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Technical Article

Cut foliage: potentiality of native Argentine ferns as new ornamental crops

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Abstract

The cut foliage constitutes an important part of the floricultural production since it represents a fundamental element in flower arrangements, and ferns are the complementary elements most used by florists. In Argentina, there is native material that has not been yet domesticated and could have suitable characteristics for foliage use. The objective of the work was to determine the potential use of 15 native ferns as cut foliage through quality parameters and vase life, generating a scoring system that allows a classification list. Morphological descriptors such as petiole length, length and width of the blade, planes in which the fronds are arranged, brightness, consistency, abundance of spores and presence of pests were taken into account. Also, the production of fronds of six selected species with good scores was recorded. The results showed that it is feasible to consider the commercial production of *Pityrogramma calomelanos*, *Niphidium crassifolium*, *Campyloneurum nitidum*, *Blechnum austrobrasilianum* and *Pteris denticulata* by the quantity of fronds obtained and their quality, represented by their size. *Campyloneurum nitidum* excelled for its vase life of more than 26 days and frond production of 273.61 fronds m^{-2} at second year cultivation. *Pteris denticulata* produces 179.44 fronds m^{-2} but vase life was only 7 days.
Keywords: foliage, frond production, native ferns, new crops, vase life.

Resumo

As folhagens de corte constituem um segmento importante da floricultura, pois representam um elemento fundamental nos arranjos florais, sendo as samambaias os elementos complementares mais utilizados pelos floristas. Na Argentina, existe material nativo, ainda não domesticado, que poderia apresentar características adequadas para o uso como folhagem de corte. O objetivo do trabalho foi determinar o potencial de utilização de 15 samambaias nativas como folhagem de corte por meio de parâmetros de qualidade e vida de vaso, gerando um sistema de pontuação que permite uma lista de classificação. Foram considerados descritores morfológicos como comprimento do pecíolo, comprimento e largura da lâmina, planos de disposição das frondes, brilho, consistência, abundância de esporos e presença de pragas. Além disso, foi registrada a produção de frondes de seis espécies selecionadas com boas pontuações. Os resultados mostraram que é viável considerar a produção comercial de *Pityrogramma calomelanos*, *Niphidium crassifolium*, *Campyloneurum nitidum*, *Blechnum austrobrasilianum* e *Pteris denticulata* pela quantidade de folhas obtidas e sua qualidade, representada pelo tamanho. *Campyloneurum nitidum* se destacou por sua vida de vaso superior a 26 dias e pela produção de 273,61 folhas m^{-2} no segundo ano de cultivo. *Pteris denticulata* produziu 179,44 folhas m^{-2}, porém a sua vida de vaso foi de apenas 7 dias.
Palavras-chave: folhagens, produção de folhas, samambaias nativas, novas culturas, vida de vaso.

Introduction

The cut foliage constitutes an important part of the floricultural production since it represents a fundamental element in flower arrangements. Despite of this, very few species are available and in low quantities in the Argentinian flower market.

Within the cut foliages, ferns are the complementary elements most used by florists worldwide (Stamps, 2007). The most commercially important fern species and genera are: *Rumohra adiantiformis*, *Adiantum*, *Cyrtomium*, *Nephrolepis*, *Platycerium*, *Polystichum* and *Pteris*. Lesser important are *Davallia* and *Polypodium*. The most popular species globally is *R. adiantifolia*, because it has a vase life

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of 3 to 4 weeks (Benavente-Garcia et al., 1998). It is also the most commercialized fern in Argentina and is extracted from the wild.

The popularity of ferns for using as cut foliage is due to the availability, consumer acceptance, low cost, and longevity of fronds. The cut flower has been the protagonist within the arrangements, but its importance has been diminishing in favour of the accompanying elements (Gutiérrez et al., 2007). Even in floral design, arrangements also are made using foliage, without any type of flowers, a trend that favours the importance of foliage production. In addition, ferns can be grown as one of the horticultural crop of ornamental value on unutilized geographical regions to bring the unused soil under cultivation (Singh and Johari, 2018). Ferns also have been in use for food, as ornamental plants, valuable unexplored chemicals and for the phytoremediation of contaminated soils providing ecological services (Kumar and Fernandez, 2019; Anderson, 2021).

The Floriculture Institute has started a project for the domestication and use of native ferns for ornamental purposes in order to collaborate in the diversification of production and also, to reduce extractive use (Facciuto et al., 2014). This situation is aggravated when very little information is available about the sustainability of the extractive activities.

In Argentina, ferns comprise 28 families, 91 genera and 366 species distributed in four regions: the Yungas cloudforest, the Andean-Patagonian rainforest and the Pampas Hills (Ponce et al., 2002). This floristic richness creates an opportunity for diversification the production and to provide new textures and shapes for floral art.

There is no single methodology to determine the ornamental potential of a new species, but, before it is launched on the market, it is necessary to identify it taxonomically, to find out the propagation and cultivation methods and objectively determine its ornamental value. Stumpf et al. (2007) tested the ornamental potential of 11 species native to Rio Grande do Sul, Brazil, as a sum of scores given to ten traits chose by their importance for the floral art and for the market. Also, Beckmann-Cavalcante et al. (2017) evaluated ornamental potential of native species through a score system considering features of interest for floral art and consumer market. Sankar et al. (2019) evaluated 11 ferns native to India considering quantitative and qualitative characters to classify them and stablished their suitability for landscapes and commercial uses. Safeena et al. (2019) also in India, reflect the aptness of different cut foliages to function for various purposes in floristry through the evaluation of morphological characteristics and vase life of 18 species including ferns and *Asparagus* species.

In Argentina, there is native material that has not yet been domesticated and could have characteristics suitable for foliage use. Some basic parameters to optimize its production, harvest and handling are the propagation, its storage and postharvest life of the fronds (Stamps, 2007).

The objective of this work was to determine the potential use of native Argentine ferns as cut foliage through quality parameters and vase life. From these results, it is intended to value genetic resources to be considered as new crops for ornamental horticulture.

Materials and Methods

Fifteen species of ferns native to Argentina were studied. They were grown in a greenhouse with a minimum temperature control of 15 ºC in Floriculture Institute, INTA (Table 1). The plants used were propagated by spores. The evaluations were carried out when the plants reached their reproductive stage in 3 L containers, except for *Microgramma squamulosa* and *Blechnum lanceola*, which was grown in 400 cm^3 pots.

Table 1. Institute of Floriculture INTA (IF) codes, species, procedencies and growth habit of 15 ferns native to Argentina.

IF Codes	Species	Procedencies	Growth habits*
20100728D2	*Adianthopsis radiata* (L.) Fée	Dpto. Montecarlo, Misiones	T
20101126E1	*Anemia tomentosa* (Savigny) Sw.	Dpto. Monteros, Tucumán	T
20100801E1	*Asplenium auritum* Sw.	Dpto. Oberá, Misiones	E R
20101126A2	*Blechnum austrobrasilianum* de la Sota	Dpto. Monteros, Tucumán	T
20090611C1	*Blechnum brasiliense* Desv. var. *brasiliense*	Dpto. Concordia, Entre Ríos	T
20100729B5	*Blechnum lanceola* Sw.	Dpto. Iguazú, Misiones	T R
20090611C2	*Campyloneurum nitidum* (Kaulf.) C.	Dpto. Concordia, Entre Ríos	E
20100728D11	*Doryopteris nobilis* (T. Moore) C. Chr.	Dpto. Montecarlo, Misiones	T
20100801G1	*Lomariocycas schomburgkii* (Klotzsch) Gasper & A.R. Sm.	Dpto. Oberá, Misiones	T
20101126B5	*Microgramma squamulosa* (Kaulf.) de la Sota	Dpto. Monteros, Tucumán	E
20100728D18	*Niphidium crassifolium* (L.) Lellinger	Dpto. Montecarlo, Misiones	E
20100225A3	*Phlebodium areolatum* (Humb. & Bonpl. ex Willd.) J. Sm.	Dpto. Río Seco, Tucumán	E
20170915x1	*Pityrogramma calomelanos* (L.) Link	Dpto. Oberá, Misiones	T
20100225A2	*Pteris deflexa* Link	Dpto. Río Seco, Tucumán	T
20100729B4	*Pteris denticulata* Sw.	Dpto. Iguazú, Misiones	E

*According to Arana et al. (2016), T: terrestrial, E: epiphytic, R: rupicolous

Ornamental Potentiality

The quality parameters were evaluated considering the leather fern (*R. adiantiformis*) as a reference (Verdugo et al., 2006) and other characteristics of the cut foliage. The length of the frond petiole and length and width of the frond blade were measured. Brightness and consistency of the fronds, abundance of spores, presence of pests and diseases were analysed visually. Also, frond development in one or more than one plane was record. Thirty fronds were used for the morphological characterization. These values were transferred to categories as presented in Table 2. The sum of the scores reached a maximum value of 21 for the best condition. For the vase life another 20 points were considered, since it is an essential characteristic for cutting foliage aptitude.

Table 2. Attributes of frond quality of ferns native to Argentina.

Descriptors	Scores			
	1	**2**	**3**	4
A. Frond petiole length (cm)	≤ 5	5-15	> 15	
B. Frond blade lenght (cm)	short (≤ 40)	medium (40-55)	long (> 55)	
C. Frond blade width (cm)	≤ 15	15-255	> 25	
D. Planes	more than 1	1		
E. Brightness	No	Yes		
F. Consistency	no coriaceous	semi coriaceous	coriaceous	
G. Spores abundance	dirty the frond	moderately dirty	no dirty	
H. Presence of pests and diseases	yes	no		
I. Vase longevity (days)	short (≤5) score: 0	medium (6~10) score:10	large (11~20) score:15	very large (> 20) score: 20

For the determination of the vase life, homogeneous fronds were selected; the basal 2 cm were cut and placed in 250, 500 and 100 mL containers depending on the size of the plant materials to be evaluated, with distilled water immediately after being harvested. The upper part of the containers was covered with film to avoid the loss of water by evaporation. The film was perforated to place the fronds. Three vases were used per species with three fronds each, and the test was carried out in triplicate, in a postharvest room (18 ºC, 64% RH, 700 lux).

The variation in the external appearance of the fronds was recorded daily, in order to determine the end of the vase life. It was determined by the occurrence of some symptom that indicated a loss of quality and that made it impossible to fulfil its ornamental function, such as wilting and / or yellowing and / or curving of the fronds.

The ornamental potential was defined by the sum of the scores.

Productivity of selected species

The production of fronds of six selected species with good scores was recorded. Despite *M. squamulosa* and *A. auritum* showed very good vase life, they were discarded in this experiment due to the small sizes of the fronds. The arborescent habit of *L. schomburgkii* was considered not suitable for cut foliage production and it was also discarded.

Once the plants had a size according to a 3 L pot, 12 plants per species were planted in 2 batches of 6 plants, in 90 cm wide ridges and staggered at a distance of 45 cm, in a greenhouse with 10 °C minimum temperature control (Figure 1A). A 50% shading mesh was placed that covered the roof and the sides of the trial. The substrate was a recycled with the addition of 40% bark to generate aeration. Irrigation was manual and biweekly fertilizations were carried out with a 15:15:15 NPK fertilizer.

Mature fronds were collected, the number of fronds per plant was counted in the second year of cultivation and the fronds production per square meter was calculated. Petiole length and blade length and width of 30 fronds were measured. The data were statistically analysed with an analysis of variance and Fisher's test with the statistical program Infostat 2009 (Di Rienzo et al., 2011).

Results and Discussion

Ornamental Potentiality

The evaluation of ornamental potentiality through morphological descriptors and vase life is presented in ascending order in Table 3. *Phlebodium areolatum*, *N. crassifolium* and *C. nitidum* stood out with values of 37, 36 and 35, respectively. *Phlebodium areolatum* retained its appearance in vase for 26 days (Figure 2), and its large fronds with a developed petiole gave it interesting properties. The petiole is curved, so it is suggested for pendulous arrangements.

Figure 1. Production of native ferns: a: general view of beds; b. *Campyloneurum nitidum*; c. *Pteris denticulata*.

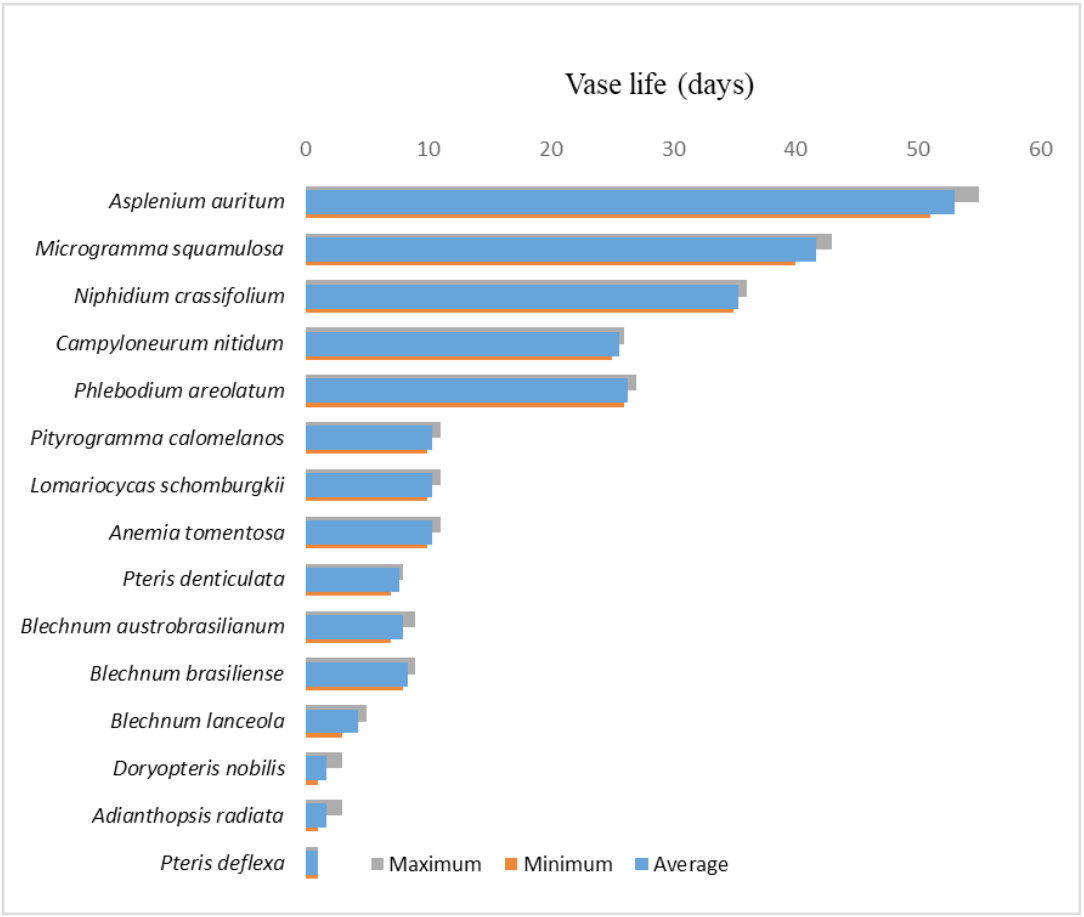

Figure 2. Vase life (days) of 15 ferns native to Argentina values of three experiments.

Campyloneurum nitidum presented a very high vase longevity, more than 30 days (Figure 2), and also presented high values in other important characteristics such as frond length, leathery consistency, absence of pests and diseases and spores that do not make dirty the fronds. The morphology of the frond in one plane is interesting because it is suitable for the transport in boxes (Figure1B). Preparation of cut flowers and foliages is a tedious job and require specific packaging for each species (Ahmad et al., 2021).

Niphidium crassifolium excelled for its vase life of 36 days long fronds and, as *C. nitidum*, in one plane.

Microgramma squamulosa reached a score of 35 value that positions it, together with the previous species, as a potential new crop as cut foliage, although the size of its fronds is small depending on the quality standards of ferns. Despite of this, it could be used for small bouquets or other non-traditional arrangements.

These four species are epiphytes, so they could have low nutritional and water requirements. Epiphytic ferns grow naturally in soilless condition, without using the typical water and nutrient storage of soil and typically have adaptations to endure periods of desiccation (Anderson, 2021) *Microgramma* has stout suberified stems storing water and amylaceus reserves (Dubuisson et al., 2009). It is interesting to mention here that in phylogenetic studies, Labiak and Moran (2018) confirm that *Campyloneurum* forms a clade with *Microgramma* and *Niphidium*.

The species that presented a short vase life, *P. deflexa, A. radiata*, *D. nobilis* and *B. lanceola,* were discarded as possible candidates for cut foliage crops. A long vase life is the main attribute that a species must have to be used as cut foliage, and like cut flowers, it should remain vigorous and attractive for at least 10 days (Weiss, 2002). In these cases, fronds longevity was less than 5 days (Figure 2).

Blechnum brasiliense, B. austrobrasilianum, P. denticulata, A. tomentosa, L. schomburgkii and *P. calomelanos* presented medium vase life that was later reflected in intermediate scores. These ferns can be subjected to trials to improve longevity using different vase solutions, in order to maximize the quality and facilitate commercialization. The use of floral preservatives has been found to influence to a great extent, it can offer at least double longevity of cut flowers and foliages duo (Malakar et al., 2017). Furthermore, dehydration methods, like glycerinization, were developed for cut foliage (Jhanji et al., 2018).

The indicators of end of vase life differed among species (Table 3). Wilting, curving, yellowing and/or loss of brightness of fronds were the symptoms of senescence observed. In some species used as cut foliage, the rate of water absorption is less than the rate of transpiration; this leads to leaf wilting, destroys or disrupts its physical structures, and causes activity imbalances in macromolecules and organelles (Teerarak and Laosinwattana, 2019).

Table 3. Scores of ornamental attributes of 15 ferns native to Argentina, sum of scores and indicators of end of vase life.

Species	Scores									SUM of scores	Indicators of end of vase life
	A	B	C	D	E	F	G	H	I		
Blechnum lanceola	1	1	1	2	2	3	3	2	0	15	wilting, curving
Adianthopsis radiata	3	2	3	1	1	2	3	2	0	17	wilting, curving
Doryopteris nobilis	3	2	2	2	2	3	3	1	0	18	yellowing, curving
Blechnum brasiliense	1	3	2	2	2	3	3	2	0	18	wilting, curving
Pteris deflexa	3	3	3	1	2	1	3	2	0	18	wilting, curving
Anemia tomentosa	3	1	1	2	1	1	3	1	10	23	wilting, curving
Blechnum austrobrasilianum	2	1	1	2	1	2	3	2	10	24	wilting
Pteris denticulata	3	2	2	1	2	2	3	2	10	27	wilting, curving, loss of brightness
Lomariocycas schomburgkii	1	3	2	2	1	3	3	2	10	27	wilting, curving
Pityrogramma calomelanos	3	2	2	2	2	2	3	2	10	28	wilting, curving
Asplenium auritum	2	1	1	2	1	2	3	2	10	34	wilting, curving
Microgramma squamulosa	1	1	1	2	2	3	3	2	20	35	wilting, loss of brightness
Campyloneurum nitidum	1	3	1	2	2	3	1	2	20	35	wilting, loss of brightness
Niphidium crassifolium	1	3	1	2	2	2	3	2	20	36	wilting, loss of brightness
Phlebodium areolatum	3	3	3	2	1	1	2	2	20	37	yellowing,curving

A. Petiole length, B. Blade length, C. Blade width, D. Plane, E. Brightness, F. Consistency, G. Spores abundance, H. presence of pest and diseases, I. Vase longevity

It is interesting to consider the frond form variability obtained for flower arrangement according to Stamps classification of greens (1987) as linear like in *Aspidistra*, mass material in *Pittosporum*, filler in *Asparagus*, and distintictive like in palms. Here, it is represented as linear in *B. lanceola*, *A. radiata*, *D. nobilis*, *B. brasiliense* and *T. deflexa*; mass material in *A. tomentosa*, *B. austrobrasilianum*, *N. crassifolium*, *A. auritum*, *P. denticulata*, *L. schomburgkii* and *P. calomelanos*; filler material in *M. squamulosa* and *P. areolatum;* and a distintictive shape in *C. nitidum*.

Productivity of selected species

The production of fronds per plant of the species selected by the highest scores is presented in Table 4. It is important to mention that the ferns that are grown for cut foliage begin to be productive in the second year after implantation, approximately.

The production of *C. nitidum* stood out, producing 82.08 fronds per plant, which translates into 273.61 fronds m^{-2}, *P. denticulata* produced 179.44 fronds m^{-2} (Figure 1C) and *N. crassifolium* 136.66 fronds m^{-2} (Table 4).

Table 4. Production of selected fern fronds after 24 months of cultivation in beds.

Species	Fronds/plant N°	Total N°	Fronds N°/m²	Peliote length (cm)	Blade lengh (cm)	Blade width (cm)
Pityrogramma calomelanos	29.75 ±23.12 a	357	99.16	17.69 ± 2,65	49.59 ±4.46	24 ±2.24
Niphidium crassifolium	41.00 ±8.33 ab	492	136.66	0	51.71 ±9,29	8.62 ±1.10
Campyloneurum nitidum	82.08 ±26.09 c	985	273.61	0	52,19 ±7.80	4.10 ±0.55
Blechnum austrobrasilianum	29.83 ±11.53 a	358	99.44	12.40 ±3.39	35.09 ±5.26	6.71 ±1,44
Pteris denticulata	53.83 ±13.36 b	646	179.44	34.78±10.30	61.66±14.86	24.57 ±4.96
Phlebodium areolatum	15.5 ±5.5 d	186	51.60	43.47±5.54	90.32±12.57	32.45±5.48

Considering that the leather fern (*R. adiantiformis*) produces 114 fronds per square meter in the second year in cultivation (Chahin and Azocar, 2012), the mentioned species exceeded this value, so they could potentially be competitive crops. *Pityrogramma calomelanos* and *B. austrobrasilianum* produced 99.66 and 99.44 fronds m^{-2} respectively, values also near those mentioned for *R. adiantiformis*.

Phlebodium areolatum produced only 51.6 fronds m^{-2}, this low productivity, as well as the difficulty of its cultivation due to the little rigid petioles, do not make it suitable for bed production as cut foliage, despite the long postharvest life. Nevertheless, some methods for conducting the production could be analysed.

It is also important to mention that the reference value comes from outdoor crops with shading mesh, and in this case the experiment was carried out in a greenhouse, a probable reason for the higher productivity found. Besides, in this study the cultivation was initiated with already developed plants, in commercial crops many times it begins with pieces of rhizomes.

According to Strandberg (2003), frond production and development rates of *R. adiantiformis* varied greatly with the seasons and were strongly associated with weather variables, but significant rate fluctuation unrelated to weather were also detected. Therefore, it is probably that the production of the studied ferns could be considered for other production sites.

Compared with the values of the quality standards for internal use and export of fronds of *R. adiantiformis* according to Verdugo et al. (2006), being the minimum length 40 cm and the optimum 55 cm, the selected ferns presented values within or exceeding that range (Table 4). *Phlebodium areolatum* and *P. denticulata* had the longest fronds with petioles of 34.78 cm and 43.47 cm and blade length of 61.66 cm and 90.32 cm, respectively.

Despite *N. crassifolium* and *C. nitidum* do not have a developed petiole, they reached the reference value and provide a different morphology from that available in the markets. *Blechnum austrobrasilianum* had the shortest fronds but also within the accepted range in markets.

The present work showed that it is feasible to consider the commercial production of *P. calomelanos*, *N. crassifolium*, *C. nitidum*, *B. austrobrasilianum* and *P. denticulata* by the quantity of fronds obtained and their quality represented by their size. It would be important to continue the studies to determine the maximum production period. *Campyloneurum nitidum* and *P. denticulata* stood out as the most productive species in the period tested. Inclusion of new species in cultivation also promote *ex situ* conservation of biodiversity and sustainable use, preventing extractive practices. Many other ferns of Argentine are still to be prospected and the protocol proposed can be an alternative to evaluate them.

Conclusions

Ferns species were selected objectively for their aptitude to be used as cut foliage through morphological attributes, vase life and fronds production. *Campyloneurum nitidum* and *P. denticulata* stood out for their frond production.

Author Contribution

GF: Conceived and designed the analysis, collection in the wild, collected data and wrote the paper. **MJP:** cultivate ferns and collected data of production of fronds. **AP:** collected vase life experiment data. **MS:** collection in the wild, taxonomic identification of ferns.

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