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Traditional horticultural knowledge change in a rural population of the Patagonian steppe

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ABSTRACT

We investigated traditional horticultural knowledge related to plant species cultivated in homegardens in an arid rural population of North-western Patagonia, Argentina. By means of semi-structured interviews and field visits to the cultivated areas we analyzed floristic composition and structure of: vegetable-gardens, greenhouses and gardens. We evaluated species richness, cover and biogeographical origin in each cultivated area and analyzed the influence of socio-cultural factors, such as age and gender, on informants' cultivation practice. A total of 124 species was found: 75 species in vegetable-gardens, 63 in greenhouses and 68 in gardens. In all cultivated areas, most plant species (91%) were exotic and mainly used for edible purposes. Plant richness in homegardens increased with informants' age and both men and women play a relevant role in the maintenance of cultivated areas. Traditional knowledge in this community has been suffering an erosion process, which is in part influenced by the intervention of extension agents. However, their presence creates the possibility of integrating new and ancestral practices, favoring development of knowledge of a hybrid, syncretic nature. Alongside these changes, Pilcaniyeu inhabitants still maintain traditional homegardens cultivation, through which we can appreciate the intricate relationship between people and their physical, historical, cultural and spiritual contexts.

1. Introduction

In the context of the present worldwide food crisis, homegardens have received special attention as potential models for ecologically sustainable systems (Albuquerque et al., 2005; Kumar and Nair, 2004) since they might allow for the implementation of alternatives to destructive environmental practices such as large-scale agriculture (Altieri, 1987; Méndez and Gliessman, 2002; Peredo and Paz Barrera, 2005). Homegardens primarily promote greater household nutritional independence, forming the basis of a family's sustenance, providing fundamental resources and also essential specific dietary complements (e.g. spices, quelites) (Caballero, 1992; Kumar and Nair, 2004; etc.). Thus, homegardens are tangible spaces which might reflect cultural processes over time, and are therefore ideal scenarios for the analysis of changes in human and plant interaction.

Since ancestral times, horticulture, wild plant gathering and hunting have constituted sustainable sources of subsistence in most aboriginal communities from Patagonia. At present, rural populations with Mapuche ancestry still maintain these practices for their sustenance (Ladio and Lozada, 2003, 2004). However, these traditions have been affected by several socio-cultural, historical and ecological factors generating severe erosion which endanger traditional knowledge (Ladio and Lozada, 2008; Lozada et al., 2006). This tendency can be observed around the world and is evident in both large and small scale agro systems (e.g. Estrada et al., 2007; Peroni and Hanazaki, 2002).

The Mapuche people were ancient inhabitants of temperate forest in Chile and Argentina, and lived as hunter-gatherers and semi nomadic horticulturists (Estomba et al., 2006). They used to cultivate native species such as: maize, quinoa, potatoes, pumpkin, pepper and green beans before the Spanish conquerors arrived (Parodi, 1999; Pardo and Pizarro, 2005). The Spanish conquest led to severe transformations for the Mapuche people. Among others customs, their diet, health care system, and cultivation practices greatly changed. Most of their traditional crops disappeared, and were replaced by exotic species such as barley, wheat and oats (Pardo and Pizarro, 2005).

The Mapuche communities settled at present in Argentina came originally from the temperate forest. Most of them were forced to live in the arid and isolated lands of the Patagonian steppe since the 18th century, thus losing access to ancestral forest environments

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(Bandieri, 2005; Ladio and Lozada, 2004). This profound change of environment could well have had a negative impact on the maintenance of ancient practices related to land use in this new context probably perceived as extremely hostile. Harsh weather and poor soil conditions, plus water and nutrient scarcity could have generated great difficulties in the maintenance of cultivation practices and demanded a great deal of effort from the people. In this study, we will explore the present state of horticultural practice in a population with Mapuche ancestry which is settled in the arid Patagonian steppe.

Horticultural tradition is part of traditional ecological knowledge (TEK) which takes into account the cumulative body of knowledge and beliefs, evolving by an adaptive process which is handed down through generations by cultural transmission (Berkes et al., 2000; Estrada et al., 2007; Niñez, 1987). It comprises a wide spectrum of people's lives, including material, spiritual and cultural traits which respond in varying ways to environmental and socio-cultural changes. These changes are often reflected in the management and composition of cultivated areas (Vogl-Lukasser and Vogl, 2004).

Within a community, horticultural practices vary with age, gender, kinship, degree of acculturation, and opportunities for learning (Begossi et al., 2002; Benz et al., 1994; Garro, 1986; Ohmagari and Berkes, 1997). For example, in early Mapuche communities, the elderly, and particularly the women, played a key role in the maintenance of homegardens and generation of crop diversity.

In North-western Patagonia, TEK related to horticultural practice is presently influenced by western culture. For example, extension agents from Argentine governmental institutions and some non-governmental organizations (NGO's) have introduced new practices and technology in rural communities of this region (Eyssartier et al., 2007). Even though introduced technologies associated with cattle raising, grassland management, veterinary disease control, channelling of natural springs, among others have positively benefitted their living conditions (Peralta, 2002), other interventions could have negatively impacted on their traditional horticultural knowledge. New techniques, such as the use of greenhouses, have probably modified people's customs.

Despite its relevance, horticultural knowledge in temperate areas has not been extensively studied. Homegardens have mainly been studied in tropical areas (Altieri, 1987; Ban and Coomes, 2004; Fernandes and Nair, 1986; Kumar and Nair, 2004; Méndez et al., 2001; Orellana Gallego et al., 2003; Sereni Murrieta and WinklerPrins, 2003; Trinh et al., 2003), where they are generally characterized by a large variety of multi-purpose plants in various vegetation layers resembling the surrounding ecosystem (Caballero, 1992). Therefore, it might be interesting to evaluate whether homegardens located in arid environments also reflect the surrounding ecological conditions. (N.B. we use "homegardens" in accordance with Gispert's (1981) definition as being the area surrounding the house in which plants are cultivated).

The aim of the present study is to evaluate traditional horticultural knowledge and practices in a semi-rural population of Patagonia.

We analyzed the floristic composition, in terms of species and botanic families, and the structure of cultivated areas such as gardens (green areas surrounding their dwellings usually covered by grass), greenhouses (buildings with sides and roof of plastic cover used for growing plants that need protection from the weather), and vegetable-gardens (a fenced-in open area). Moreover, differences among cultivated areas in terms of species richness, cover and biogeographical origin were evaluated. We analyzed how these variables changed in relation to gender and cultivator's age. In addition, differences in plant richness, cover and size of cultivated areas among informants who have or have not incorporated greenhouses were analyzed. We also evaluated the influence of extension agents on their horticultural practices.

Considering the cultural significance of homegardens, together with the introduction of recent technologies we predict that: (1) Highest species richness in total and per person will be found in vegetable-gardens, followed by gardens and lastly by greenhouses; (2) most species found in vegetable-gardens, greenhouses and gardens will be exotic; (3) cultivated plant species will mainly be used for edible purposes and then for medicinal use; (4) plant richness will increase with size of cultivated areas; (5) locals who have incorporated the use of greenhouses will tend to abandon the use of vegetable-gardens; (6) species richness and cover will increase with cultivator's age.

2. Methods

2.1. Study site

Pilcaniyeu is a semi-rural community located in the province of Rio Negro, Argentina (41° 7′S and 70° 44′W), where approximately 1445 inhabitants live (about 350 families). Pilcaniyeu's nearest urban population is Bariloche which is located 75 km away. The area has a mean annual temperature of 7.3 °C and a mean annual rainfall of 264.80 mm. It is characterized by Patagonian steppe ecosystem, where sandy soils are dominant and the vegetation cover is mostly composed of shrubs and herbs: neneo (*Mulinum spinosum*); charcao (*Senecio filaginoides*); coirón amargo (*Stipa humilis*, *Stipa speciosa*) and *Poa huecu*, *Bromus macranthus*, *Poa ligularis*, *Festuca argentina* and other herbs (Cabrera, 1976). It is also characterized by valleys and swamp areas, with rocky patches in other sectors. Most inhabitants work in public institutions and some of them are cattle-raisers. Pilcaniyeu is a community of mestizo origin; some inhabitants are direct descendants of the Mapuche people, while others have mixed ancestry. This population's traditional Mapuche roots have largely been eroded, i.e. the inhabitants do not speak the Mapuche language (Mapudumgun), and they have lost their political leaders (caciques) and shamans (machis). As with most rural communities of this region, most Pilcaniyeu dwellers have come from rural areas, while some others have been living there since they were born. There are also some inhabitants of urban or foreign origin; however most families are related to each other.

Pilcaniyeu community has both social and political organization. There are several communal structures such as primary and secondary schools, a Town Hall, a local Hospital, and other facilities related to cultural, social, recreational and community development. Moreover, this population is head of the Pilcaniyeu Department, thus concentrating all the administrative activity, and for this reason, a great proportion of the inhabitants are public employees.

Some public and non-governmental institutions, such as the National Institute of Agricultural Technology (INTA), the Agricultural Social Program (PSA) and the Institute of Human Studies and Promotion (Iceph) frequently visit Pilcaniyeu in order to provide social assistance. For example, since 1992, extension agents from INTA have been in charge of programmes which promote the implementation of community and family homegardens in Pilcaniyeu, Ñorquinco and Bariloche. They have provided technical assistance such as the materials to build greenhouses and tools necessary for horticultural practice. Furthermore, they periodically distribute exotic plant seeds, i.e. lettuce (*Lactuca sativa*), chard (*Beta vulgaris* var. *cicla*), beans (*Vicia faba*), carrot (*Daucus carota*), etc., and visit the people to provide aid according to their needs. The Social Agriculture Program (PSA) has been working in the region since 1993 promoting programs similar to INTA. It has carried out several projects in order to improve rural people's quality of life, encouraging the use of vegetable-gardens and greenhouses through financial help.

2.2. Data collection

Ethnobotanical fieldwork was conducted by means of semi-structured interviews and the use of participatory methods during the summer and fall of 2007 (Alexiades, 1996; Tuxill and Nabhan, 2001). Domestic units were chosen at random. In each family, only people directly responsible for the cultivated areas were interviewed: 30 individuals in total (20 women and 10 men) between 18 years and 85 years old, representing around 10% of the families. All dwellers accepted being interviewed. We used semi-structured interviews in order to obtain personal information, such as interviewee's age and gender. We interviewed them on aspects related to cultivation in vegetable-gardens, greenhouses and gardens e.g. cultivated plant species, local plant names and common uses (use-categories), age and size of cultivated areas, seed origin and preferred crops. Moreover, open and in-depth interviews were conducted to explore information about Pilcaniyeu historical customs (Alexiades, 1996).

In each cultivated area we studied its floristic composition (e.g. number of species, biogeographic origin, etc.) and its structure (e.g. shape and surface). We estimated cover of cultivated species (native and exotic) by means of Braun-Blanquet method (Mateucci and Colma, 1982). Plant species were classified according to a relative scale of cover taking into consideration the following categories: one specimen, few specimens, specimens cover up to 5% of the surface, from 5 to 25%, from 25 to 50%, from 50 to 75% and more than 75% of the total surface.

In order to make field herbariums, cultivated species were gathered in informants' vegetable-gardens, greenhouses and gardens, with the participation of the dwellers. Field herbariums were deposited in the Herbarium of Centro Regional Universitario Bariloche (BCRU), following the nomenclature of Correa (1969, 1971, 1978, 1984, 1988, 1998, 1999), Marticorena and Quezada (1985), and Ezcurra and Brion (2005).

2.3. Data analysis

Species richness (in total and per person) was estimated by calculating the total number of plant species recorded in each type of cultivated area. To determine similarity among different cultivated areas (vegetable-gardens, greenhouses and gardens) we used the Jaccard similarity index (Höft et al., 1999). This index is based on plant presence or absence while taking the number of species in common as a proportion of the total number of species present, expressed as $JI = (c/a + b + c) \times 100$, where c is the number of species in common, a is the number of unique species in a given cultivated area and b is the number of species unique to the other area. The consensus index (CI) per species was estimated by calculating the proportion of plants mentioned with respect to the total number of interviewees (for example, in the case of lettuce, 28 of 30 persons cited this species, i.e. 93.3% of the population).

Non parametric tests were used to analyze data non − normally distributed (Höft et al., 1999). Chi-square test ($p < 0.05$) was used to evaluate: proportion of native and exotic crops, plant species use-categories, cultivated area differences between vegetable-gardens and greenhouses. The Spearman rank correlation was used to analyze associations between species richness, cover, size and age of cultivated areas, and also cultivated species in relation to informants' age ($p < 0.05$). Mann–Whitney test was applied to compare use-categories according to biogeographic origin and to analyze species richness, mean cover and mean size of each cultivated area between informants who have and have not incorporated greenhouses. The Kruskal–Wallis test was used to compare plant richness per person in each cultivated area (Höft et al., 1999). Data was analyzed with SPSS 10.0 for Windows.

3. Results and discussion

During in-depth interviews we got to know that homegarden cultivation in the Pilcaniyeu region has a history of only 100 years. In pre-colonization times, this arid zone was not utilized by the Mapuche people for cultivation, given that horticultural activity was carried out in more humid areas, whereas the steppe was used for cattle raising and transhumance (Menni, 1999).

At present, the semi-urban Pilcaniyeu inhabitants use their dwellings' surroundings for cultivation, in the following three different areas: vegetable-gardens (known as quintas), greenhouses (invernaderos) and gardens (jardines). This space utilization is in accordance with Gispert's (1981) definition of homegardens, which highlights the importance of having useful resources at hand, thereby minimizing travel and searching time.

Some older interviewees mentioned that previous generation (around 100 years ago) utilized larger areas than nowadays, known as "chacras" as well as homegardens and gardens. In this way they could provide themselves not only with edible resources but also animal fodder, medicinal and ornamental species. They used to cultivate more species than now, such as cereals (wheat, barley, alfalfa *Medicago sativa*) and vegetables (carrots, beans, peas, cabbage, radish, garlic, etc.), and use tools such as the plough and windmill. During that period, it seems they incorporated greater mechanization which enabled development of this horticultural tradition. Conversely, nowadays, whereas in other areas these tools are present, none were observed in Pilcaniyeu, suggesting the loss of these technologies, which could be associated with a decrease in area cultivated. This could be linked to the fact that this population is undergoing changes produced by urbanization as well as the general deagrarization process occurring in other rural regions (Estrada et al., 2007; Peroni and Hanazaki, 2002; Pulido et al., 2008). Despite this, some ancestral customs are still prevalent among Pilcaniyeu inhabitants; such as: following moon cycles, using ash and making home-made pesticides, cultivating particular species to avoid the presence of insects and other animals and using manure as natural fertilizers.

In addition, our results show that the majority of homegardens in Pilcaniyeu are not related to commercial purposes or extensive fodder crops. Products obtained through the management of cultivated areas are primarily for family use (54.5%), occasional surpluses sometimes being given away to relatives or friends (33%).

3.1. Floristic composition

In total, we found that the Pilcaniyeu dwellers cultivated 124 species distributed among 41 plant families (Appendix 1). In accordance with our hypothesis (1) related to total plant richness, we found more species in vegetable-gardens (75 species) than in gardens (68 species) and greenhouses (63 species) (Appendix 1). When comparing species richness per interviewee, no significant differences were observed among cultivated areas (vegetable-gardens: 7.86 ± 8.22; greenhouses: 7.76 ± 6.58 and gardens: 4.5 ± 5.66) (Kruskal–Wallis test, $p = 0.86$), indicating that these scenarios are equally utilized in terms of species number. However, the standard deviation of data is relatively high showing a great variability among interviewees in relation to richness among cultivated areas. Moreover, analyzing species similarity among cultivated scenarios, Jaccard index was relatively low, i.e. 37.5% between vegetable-gardens and greenhouses, 36.5% between homegardens and gardens, and only 15% between greenhouses and gardens. This reflects differential cultivation purposes associated with the distinctive physical conditions in each scenario, generating diverse species selection patterns.

As stated in a recent review (Pulido et al., 2008), homegardens are idiosyncratic. The absence of distinguishable objective patterns seems to answer to complex and unpredictable variables associated with environmental conditions, cultural, economic and social factors (land ownership and control). Due to this intricacy, the structural coupling perspective (which includes integration of subjective and objective parameters) might contribute to the understanding of homegardens as complex scenarios of the convergence of human beings, nature, history, perceptions and actions (Varela et al., 1992).

3.2. Species consensus in cultivated areas and biogeographic origin

As predicted in our hypothesis (2), we found that most plant species recorded in vegetable-gardens, greenhouses and gardens were exotic (X_1^2:77.760, $P < 0.001$). Total plant richness included 113 exotic (91%) and 11 native (9%) species (Appendix 1). Most informants named lettuce (*L. sativa*) (67%) and chard (*B. vulgaris* var. *cicla*) (17%) as the two most favored and frequently cultivated crops. Garlic (*Allium sativum*), beans (*V. faba*) and tomatoes (*Lycopersicum esculentum* var. *esculentum*) were also mentioned as preferred crops (Appendix 1).

This high proportion of exotic species would seem to indicate a replacement of their traditional crops. This replacement of native crops is a process which began after the Spanish conquest (Pardo and Pizarro, 2005). A higher number of exotic cultivated species has also been recorded in other investigations (Albuquerque et al., 2005; Del Río et al., 2007; Torrejón and Cisternas, 2002; Vogl-Lukasser and Vogl, 2004), showing the prevalence of certain worldwide crops with commercial and economic relevance, and the replacement or abandonment of local cultivars, in accordance with global tendencies (Hildebrand et al., 2002; Peroni and Hanazaki, 2002). Mainstream dietary habits are related to the loss of food sovereignty and to a decrease in plant diversity, thus contributing to the general process of cultural diversity erosion. Rapoport and Drausal (2001) found that there are more than 15,000 species of food plants recorded worldwide, despite the fact that most of the world's population is fed with about 20 crops, demonstrating the impact of cosmopolitan dietary patterns.

The globalization process previously mentioned might be related with an acculturation process by which a culture is transformed due to the massive adoption of cultural traits form another society (Caballero, 1992). Globalization together with acculturation processes have their consequences on the floristic diversity of homegardens, modifying nutrition patterns which involve the progressive disuse of traditional crops for other species or industrialized products offered by the national market.

3.3. Plant families

The most representative plant family was Asteraceae (36.5%), followed by Lamiaceae (32%), Rosaceae (24%), Fabaceae (22%), Liliaceae and Brassicaceae (17%), Apiaceae (14.5%), Cucurbitaceae (12%), Chenopodiaceae and Saxifragaceae (10%), Papaveraceae, Salicaceae and Solanaceae (7%), Enoteraceae, Malvaceae, Poaceae and Rutaceae (5%). Interestingly, Asteraceae, Lamiaceae, Rosaceae, Liliaceae and Brassicaceae are the most representative plant families in homegardens of temperate areas of Europe (Vogl-Lukasser and Vogl, 2004).

However, it has been documented that in the past, the Mapuche people traditionally cultivated species belonging to different plant families such as Solanaceae, Amarantaceae, Cucurbitaceae, Poaceae and Fabaceae (Parodi, 1999; Pardo and Pizarro, 2005), showing a remarkable change in plant selection and cultivation.

3.4. Use-categories

In Pilcaniyeu, plant species were used for several purposes, showing significant differences among categories (X_5^2:1, $P < 0.01$). In accordance with our third prediction, cultivated areas were mainly used for food production (59 species, 47.5%). Fewer species were used for ornamentation (43 species, 35%), followed by 27 species (22%) for medicinal purposes. Moreover, approximately 8 plants (7%) were used for shade and hedging and only one species (0.8%) was recorded for animal fodder. Additionally, approximately 7 plant species (6%) were utilized as herbicides: *Urtica dioica*, *Rosmarinus officinalis*, *Lavandula* sp., *Origanum vulgare*, *Salvia officinalis* and *Artemisia absinthium*. Furthermore, *Ruta graveolens* is used for the spiritual protection of houses and people (Appendix 1).

3.5. Use-categories and biogeographic origin

Interestingly, most edible plant species were exotic (Mann–Whitney test, U:331, $P = 0.013$), whereas more native species were utilized for medicinal purposes (Mann–Whitney test, U:390, $P = 0.027$). In accordance with what we mentioned above, this result highlights the dietary global tendency. In this community, this pattern is promoted by extension agents who exert more influence on edible species than on medicinal ones. As in many other studies in the region, locals tend to maintain the use of native species in health care (Estomba et al., 2006). In general, this tendency is strengthened by confidence in traditional medicines plus sporadic official health assistance.

3.6. Cultivated area structure

In Pilcaniyeu, vegetable-gardens and greenhouses were most commonly rectangular, with a mean area of 41 m^2; vegetable-garden mean area was 35.5 m^2 (between 2.82 m^2 and 103.84 m^2), while greenhouse mean area was 23.01 m^2 (between 9.72 m^2 and 54 m^2) (Mann–Whitney, $Z = 1.79$, $P = 0.07$). Vegetable-gardens showed a greater area variation than greenhouses. This could be because most greenhouses were built following a community project promoted by the P.S.A, which provided not only training but also the building instructions and necessary materials. On the other hand, vegetable-gardens were designed by locals according to their needs, family traditions, land area owned, etc.

Fernandes and Nair (1986) proposed that homegardens in tropical regions are smaller than 1 ha are typical of subsistence agriculture irrespective of climatic conditions and access to technology. Nevertheless, in general, homegardens have different extensions according to environmental and cultural conditions (e.g. Albuquerque et al., 2005; Méndez et al., 2001; Pulido et al., 2008; Vogl-Lukasser and Vogl, 2004).

Some investigations have demonstrated that homegardens are commonly rectangular, and showed a vertical structure which reflected degrees of specialization and complexity (Albuquerque et al., 2005; Caballero, 1992). However, in Pilcaniyeu, homegardens were not characterized by this structure. Plant species were only distributed within the available horizontal space, and in some cases, even without any specific vertical or horizontal distribution. Trees and bushes, such as *Populus nigra*, *Populus alba* and *Ribes aureum* (corinto), were mainly exotic and were usually found as hedges, surrounding vegetable-gardens or surrounding the house area. In general, tropical homegardens, which contain a high density of fruit trees, resemble the neighboring forest in physiognomic terms (Albuquerque et al., 2005; Blanckaert et al., 2004; Das and Das, 2005; De Clerck and Negreros-Castillo, 2000; Kumar and Nair, 2004; Méndez et al., 2001). However, cultivated areas in Pilcaniyeu are different from their surroundings, as it is situated in a dry steppe.

The fact that more than half of the people use greenhouses (68.8%), might indicate a frequent use of this new technology. Extension agents have influenced local people's traditions through the transmission of new agricultural practices and technology, as well as promoting the cultivation of exotic crops. Therefore, in their horticultural practice, locals make use both of their traditional knowledge and the new information from western influence.

3.7. Differences in cultivated areas according to richness, cover, time of construction and size

As predicted in hypothesis (4), the number of species in vegetable-gardens and in greenhouses increased with the size of cultivated area ($r_{30} = 0.862$, $P < 0.001$; $r_{30} = 0.839$, $P < 0.001$ respectively), an association not always found in other studies (Albuquerque et al., 2005; Blanckaert et al., 2004; Perrault-Archambault and Coomes, 2008). Moreover, a negative correlation was found between plant richness in vegetable-gardens and plant richness in greenhouses ($r_{30} = -0.458$, $P = 0.01$, Fig. 1), and gardens ($r_{30} = -0.475$, $P = 0.08$). In addition, a negative association was found between vegetable-garden and greenhouse plant cover ($r_{30} = -0.589$, $P = 0.001$). In accordance, this relationship was also negative between vegetable-garden and greenhouse size ($r_{30} = -0.648$, $P < 0.001$). All these results could indicate a replacement of vegetable-gardens, their traditional cultivated area, by greenhouses, as hypothesized in our prediction (5). Therefore, some crops traditionally cultivated in vegetable-gardens, such as lettuce (*L. sativa*), chard (*B. vulgaris* var. cicla) and coriander (*Coriandrum sativum*), are now cultivated in greenhouses.

Finally, we found a positive correlation between size and time of construction (i.e. years since when cultivated areas were constructed) of vegetable-gardens ($r_{30} = 0.772$, $P < 0.001$) and greenhouses ($r_{30} = 0.796$, $P < 0.001$), indicating that dedication and care of cultivated areas increase with time, and it is related to an increment in species richness.

3.8. Influences of socio-cultural factors on cultivated areas

3.8.1. Informant gender and age

The average age of inhabitants dedicated to horticultural practices is 50 years old, but our informants ranged from 18 to 85 years old.

As predicted (hypothesis (6)), a positive correlation was found between the total number of species recorded per person and their age (Spearman correlation coefficient, $r_{30} = 0.363$, $P = 0.049$, Fig. 2), showing that older people cultivate more species than younger ones. It suggests that experience accumulates with age, as all the informants mentioned that they had started learning about cultivating the land in their childhood. This result may also suggest that local horticultural activities are decreasing in the young, indicating that traditional values are changing, the older generation being those who mainly maintain traditional practices. As also found in other studies, traditional ecological knowledge related to plant use is suffering an erosion process in many rural and aboriginal communities of Patagonia (Estomba et al., 2006; Ladio and Lozada, 2003, 2004; Ladio et al., 2007).

3.9. Greenhouses as innovation

Interestingly, we found that total species richness in all cultivated areas belonging to people without greenhouses showed similar number of species in comparison with those have incorporated this new technology, implying that the absence of an increase in agro-diversity (U: 73, $p > 0.05$, Fig. 3d). In addition, gardens are similar in terms of number of species between both groups (Mann–Whitney test, U: 68.5, $p > 0.05$, Fig. 3c). However, vegetable-gardens belonging to people without greenhouses showed higher richness than vegetable-gardens of those who have incorporated this new technology (Fig. 3a, Mann–Whitney test, U: 25, $p < 0.01$). This fact could suggest that the incorporation of this horticultural technology might have induced the change of cultivation site, adding new crops while abandoning others.

Moreover, people who incorporated greenhouses decreased the area of cultivation in vegetable-gardens, i.e. vegetable-gardens of 11.05 m^2 versus 24.40 m^2 for people with and without greenhouses respectively (Kruskal–Wallis test, X_1^2:16.12, $P < 0.01$).

This result suggests that greenhouses have become a significant option for Pilcaniyeu dwellers; while, in the past, crops were only found in homegardens. However, the incorporation of this new technology could be having an impact on their traditional way of practicing horticultural customs (Brodt, 1999, 2001; Godoy et al., 1998; Padoch et al., 1998; Sears et al., 2007).

3.10. Seeds

Forty-seven seed species (all from exotic origin except *Ribes magellanicum*) are gathered by the dwellers for the next cultivation period (Appendix 1). However, only 16.6% of total informants collect seeds from previous harvests or from other people in the community (endogenous sources); the rest of interviewees get them principally from exogenous sources (i.e. provided by extension agents of P.S.A, I.N.T.A., etc.). Particularly, only 10% of informants with greenhouses obtain seeds from previous harvests, whilst among locals without greenhouses, 30% collect seeds from previous harvests or exchange with relatives, friends and neighbors. This might be indicating that the practice of gathering their own seeds is decreasing, generating clear dependence on external

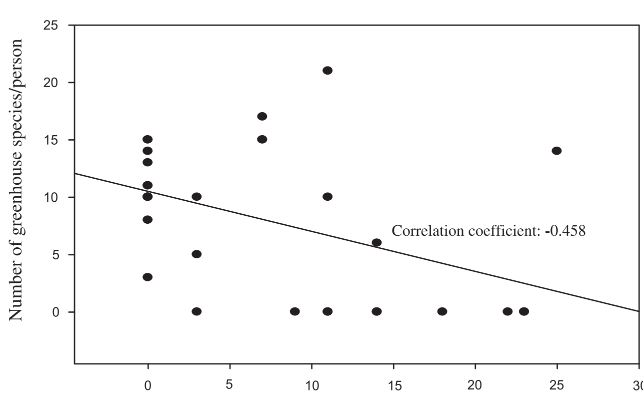

Fig. 1. Relationship between the number of species recorded in vegetable-gardens per person and number of species in greenhouses per person.

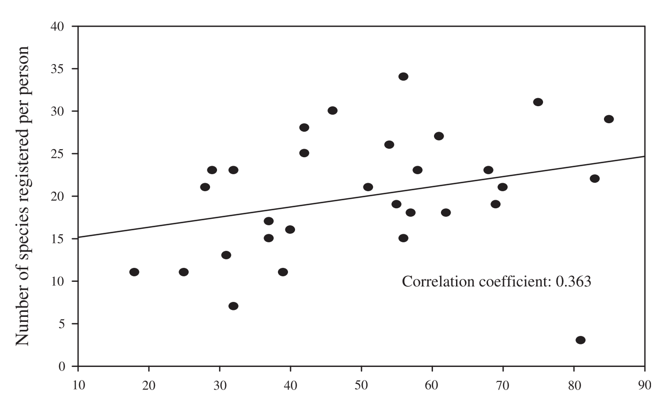

Fig. 2. Relationship between the total number of species recorded per person and their age.

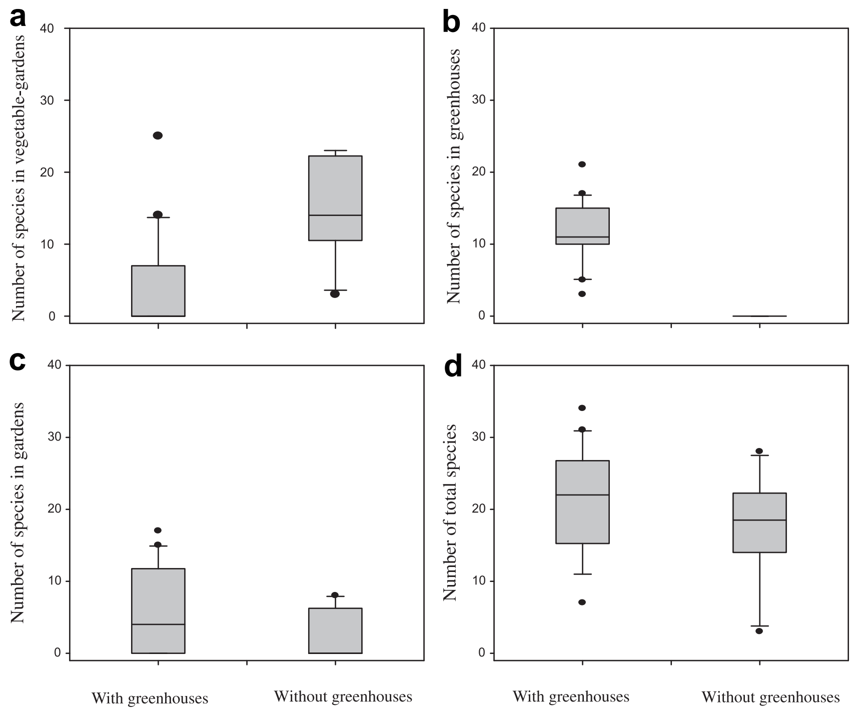

Fig. 3. Number of species in vegetable-gardens (a), greenhouses (b) and gardens (c), and total richness (d) according to the presence and absence of greenhouses.

institutions, impoverishing local genetic varieties and causing the loss of traditional skills. In participatory meetings with the community, we observed how older Pilcaniyeu dwellers had became aware of their dependence on seed provision from extension agents, as well as losing their custom of gathering seeds after ripening, as the elderly traditionally did. They seem to have become aware that losing access to seeds adapted to their environmental conditions, together with losing autonomy, i.e. access to their internal and external resources, impoverishes their cultural and biological diversity, and consequently the quality of their lives.

4. Conclusions

This study case shows how horticultural traditional knowledge is highly changing at present in rural communities from Patagonia. Several factors, such as the incorporation of exotic crops, new practices, knowledge and technology, introduced from external sources, have led to noticeable changes in local horticulturist practices. The spreading of exotic plants and animal species occurred during the colonization period, between 16th and 17th century; producing ecological alterations throughout the territories inhabitated by locals (Torrejón and Cisternas, 2002). The introduction of hoofed animals (e.g. cows, horses, sheeps and goats) produced significant impacts on soil and certain plant communities (Torrejón and Cisternas, 2002). Over all, the adaptation of land-use conditions introduced by Spanish conquerors led to environmental, social and cultural impacts carried up to the present.

The Patagonian region has suffered severe desertification processes due to the convergence of aridity plus intensive cattle grazing and difficult socio-economic conditions (Golluscio et al., 1998). This impact, still occuring nowadays, could be attenuated increasing cultivated areas that could help diminish dependence on cattle raising, and thus overgrazing. Community based management taking into account the development of horticulturism could reduce land degradation while strengthening sources of productive re-conversion. In this sense, income related to pastoral activities could be partially replaced by horticultural production.

Traditional knowledge is integrating with western practices. Locals have adopted new materials and new cultivation methods, such as the use of greenhouses, whilst still taking ancestral customs into account. Integrative processes between local and external sources of horticulture knowledge lead to a continuous process of on-farm experimentation and innovation (Sears et al., 2007).

Considering this integrative perspective, horticultural scenarios could be useful for conservation purposes. On one hand, horticulturism could be a sustainable activity for its potential contribution to diminish desertification. On the other hand, it could be beneficial for people to cultivate their own vegetables considering the natural food scarcity in arid zones, providing nutritional autonomy. Moreover, the traditional practice of gathering seeds after ripening, promotes biodiversity conservation of plants adapted to a hostile environments, while conserving regional germoplasm. In this sense, this integrative practice not only contributes to the production of food, but also to protect a sensitive and threatened environment (Vogl-Lukasser and Vogl, 2004), while improving the quality of life of people inhabiting harsh and arid lands.

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Appendix 1

Plant species registered in vegetable-gardens, gardens and greenhouses in the Pilcaniyeu community. BCRU: Voucher specimen, C.A. (Cultivated area), vg (vegetable-garden), g (garden), gh (green house) C.I (Consensus index). * = seeds gathered for the next cultivation period.

BCRU	*Plant species*/Local name	Plant family	Uses	Origin	C.A	C.I
E019	*Lactuca sativa* L./Lechuga*	Asteraceae	Edible	Exotic	vg, gh	93.33
E037	*Beta vulgaris* var. *cicla* L./Acelga*	Chenopodiaceae	Edible	Exotic	vg, gh	83.33
E067	*Origanum vulgare* L./Orégano*	Lamiaceae	Edible, medicinal	Exotic	vg, g, gh	66.67
E004	*Coriandrum sativum* L./Cilantro*	Apiaceae	Edible	Exotic	vg, gh	56.67
E113	*Ribes aureum* Pursh./Corinto*	Saxifragaceae	Edible, shade/living fences	Exotic	vg, g, gh	53.33
E119	*Lycopersicum esculentum* var. *esculentum* Mill./Tomate*	Solanaceae	Edible	Exotic	vg, gh	50.00
E077	*Allium cepa* L./Cebolla*	Liliaceae	Edible, medicinal	Exotic	vg, gh	46.67
E080	*Allium schoenoprasum* L./Chalota*	Liliaceae	Edible	Exotic	vg, gh	43.33
E031	*Brassica oleraceae* var. *capitata* L./Repollo*	Brassicaceae	Edible	Exotic	vg, gh	43.33
E012	*Artemisia absinthium* L./Ajenjo*	Asteraceae	Medicinal	Exotic	vg, g, gh	40.00
E008	*Daucus carota* var. *sativa* L./Zanahoria*	Apiaceae	Edible	Exotic	vg, gh	40.00
E101	*Fragaria vesca* L./Frutilla*	Rosaceae	Edible	Exotic	vg, g, gh	40.00
E013	*Calendula officinalis* L./Caléndula	Asteraceae	Ornamental	Exotic	vg, g, gh	36.67
E043	*Cucumis sativus* L./Pepino*	Cucurbitaceae	Edible	Exotic	gh	36.67
E006	*Petroselinum crispum* (Mill.) Nym./Perejil*	Apiaceae	Edible	Exotic	vg, gh	36.67
E103	*Malus domestica* Borkh/Manzano	Rosaceae	Edible	Exotic	vg, g, gh	33.33
E073	*Melisa officinalis* L./Toronjil	Lamiaceae	Medicinal	Exotic	vg, g, gh	33.33
E051	*Pisum sativum* L./Arveja*	Fabaceae	Edible	Exotic	vg	33.33
E114	*Ribes grossularia* L./Grosella	Saxifragaceae	Edible	Exotic	vg, g	33.33
E097	*Prunus domestica* L./Ciruelo	Rosaceae	Edible	Exotic	vg, g, gh	30.00
E118	*Solanum tuberosum* L./Papa*	Solanaceae	Edible, medicinal	Exotic	vg	30.00
E120	*Ulmus* sp./Olmo	Ulmaceae	Ornamental, shade/living fences	Exotic	vg, g	30.00
E040	*Beta vulgaris* var. *rapacea* L./Remolacha*	Chenopodiaceae	Edible	Exotic	vg, gh	26.67
E066	*Mentha spicata* L./Menta negra	Lamiaceae	Medicinal	Exotic	vg, g, gh	26.67
E102	*Prunus cerasus* L./Guindo	Rosaceae	Edible	Exotic	vg, g, gh	26.67
E106	*Rosa* sp./Rosa	Rosaceae	Medicinal, ornamental	Exotic	vg, g	26.67
E054	*Vicia faba* L./Haba*	Fabaceae	Edible	Exotic	vg, gh	26.67
E092	*Zea mays* L./Maíz*	Poaceae	Edible	Exotic	vg, gh	26.67
E003	*Apium graveolens* L./Apio*	Apiaceae	Edible	Exotic	vg, g, gh	23.33
E095	*Consolida ajacis (*L.) Schur/Espuela de caballero, pajarito*	Ranunculaceae	Ornamental	Exotic	vg	23.33
E091	*Plantago lanceolata* L./Llantén*	Plantaginaceae	Medicinal	Exotic	vg, g, gh	23.33
E086	*Syringa vulgaris* L./Lila	Oleaceae	Ornamental	Exotic	vg, g	23.33
E011	*Taraxacum officinale* Web./Achicoria*	Asteraceae	Edible	Exotic	vg, g, gh	23.33
E076	*Allium porrum* L./Ajo puerro*	Liliaceae	Edible	Exotic	vg, gh	16.67
E075	*Allium sativum* L./Ajo*	Liliaceae	Edible	Exotic	vg, gh	16.67
E052	*Lupinus arboreus* Sims./Chocho*	Fabaceae	Ornamental	Exotic	vg, g	16.67
E065	*Mentha rotundifolia* (L.) Huds./Menta blanca	Lamiaceae	Medicinal	Exotic	vg, g	16.67
E060	*Pelargonium* sp./Malvón	Geraniaceae	Ornamental	Exotic	vg, g, gh	16.67
E030	*Raphanus sativus* L./Rabanito*	Brassicaceae	Edible	Exotic	vg, gh	16.67
E100	*Rubus idaeus* L./Frambuesa	Rosaceae	Edible	Exotic	vg, g, gh	16.67
E070	*Salvia officinalis* L./Salvia	Lamiaceae	Edible, medicinal	Exotic	vg, g, gh	16.67
E034	*Sambucus nigra* L./Sauco	Caprifoliaceae	Edible, ornamental, medicinal	Exotic	vg, g	16.67
E017	*Artemisia abrotanum* L./Éter	Asteraceae	Medicinal	Exotic		13.33
E117	*Capsicum annuum* L./Morrón	Solanaceae	Edible	Exotic	gh	13.33
E039	*Chenopodium ambrosioides* L./Paico	Chenopodiaceae	Medicinal	Native	vg, g	13.33
E046	*Cucurbita pepo* L./Zapallo*	Cucurbitaceae	Edible	Exotic	vg, gh	13.33
E063	*Lavandula* sp./Lavanda	Lamiaceae	Ornamental, other uses	Exotic	vg, g	13.33
E110	*Populus alba* L./Álamo plateado*	Salicaceae	Ornamental, shade/living fences	Exotic	vg	13.33
E109	*Populus nigra* L./Álamo	Salicaceae	Ornamental, shade/living fences	Exotic	vg, g	13.33
E099	*Prunus persica* L. Batsch/Duraznero*	Rosaceae	Edible	Exotic	vg, g, gh	13.33
E038	*Spinacia oleracea* L./Espinaca*	Chenopodiaceae	Edible	Exotic	vg, gh	13.33
E027	*Coronopus didymus* (L.) Smith/Matuerzo*	Brassicaceae	Edible	Exotic	vg, gh	10.00
E058	*Cytisus scoparius* L. (Link.)/Retama	Fabaceae	Ornamental	Exotic	vg, g	10.00
E083	*Malva sylvestris* L./Malva*	Malvaceae	Medicinal	Exotic	g	10.00
E061	*Ocimum basilicum* L./Albahaca*	Lamiaceae	Edible	Exotic	gh	10.00
E087	*Papaver rhoeas* L./Amapola*	Papaveraceae	Ornamental	Exotic	vg, g, gh	10.00
E069	*Rosmarinus officinalis* L./Romero	Lamiaceae	Edible, medicinal	Exotic	g, gh	10.00
E108	*Ruta graveolens* L./Ruda	Rutaceae	Medicinal, spiritual protection	Exotic	g, gh	10.00
E111	*Salix* sp./Sauce	Salicaceae	Ornamental, shade/living fences	Exotic	vg, g	10.00
E124	*Vitis vinifera* L./Uva*	Vitaceae	Edible	Exotic	g, gh	10.00
E116	*Antirrhinum majus* L./Conejito	Scrophulariaceae	Ornamental	Exotic	g	6.67
E029	*Brassica rapa* L./Nabo	Brassicaceae	Edible	Exotic	vg, gh	6.67
E021	*Chrysanthemum* sp./Margarita	Asteraceae	Ornamental	Exotic	vg, g	6.67
E042	*Cucumis melo* L./Melón	Cucurbitaceae	Edible	Exotic	gh	6.67
E045	*Cucurbita pepo* convar. *giromontiina* Duch/Zapallito zuchini	Cucurbitaceae	Edible	Exotic	gh	6.67
E104	*Cydonia oblonga* Mill./Membrillo	Rosaceae	Edible	Exotic	gh	6.67
E050	*Medicago sativa* L./Alfalfa*	Fabaceae	Fodder	Exotic	vg	6.67
E062	*Origanum* sp.(?)/Chascudo	Lamiaceae	Edible	Exotic	gh	6.67
E057	*Phaseolus* sp./Poroto*	Fabaceae	Edible	Exotic	gh	6.67
E090	*Pinus* sp./Pino	Pinaceae	Ornamental, shade/living fences	Exotic	g	6.67

(*continued on next page*)

Appendix (*continued*)

BCRU	*Plant species*/Local name	Plant family	Uses	Origin	C.A	C.I
E096	*Prunus avium* L./Cerezo	Rosaceae	Edible	Exotic	g, gh	6.67
E115	*Ribes magellanicum* Poir./Zarzaparrilla*	Saxifragaceae	Edible, medicinal	Native	vg, g	6.67
E098	*Spiraea lanceolata* Poir./Corona de novia	Rosaceae	Ornamental	Exotic	g, gh	6.67
E025	*Tanacetum balsamita* L./Yerba de San Juan, menta extrajera o turca	Asteraceae	Medicinal	Exotic	gh	6.67
E072	*Thymus vulgaris* L./Tomillo	Lamiaceae	Ornamental, other uses	Exotic	vg, g	6.67
E059	*Vicia* sp./Vicia*	Fabaceae	Ornamental, other uses	Exotic	vg, g	6.67
E112	*Ribes* sp./Casis*	Saxifragaceae	Edible	Exotic	vg	3.33
E041	(?)/Rochela	Crassulaceae	Medicinal	Exotic	gh	3.33
E023	*Achillea millefolium* L./Milenrama	Asteraceae	Ornamental	Exotic	g	3.33
E056	*Adesmia boronioides* Hook.f./Paramela	Fabaceae	Medicinal	Native	g	3.33
E078	*Allium fistulosum* L./Cebolla de verdeo	Liliaceae	Edible	Exotic	vg	3.33
E079	*Allium* sp./Cebollita	Liliaceae	Edible	Exotic	vg	3.33
E084	*Althaea officinalis* L./Malvón*	Malvaceae	Ornamental	Exotic	vg, g, gh	3.33
E055	*Anarthrophyllum rigidum* (Gilies ex Hook. & Arn.) Hieron./Monte guanaco	Fabaceae	Ornamental	Native	vg	3.33
E010	*Araucaria araucana* (Mol.) K. Koch/Araucaria	Araucariaceae	Ornamental	Native	gh	3.33
E014	*Baccharis sagittalis* (Less.) DC./Carqueja	Asteraceae	Medicinal	Native	vg	3.33
E015	*Baccharis salicifolia* (Ruiz & Pav.) Pers./Chilca	Asteraceae	Ornamental	Native	vg	3.33
E016	*Bellis perennis* L./Coqueta	Asteraceae	Ornamental	Exotic	g	3.33
E028	*Brasicca napus* var. *arvensis* f. *annus* (Schubl. et Mart.) Thell/Nabiza*	Brassicaceae	Edible	Exotic	vg	3.33
E032	*Brassica oleraceae* L./Repollo corazón de buey	Brassicaceae	Edible	Exotic	gh	3.33
E033	*Buddleja araucana* Phil/Pañil	Buddlejaceae	Medicinal	Native	vg, g	3.33
E026	*Cheirantus cheiri* L./Alelí	Brassicaceae	Ornamental	Exotic	vg	3.33
E088	*Chelidonium majus* L./Celedonia	Papaveraceae	Ornamental	Exotic	gh	3.33
E020	*Chrysanthemum parthenium* (L). Bernhardi/Manzanilla*	Asteraceae	Ornamental	Exotic	vg, gh	3.33
E107	*Citrus cinensis* L./Naranjo	Rutaceae	Other uses	Exotic	gh	3.33
E048	*Clarkia elegans* Dougl./Clarquea	Enoteraceae	Ornamental	Exotic	g	3.33
E044	*Cucurbita maxima* var. *zapallito* (Carr.) Millán/Zapallito	Cucurbitaceae	Edible	Exotic	gh	3.33
E035	*Dianthus caryophyllus* L./Clavel	Caryophyllaceae	Ornamental	Exotic	g	3.33
E122	*Diostea juncea* (Gillies & Hook) Miers./Retamo	Verbenaceae	Ornamental	Native	vg	3.33
E047	*Elaeagnus angustifolia* L./Olivillo	Elaeagnaceae	Ornamental, shade/living fences	Exotic	g	3.33
E089	*Eschscholtzia californica* Cham./Copa de oro	Papaveraceae	Ornamental	Exotic	g	3.33
E085	*Eucalyptus* sp./Eucaliptus	Myrtaceae	Medicinal, shade/living fences	Exotic	g	3.33
E005	*Foeniculum vulgare* Mill./Hinojo	Apiaceae	Edible	Exotic	gh	3.33
E049	*Godetia* sp./Godesia	Enoteraceae	Ornamental	Exotic	g	3.33
E009	*Hedera helix* L./Hiedra	Araliaceae	Ornamental	Exotic	g	3.33
E018	*Helianthus tuberosus* L./Girasol enano*	Asteraceae	Ornamental	Exotic	vg, g	3.33
E053	*Lathyrus latifolius* L./Clarín	Fabaceae	Ornamental	Exotic	g	3.33
E074	*Laurus nobilis* L./Laurel	Lauraceae	Edible	Exotic	gh	3.33
E082	*Linum usitatissimum* L./Lino	Linaceae	Edible, medicinal	Exotic	gh	3.33
E064	*Marrubium vulgare* L./Malva rubia	Lamiaceae	Medicinal	Exotic	vg	3.33
E022	*Matricaria inodora* L./Margarita	Asteraceae	Ornamental	Exotic	vg, g	3.33
E036	*Maytenus boaria* Molina/Maitén	Celastraceae	Medicinal	Native	vg	3.33
E068	*Mentha pulegium* L./Poleo	Lamiaceae	Medicinal	Exotic	gh	3.33
E105	*Mespilus germanica* L./Níspero	Rosaceae	Edible	Exotic	gh	3.33
E001	*Narcissus* sp./Narcizo	Amaryllidaceae	Ornamental	Exotic	g	3.33
E071	*Nepeta musinii* Henk./Té del gato	Lamiaceae	Medicinal	Exotic	gh	3.33
E007	*Petroselinum crispum* var. *crispum* (Mill.) Airy-Shaw/Perejil crespo	Apiaceae	Edible	Exotic	gh	3.33
E093	*Poa* sp/Poa	Poaceae	Ornamental	?	vg	3.33
E094	*Rheum rhabarbarum* L./Ruibarbo	Polygonaceae	Edible, ornamental	Exotic	g	3.33
E002	*Schinus ódonellii* Barkley/Molle	Anacardiaceae	Ornamental, shade/living fences	Native	vg	3.33
E024	*Tanacetum vulgare* L./Palma	Asteraceae	Medicinal, ornamental	Exotic	g	3.33
E081	*Tulipa* sp./Tulipán*	Liliaceae	Ornamental	Exotic	g	3.33
E121	*Urtica dioica* L./Ortiga	Urticaceae	Medicinal, other uses	Exotic	vg, g	3.33
E123	*Viola tricolor* L./Pensamiento	Violaceae	Ornamental	Exotic	g	3.33

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