitable environments. Looking at the distribution of the natural populations of *L. philippinense,* we can conclude that while the peaks in the CCR vary, the distribution of the populations tend to aggregate at an altitudinal range between 754 m to 2,155 m, with the highest number of populations distributed between 754 to 1,243 m. The assemblage of the populations within a limited area of the CCR is due primarily to a specific habitat requirement which the southern part of the CCR is characterized. Likewise, a distinct climate pattern exists at the areas occupied by the *L. philippinense* populations. Threats to this species are attributed to habitat loss which is caused by natural events such as soil erosion and anthropogenic activities such as road widening, over collection and land conversion. With these threats, the natural populations of this species are declining and therefore require immediate conservation strategies before they become totally extinct.

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菲律賓百合（*Lilium Philippinense* Baker, 百合科）於菲律賓呂宋島中央山脈區域的地理分布

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摘要：菲律賓百合（*Lilium philippinense* Baker）在菲律賓呂宋島中央山脈區域（Cordillera Central Range, CCR）的地理分布，在以前出版的文獻中尚未有準確記錄；由於菲律賓百合族群數量的下降，此類型研究的需要變得更直接且迫切。本文藉由廣泛的調查整個中央山脈區域，來鑑識、建立並描述當地固有種菲律賓百合的地理分布。利用地理資訊系統（ArcMap, ArcGIS9）測量描繪整個研究區中118個菲律賓百合自然種群，顯示了其狹窄和片段的分布格局，特別是中央山脈區域的西南山坡上。描述性分析顯示種群分布範圍在海拔754和2,155公尺之間，地理位置於北緯16º27'90"和17º15'55"間、東經120º51'86"和121º09'22"之間。此外，階層群集分析的結果和方差分析也表示，海拔對此物種分布扮演重要的角色。本文也判斷該物種所受的威脅。本研究所提供的訊息可以協助保育生物學家制定策略以保護這個特有且受威脅的物種。

關鍵詞：中央山脈區域、分布、片段的、地理位置、地理資訊系統。