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REVIEW

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Has grey literature a value in conservation? The Case of *Queñoa Polylepis* spp. in Northwestern Argentina

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ABSTRACT

The *Polylepis* genus faces significant conservation challenges, with all species experiencing declining population trends. Northwest Argentina, home to five species, represents a hotspot, yet this region has received less research attention in the country. This review assesses the role of grey literature in *Polylepis* conservation, supplemented by fieldwork. Our findings reveal that most data focus on *Polylepis tomentella*, with less entries on *P. australis, P. tarapacana*, and especially *P. hieronymi*, and *P. crista-galli*. More than half of the information rated as useful for conservation purposes was provided by grey literature (51.8%). Locally informed population trends for *P. australis* offer valuable insights, though broader conclusions are still required. The available information was essential in identifying knowledge gaps and threats. This work underscores the need for field experiments to validate prevailing assumptions about the genus. The information presented here provides a solid foundation for future conservation strategies and we recommend including grey literature in reviews on little-known species or underrepresented regions.

KEYWORDS

Ecological data gaps; Literature review; Mountain ecosystems; Population dynamics

ARTICLE HISTORY

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Introduction

Grey literature consists of materials and research produced by organizations outside the traditional commercial or academic publication and distribution channels [1]. In conservation biology and management, the review method has gained popularity based on the premise that more information leads to better decision-making and improved management practices [2].

In this context, grey literature is particularly valuable for understanding species and ecosystems that are not well-documented in peer-reviewed journals. Although the use of grey literature can be risky due to potential gaps in scientific rigor and representation of data or analysis, it also broadens the scope of relevant studies, offering a more comprehensive view of the available evidence [3]. This breadth of information is crucial for ecosystems like those dominated by the genus *Polylepis*, which represent the highest-altitude forest formations in the Andes and sub-Andean valleys. These forests extend latitudinally from Venezuela to northern Chile and central Argentina [4]. *Polylepis* forests provide numerous ecosystem services, including erosion prevention, regulation of the water cycle, and resources for local populations such as posts, utensils, firewood, and grazing [5]. Serving as "biodiversity islands" in a matrix of lower diversity, particularly in arid and semi-arid regions, these unique ecosystems play a vital role in maintaining ecological balance [6-8]. However, they face various degrees of threat and require targeted conservation actions. To manage *Polylepis* forests effectively and restore balanced, functional ecosystems, clearly defined restoration goals are essential [9]. Unfortunately, there is currently a lack of baseline knowledge regarding *Polylepis* species in northwest Argentina.

There are 45 recognized species of *Polylepis*, of which 11.1% (5 species) are found in northwest Argentina, making it a hotspot for the genus. However, this region has seen fewer investigations compared to the rest of the country, despite Argentina having the highest number of publications on *Polylepis*. Notably, *P. hieronymi* is among the species with the fewest publications in this area [10]. Unknown aspects on the genus in the NOA persist, on population dynamics, habitat specificity; although general distribution maps exist, finer-scale information on the specific ecological preferences and microhabitats is incomplete, genetic diversity, regeneration mechanisms, and interactions with other species.

Given these gaps in knowledge, this review examines both grey and formal scientific literature on the genus *Polylepis* in northwest Argentina. The main objective is to integrate and assess the utility of grey literature alongside scientific research for advancing conservation strategies for *Polylepis* species. The specific objectives are as follows: (1) to assess and synthesize existing knowledge from both scientific works and grey literature, (2) to evaluate the relevance and implications of grey literature in conservation efforts, and (3) to validate the practical application of insights gleaned from grey literature. We posit that *Polylepis* species in northwest Argentina are underrepresented in mainstream literature and that grey literature may provide critical insights to inform and enhance conservation strategies.

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Methodology

Study area

Northwest Argentina includes the provinces of Jujuy, Salta, Tucumán, and Catamarca (Figure 1).

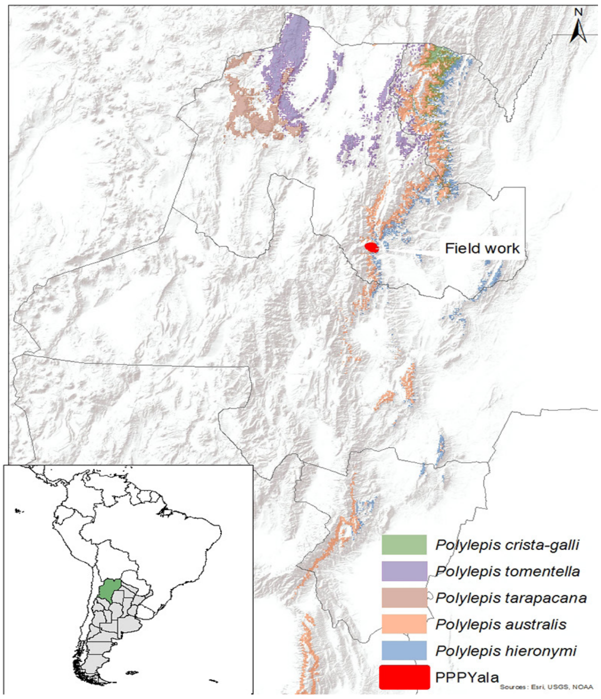

Figure 1. The four Argentinean provinces considered in this work (Jujuy, Salta, Tucumán, and Catamarca), and the field work site (PPPY) *Polylepis* spp. distribution (based on Renison et al., 2013), inside: the location of the NOA, Argentina in South America.

Species studied

The genus *Polylepis* is a member of the Rosacea family. It is characterized by the curved branches and the multiple rhytidome layers. In general, it grows higher than the timberline (in grasslands). In the NOA five species are present (Figures 1,2 and 3). In the humid forests that grow on the sub-Andean hills we find *Polylepis australis*, *Polylepis crista-galli* and *Polylepis hieronymi*. These can be differentiated based on leaflets and distribution. In the High Andes, we find *Polylepis tarapacana* (Figure 3) which, in general has a bushy growth, in the Puna region we find *Polylepis tomentella*.

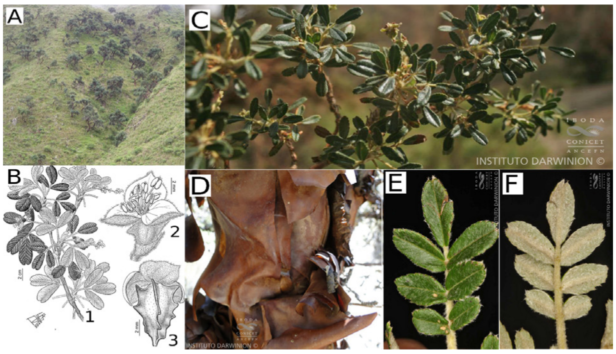

Figure 2. *Polylepis* species present in northwest Argentina A. *P. crista-galli* forest, B. drawings of details of *P. crista-galli*, B1-Branch, B2-Flower, B3-Cupela, C. *P. tomentella* branch, D. bark of *P. australis*, E. leaf of *P. hieronymi* E. adaxial side, F. abaxial side. Source: Argentina Flora. https://buscador.floraargentina.edu.ar/species/byscientificname

Figure 3. *Polylepis tarapacana* present in the Jujuy province.

Our methodology comprised two main approaches

Bibliographic review

The Agricultural Ecology Department at the National University of Jujuy pioneered research on *Polylepis* in northwest Argentina. First, we conducted a systematic search of the department's library and field notes for materials related to *Polylepis*. Second, we performed an online search using Google Scholar with the search terms "*Polylepis*" + "northwest Argentina" and "Queñoa" + "northwest Argentina".

Following these initial searches, we examined the bibliographies of the obtained studies, a technique known as the "paper trail," which allows researchers to identify additional relevant studies that may not appear in traditional search results [2]. We included all the information on *Polylepis* located in the NOA. Our inclusion criteria encompassed abstracts from scientific events, theses, drafts of scientific articles, research project reports, unpublished data sheets, guides, and artworks. We systematically reviewed and summarized the most pertinent information for conservation purposes, which we have listed (Supplementary Material 1).

Information was collected and carefully read between March 2021 and June 2024. We systematically categorized the data, extracting the following information: species studied (*P. australis*, *P. crista-galli*, *P. hieronymi*, *P. tarapacana*, and *P. tomentella*), year of publication, principal study area, and subject matter. Subjects included: Mention (where the species is only noted, e.g., in study area descriptions), Taxonomy, Species Description (e.g., guidebooks), Biogeography/Distribution, Physiology/Ecology, Conservation, Dendrochronology, Archaeology, Ethnobiology, Genetics, Associated Groups (e.g., birds, fungi), and Outreach (where information is reproduced). We classified the information into "grey literature" and "scientific peer-reviewed work," noting whether each publication was accessible online.

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Each item was rated for its conservation input based on the experience of the authors, as follows: 0 we rated information with no use for conservation when it was only description of the species or the information was already mentioned in previous works, we rated information with 0.5 when it has information that has potential use in conservation, but was not scientifically based, and we rated the item with 1 when it has information deemed useful for conservation purposes. There were no differences in judgement between authors. We evaluated both grey and scientific literature and analyzed the contributions from each type based on the sum of the three rating categories. For each item, we extracted and highlighted key conclusions and critical insights.

Fieldwork

Fieldwork was done in the Provincial Park "Potrero de Yala" (PPPY hereafter wards). The PPPY is in the northern sector of the Southern Andean Yungas Australes (24° 05′ 29.16″ S, 65° 30′ 15.36" W, 2619 m) (Figure 1) and extends altitudinally between 1600 and 5000 m, with a surface of 4300 ha.

The Southern Andean Yungas ecoregion or Tucuman-Bolivian rainforest develops between 400 m and 2300 m asl, from Bolivia (Tarija) to the Argentinean province Catamarca. The climate of the Southern Andean Yungas is temperate and humid with mainly summer rains (80%) and frosts during the winter [11].

To test the practical application of grey literature, we selected one report that we had the opportunity to reassess [12]. This is a park ranger's report detailing the presence of *P. australis* within the PPPY by mapping the area and counting individuals. To verify the accuracy and relevance of the information, we revisited the site to check whether the population remained consistent with the original report. We used the map provided in the report and visited the park twice.

Results

In total, we obtained 157 entries that mentioned 215 times one species of the genus. Two abstracts, which were previous oral presentations of this work, were excluded [13]. One entry uses the common name "Queñoa" and "Queuñoal", but refers to another species *Cochlospermun zahlbruckneri* and was excluded from the analysis (n=156). The majority (59.6%) belonged to grey literature [14]. The most studied species was *P. tomentella* (Figure 4). The information spanned 113 years (1911–2024).

The number of publications fluctuated over time. After the first publication in 1911, there was a 40-year gap until the second publication in 1951. Over the years, there has been a general, albeit inconsistent, increase in studies on *Polylepis*, with a peak of 12 publications in a single year in 2016 (Figure 5). Research efforts are predominantly concentrated in Jujuy, with limited studies in Salta (documenting only three species) and less data from Tucumán. The most studied topic was Physiology/Ecology (24%), followed by entries that only mentioned the species (22%) (Figure 6). 33.3% of the entries were not available online. The total conservation input score for the 157 entries amounted to 106, with 51 points (48.1%) derived from scientific articles and 55 points (51.8%) from grey literature.

Mention: None of the articles that only mention the species

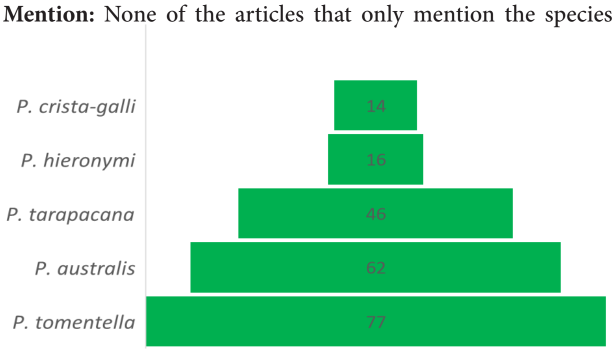

Figure 4. Total number of publications per *Polylepis* species obtained in a review on the genus in northwest Argentina (n=215).

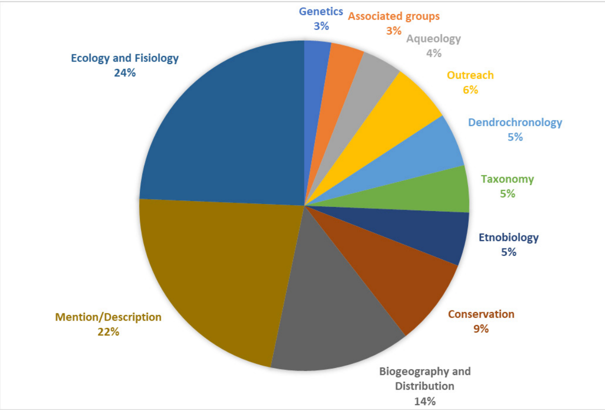

Figure 5. Total number of *Polylepis* publications over time (1911 – 2024), years without publications are eliminated.

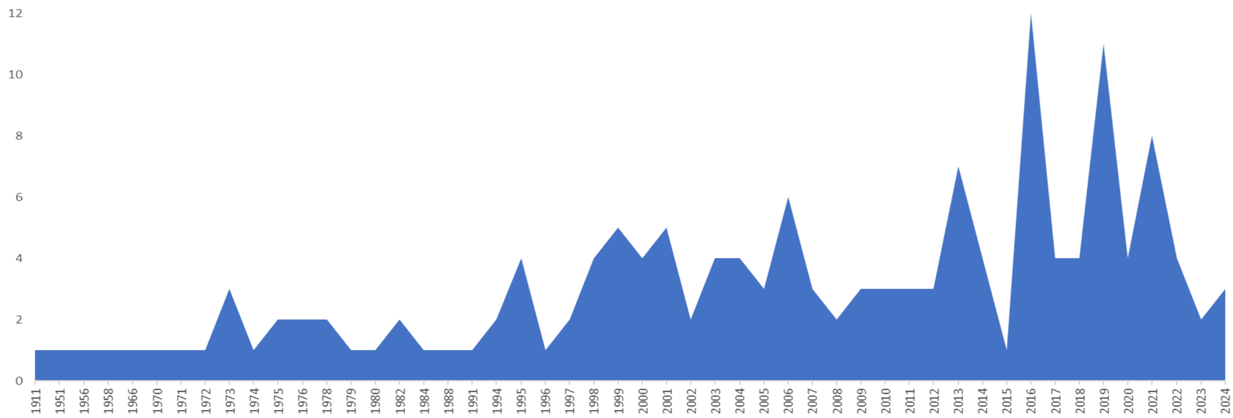

Figure 6. Pie chart indicating the topics of the 143 entries resulting from a review on *Polylepis* spp. in northwest Argentina.

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were useful for conservation purposes and therefore they were not analyzed further. We also discovered a poem on *Polylepis*, but it was unfortunately misidentified as *P. racemosa* [15]. Also, Wikipedia spells incorrectly two species (*P. cristagalli* and *P. hyeronymi*) [16].

Taxonomy: The genus shares a common origin with *Acaena* and occupies a primitive phylogenetic position based on specific wood characteristics observed in *P. tomentella* [17,18]. Leaf morphology has been used in taxonomy, alongside differences in seed weight, seedling height, and leaf length to distinguish among the species in NOA [19,20].

Species description: Several examples of misnaming exist [21-23]. Early publications indicate that the fruit of the species is achene, while other authors refer to it as a cupela [17,24,25]. Also, some outreach work made mistakes by naming the inflorescences spigots, and leaves with serrated edge for *P. tarapacana* [22].

Biogeography/Distribution: The first article we located indicates *P. hieronymi*, *P. australis*, and *P. tomentella* present in the northwest of Argentina [17]. Later *P. australis* and *P. hieronymi* were noted in Catamarca [26,27]. *P. australis* is distributed across the provinces of Jujuy, Salta, Tucumán, Catamarca, Córdoba, and San Luis [28]. Segovia carefully mapped the distribution of *P. tomentella*, however, this report included areas within the distribution range of *P. tarapacana*. *P. tomentella* in Jujuy covers 832.71 ha [29,30]. The genus has also been mapped at a regional level [31], but this map is no longer available online.

P. tomentella is found in an elevational belt between 3700 and 4700 meters and adopts a shrubby form above 4200 m asl. Legname notes the presence of *P. tomentella* above 3000 m asl. for *P. australis* in Tucumán [32]. Krussmann mentions an elevational gradient between 2000 and 3500 m asl [27]. Other studies indicate it can be found between 1680 and 2800 m asl in Tucumán or between 1200 and 3500 m asl [33,34]. *P. hieronymi*, *P. australis*, and *P. crista-galli* are found at 2500 meters in the Yungas, while *P. tomentella* ranges between 3800 and 4200 meters. *P. tarapacana* occurs at elevations from 4400 to 4900 meters [19]. The elevational gradient for *P. crista-galli* was recorded between 2400 and 2700 m asl [35]. *P. tarapacana* is found at elevations between 4000 and 4750 meters above sea level, while *P. tomentella* starts from 3000 meters [26].

Physiology/Ecology: *P. tomentella* prefers narrow ravines and rocky slopes [36]. Bonaventura et al. describe moderate rocky slopes with a northeast or east orientation (warm slopes) as suitable habitat for *P. tomentella* while Ruthsatz and Movia mention north and east slopes [37,38]. In 1972 *P. australis* was described as a "shrub" (4 stems, 10 cm DBH, 2.6 m height and 3 m wide), based on a single individual present in the Botanic Garden of Copenhagen [27]. Frangi emphasizes the root system of *P. australis* in the Puna ecoregion; however, this should likely pertain to *P. tomentella* [23]. Additionally, Ruthsatz and Movia mention an extensive root system both horizontally and vertically for *P. tomentella* [38]. When examined at sea level, the foliar anatomy of *P. tomentella* changes, whereas *P. australis* does not [33]. Differences in seed weight, seedling height, and leaf length also play a crucial role in understanding their ecological adaptations [20]. Segovia reported an average height of 3.1 m and 25.6% cover for *P. tomentella* [29]. Based on a thesis, we calculated forest structure data for *P. tomentella*, finding 0.33±0.21 seedlings per square meter and 362.5 adult individuals per hectare [39].

A provincial report suggests that UV rays inhibit growth due to hormonal effects without citing a source for this information; however, it was noted that leaf wax may protect against ultraviolet radiation [40]. Rock outcrops and edges are highlighted as important for the regeneration of *P. tarapacana* forests [41,42]. The germination rate of *P. tomentella* is 3.1%, 3% or 3.8 ± 3.1, compared to 4.3 ± 4.4 for *P. tarapacana*, which is markedly different from the rates for *P. australis* and *P. hieronymi* (14.9 ± 16.6 and 14.7± 9.0, respectively) and 9.8% for *P. crista-galli* [35,40,43,44]. In *P. australis* forests, the individual density is 60 individuals per hectare, while *P. tomentella* forests host 325 individuals per hectare, with coverages of 9% and 13%, respectively [45]. For *P. crista-galli*, the density is 0.81 seedlings/m² and 386 individuals/ha, with a mean diameter at the base of 16.9 cm [35].

Conservation: As early as 1984, *P. tomentella* was classified as endangered due to the effects of intensive firewood collection in Jujuy, a concern that was subsequently echoed by Braun Wilke [46,47]. While *P. tomentella* is occasionally regarded as a plant of interest for livestock, it has a low to moderate forage value [46]. Livestock grazing significantly hinders regeneration in *P. tomentella* [43]. This was also quantified in one site for *P. australis*, with cattle negatively affecting the herbaceous stratum [48-50]. Furthermore, northern populations of *P. australis* tend to be less well-conserved than their southern counterparts [4].

Important management data indicate that only *P. tomentella* faces serious threats, primarily from military and educational institutions rather than residents. A partially cut tree requires 20 years to recover, and trees up to 60 cm in diameter provide excellent firewood quality. The bark layer is crucial for germination [51]. This information is based on interviews, without citation of scientific sources. The current distribution of *Polylepis* species has been significantly affected by climate change, further fragmenting their already patchy distribution [52,53]. Human influence over the past 11,000 years has also played a role, with *P. tarapacana* and *P. tomentella* historically exhibiting limited distribution during the Holocene [54]. Since the Glacial Maximum, approximately 35% of suitable habitat for the genus has been lost [55].

Currently, the Administration of National Parks in Argentina mentions 7 species, of which two (*P. racemosa* and *P. rugulosa*) are not present in Argentina. In the NOA *P. australis* is present in five protected areas, *P. hieronymi* in three, and *P. tomentella* in two. No information is available regarding *P. crista-galli*, and *P. tarapacana* is not represented in any protected area.

Dendrochronology: Braun Wilke presents the relationship between the diameter at the base, height, and estimated age of *P. tomentella* individuals (Figure 7), also he notes significant growth differences among individuals, although he may have confused *P. tarapacana* with *P. tomentella* [56,57]. Corcuera reported an individual tree aged 65 years and suggests that trees reach a diameter of 30 cm after 50 years [51]. Simultaneously, González Arzac indicates that a perimeter of 100cm

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corresponds to 50 years (based on n=3), nevertheless, this author mentions the presence of rotten trunk centers that could indicate a threat for conservation and hinders the correct counting of rings [57]. Alonso indicates that one meter of trunk diameter corresponds to approximately 400 years of growth [40]. Chocovar and Picchi, found that the average annual increment in height for *P. australis* specimens was 13.5 cm, while the increase in diameter was 3.2 mm and 2.9 mm/year for *P. tomentella*, with an average age of 118 years [58,59]. However, this information was based on a small sample size (N = 2 for *P. tomentella* and N = 14 for *P. australis*).

Archaeology: Albeck found remnants of charcoal from *P. tomentella* at an archaeological site near Casabindo [60]. Additionally, a *P. tomentella* tree over 300 years old (3 meters high) was discovered above a kiln in Coyahuayma [61]. The use of queñoa wood for metal smelting during the colonial period (18th century) has been documented [62].

Ethnobiology: Parker mentions medicinal (anti-hemorrhoidal properties) for *P. australis* for the first time in the region [63]. Later chemical compounds of *P. australis* were identified [64]. Ponessa et al. used chromatography to detect flavonoids in *P. australis* [33]. The medicinal use of *P. australis* leaves was also noted [65].

Genetics: There is a notable difference in polyploidy between northern and southern populations of *P. australis*, with northern populations predominantly being diploid [66]. Additionally, the genetic diversity of adult *P. tarapacana* decreases with increasing elevation, indicating upward migration during interglacial periods [67].

Associated groups: *P. tomentella* has been associated with the endemic bird species Saí Grande (Oreomanes fraseri) in Salta province. Species richness, relative abundance, and bird diversity are higher in *P. australis* forests compared to *P. hieronymi* forests, though there were no highly associated bird species reported [68]. A survey of one *P. australis* forest detected 31 species of birds and 25 species of mosses, lichens, and ferns associated with the habitat [69].

Outhreach: Some outreach efforts encountered challenges, including incorrect or missing scientific names or no mention of the scientific name, mention of medical use, the growth rate of the diameter, and the use of the ritidoma to make cigarettes [40,70,71]. We also discovered two paintings, one in street art and the other on social media [72,73].

Field work: We successfully identified the six *P. australis* groups visited in 1999 [12]. The total number of individuals decreased, especially at the lower altitudes (Table 1). We found other groups of *P. australis* in PPPY.

Table 1. Number of adult *P. australis* trees, seedlings (<30 cm) obtained by Mariani [12] in 1999 and in this work (2022), including difference over time (1999-2022) and altitude measured by us present in the Provincial Park "Potrero de Yala", along the Infiernillo River.

1999				**2022**					
Group	Adults	Seedlings	Total	Adults	Death Trees	Seedlings	Total	Δ time	Altitude
1	32	0	32	6	4	0	6	-26	2105
2	60	0	60	6	19	0	6	-54	2141
3	16	3	19	23	0	3	26	+7	2174
4	21	0	21	20	1	11	31	+10	2240
5	9	0	9	9	0	3	12	+3	2260
6	3	0	3	2	1	1	3	0	2258
TOTAL	141	3	144	66	25	18	84	-60	

Discussion

Publication trends show a peak in articles during years when the International Congress on the Ecology and Conservation of *Polylepis* was organized (Quito-Ecuador 2019, Jujuy-Argentina 2016, Arica-Chile 2013, Cusco-Peru 2006, Cochabamba-Bolivia, 2000), especially when this congress was in Jujuy (NOA) with the record of 12 publications. This underscores the importance of local events and the organization of specific congresses on conservation. We, therefore, recommend organizing new international congresses on the topic. These congresses were interrupted during COVID-19 pandemia and not retaken afterward. Access to congress abstracts remains challenging, and this article aims to address this gap.

Although the genus *Polylepis* was described early and according to Simpson no synonym exists, we found the synonym *Quinasis*, indicating that some taxonomic inconsistencies may have persisted in earlier literature [74-76]. This was later solved by considering it a heteroteric synonym [77]. Nevertheless, considerable confusion remains at the species level, both locally and regionally. Recently, 45 species have been revised and accepted, but since then, two more species have been described in Peru, totaling 47 species [78-80]. In *P. australis* in northwest Argentina, the difference in ploidy levels with populations in the south suggests the potential existence of different species [66]. Given the challenging morphological diagnosability, we propose a comprehensive review of the systematics based on genetic and/or niche differences between *P. tarapacana* and *P. tomentella* and between different *P. australis* populations.

There has been confusion regarding the correct terminology for its fruits. Most authors have referred to the fruits as achenes, while authors outside the NOA have even referred to them as nuts e.g. [16,24,81]. However, despite their similarity to achenes, the flowers of *Polylepis* have an inferior ovary, making "cupela" (flower cup) the correct term, as supported by Zardini and Acosta and Moroni [25,82]. Also, the correct term is amentiform spikelike racemes. Those multiple errors suggest that generators of outreach material should rigorously check scientific sources.

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Historically, there has been considerable confusion regarding the species present in NOA. Early, three species (*P. australis*, *P. hieronymi*, *P. tomentella*) were mentioned in the NOA, which fluctuated to one or two species. The early works of the Ecology department abled identifying two new species present in the NOA (*P. crista-galli* and *P. tarapacana*) and it was only in the year 2021 that the five species were finally included in the Flora Argentina [83,84].

Toponymy associated with *P. tomentella*, corresponds in some cases to *P. tarapacana* [85]. In 2003 a detailed dot-based distribution map was elaborated. Nevertheless, in 2016 *P. australis* was erroneously cited in Puna, which should be *P. tomentella* [21]. Additionally, there is also confusion between *P. tomentella* and *P. tarapacana* [56]. The shrubby form observed above 4700 m most likely belongs to *P. tarapacana* [86]. Also, in recent studies, populations most likely belonging to *P. tomentella* in the El Aguilar location have been identified as *P. tarapacana* [87]. Renison et al. attempted to clarify their distributions using Species Distribution Models, which have their limitations [4]. Recently, the species from the Puna (*P. tomentella*) and High Andes (*P. tarapacana*) have been mapped in detail based on satellite images and fieldwork [30]. We recommend a detailed mapping of all five species in the NOA and re-uploading the regional map.

The most important category was ecology/physiology. The characterization as a pioneer species of *P. hieronymi*, *P. tomentella* and *P. australis* were not scientifically sustained. The effect of cattle on *P. tomentella*, although widely mentioned was never quantified and for *P. australis* more experiments should be done as it was only tested in one site (PPPY). Also, the management directions provided by outreach are not based on ecological experiments. Therefore, we suggest using those affirmations as hypotheses for scientific investigations [51].

We consider that forest structure and especially the germination potential of *P. tomentella* are sufficiently studied. However, this subject could be complemented with other questions for conservation to enhance germination efficacy. For example, the longevity of seeds remains unknown, and the interannual seed germination of a single tree is also uncharted territory. We suggest more studies that aim to improve practical application for *P. tomentella* and studies on forest structure and regeneration on the other four species which are poorly studied, especially *P. crista-galli* and *P. hieronymi*. There is growing evidence that the current distribution of *Polylepis* may be influenced by anthropogenic factors, though it remains unclear if this applies to NOA. According to toponomy *Polylepis* has been locally extirpated from many areas, it persists in restricted environments such as ravines and protected areas [85]. However, restricted distribution can also be related to environmental factors like wind or water availability for *P. australis*. Wind has been identified as a limiting factor, and precipitation concerns are noted for *P. tarapacana* [88,89]. Factors influencing the distributions of the species still need to be disentangled.

P. australis has not been classified by the IUCN, but was considered of Least Concern on the country level [90]. The other four species have not been categorized in NOA. *P. tomentella* might be the most threatened species, but this assertion was not based on empirical evidence, reflecting a broader issue with the lack of formal categorization, especially since *P. tomentella* has been recognized by the provincial government of Jujuy for conservation [47,91]. We recommend an assessment of the conservation status of *P. australis*, as well as a local categorization for the other four species. Additionally, we suggest research on the effect of cattle and exotic species such as the European hare, whose presence was documented in the area since the 1980s [92]. At the national level, the Administration of National Parks, which is the maximum authority, on its website cites two species not present in Argentina [22]. Also, it mentions the presence of *P. tomentella* in the National Park El Rey, which should be *P. hieronymi*. Additionally, the ANP website mentions *P. australis* as Vulnerable by the IUCN, but this species is not (yet) classified by IUCN. Finally, it indicates that the presence of *P. australis* in PPPY is not confirmed, although scientific and grey literature indicates its presence [49,50,93]. We suggest a revision of this website [22].

The assumption that there is extensive unpublished material on *Polylepis* has been partially substantiated, as 33% were not available online and grey literature contributed 51.8% to conservation knowledge, but outreach works generated confusion. Although we used a subjective indicator, it was useful to solve the aim of our work. Unfortunately, a significant amount of information circulating lacks scientific or empirical backing. For example, the use of bark for cigarette rolling and writing and the medicinal use of leaves and bark is not scientifically sustained [63,94]. Although the chemical components were investigated, no reference to medicinal use is made and therefore we suggest caution [33,64]. Further ethnobotanical studies could help to elucidate this issue. Archeological studies show the long-standing relation between *Polylepis* forests and humans, maintained until nowadays [62,94,95]. The number of mentions and species descriptions in literature, the amount of outreach work, and even the artwork on the genus (Figure 6) show that the genus is charismatic, nevertheless, this recognition has not translated into sufficient

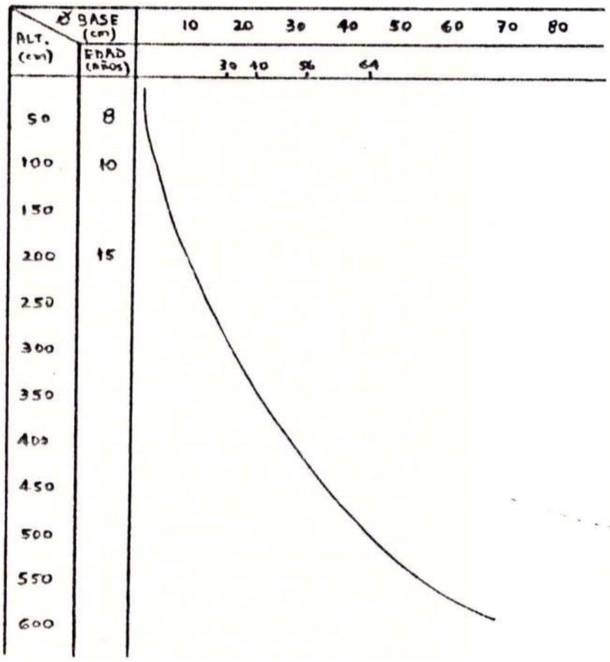

Figure 7. Estimated relationship between age, height, and base diameter of *P. tomentella*, derived from a sample of 400 felled trees (reproduced from [56]).

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conservation efforts.

The limited amount of unpublished data contains important information with conservation implications, particularly regarding population dynamics and structure of *P. australis*. The comparison between the report and our fieldwork indicated that there is a significant decline in adult trees, particularly at lower altitudes [12]. This could be an effect of climate change, or due to differences in altitude or climatic conditions. These hypotheses should be tested. Continuous monitoring is essential to better understand the population dynamics of *Polylepis* and to develop more effective conservation strategies.

Conclusions

Our review demonstrates that grey literature has been valuable for informing conservation efforts for *Polylepis* spp. in northwest Argentina (NOA). Grey literature provided critical data on species distributions, population trends, and threats. It is essential to do field experiments to address the knowledge gaps identified, especially for lesser-studied species such as *P. hieronymi* and *P. crista-galli*. With *Polylepis* species continuing to face significant environmental pressures, a collaborative effort between researchers, policymakers, and local communities is necessary to ensure the long-term preservation of these unique and threatened ecosystems. This approach can be similarly useful for other species that, while underrepresented in formal scientific publications, are present in grey literature due to their conservation status or charismatic nature. This is particularly relevant in regions with limitations on scientific publishing, such as the Southern Hemisphere, where grey literature remains a key resource for conservation planning.

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References

1. Pullin AS, Stewart GB. Guidelines for systematic review in conservation and environmental management. Biol Conserv. 2006; 20(6): 1647-1656. https://doi.org/10.1111/j.1523-1739.2006.00485.x
2. Haddaway NR, Bayliss HR. Shades of grey: two forms of grey literature important for reviews in conservation. Biol Conserv. 2015;191:827-829. https://doi.org/10.1016/j.biocon.2015.08.018
3. Farace DJ, Schöpfel J. Grey literature in library and information studies. KG Saur. New York. 2010. Available at: https://library.oapen.org/handle/20.500.12657/45661
4. Renison D, Cuyckens GA, Pacheco S, Guzmán GF, Grau HR, Marcora P, et al. Distribution and conservation status of tree and shrub populations of the genus *Polylepis* (Rosaceae) in the mountains of Argentina. Austral Ecol. 2013;23(1):27-36. https://doi.org/10.25260/EA.13.23.1.0.1189
5. Cuyckens GA, Renison D. Ecology and conservation of montane *Polylepis* forests: An introduction to the special issue. Southern Ecol. 2018;28(1):157-162. https://doi.org/10.25260/EA.18.28.1.1.766.
6. Gareca EE, Hermy M, Fjeldså J, Honnay O. *Polylepis* woodland remnants as biodiversity islands in the Bolivian high Andes. Biodivers conserv. 2010;19:3327-3346. https://doi.org/10.1007/s10531-010-9895-9
7. Lloyd H, Marsden SJ. Bird community variation across *Polylepis* woodland fragments and matrix habitats: implications for biodiversity conservation within a high Andean landscape. Biodivers conserv. 2008;17:2645-2660. https://doi.org/10.1007/s10531-008-9343-2
8. Tinoco BA, Astudillo PX, Latta SC, Strubbe D, Graham CH. Influence of patch factors and connectivity on the avifauna of fragmented *Polylepis* forest in the Ecuadorian Andes. Biotropica. 2013;45(5):602-611. https://doi.org/10.1111/btp.12047
9. Clewell A, Rieger JP. What practitioners need from restoration ecologists. Restor Ecol. 1997;5(4): 350–354. https://doi.org/10.1046/j.1526-100X.1997.00548.x
10. Renison D, Morales L, Cuyckens GA, Sevillano CS, Cabrera Amaya DM. Ecology and conservation of *Polylepis* forests and shrublands: what do we know and what do we not know?. Ecología Austral. 2018;28(1):163-174. https://doi.org/10.25260/EA.18.28.1.1.522
11. Bianchi AR, Cravero SAC. Atlas climático digital de la República Argentina. Ediciones INTA; Estación Experimental Agropecuaria Salta. 2010. https://repositorio.inta.gob.ar/handle/20.500.12123/16040
12. Mariani, E. Report on the Tour of June 29, 1999. Potrero de Yala Provincial Park, General Directorate of Renewable Natural Resources of Jujuy, San Salvador de Jujuy, 1999;2.
13. Cuyckens GAE, Guzmán GF. The Value of Gray Literature in Conservation: The Case of *Polylepis* Spp. in Northwestern Argentina. Book Abstr Virtual Event. 2021. https://conbio.org/mini-sites/iccb-2021/
14. Ragonese AE, Castiglioni JC. The Vegetation of the Chaco Park. Bull Argent Bot Soc. 1968;12(2):133-160. https://botanicaargentina.org.ar/la-vegetacion-del-parque-chaqueno/
15. Tregin DB. The Queñua. Flora Northwest Argent. San Salvador de Jujuy. 1996;223.
16. *Polylepis*. Wikipedia. 2024. https://es.wikipedia.org/wiki/*Polylepis*
17. Bitter G. Revision of the Genus *Polylepis*. Bot Yearb Syst. Plant History, and Plant Geography. 1911;45:633. https://www.gbif.org/species/7272254
18. Ancibor E. Wood Structure of *Polylepis tomentella* Wedd. (Rosaceae). Physis Secc C. 1984:23-28.
19. Picchetti LPE. Environment and Variations of the Genus *Polylepis* in Jujuy. Book Abstr Tucumán. 1999:236.
20. Picchetti LPE, Guzmán GF, López AV. Variability in Seed (Fruit) Weight, Seedling Height, and Leaf Length in *Polylepis* spp. from the Jujeña Puna, Argentina. Book Abstr Cochabamba. 2000:77. https://e8392e22-ac2a-45dc-889a-504528ea9f34.filesusr.com/ugd/dc197f_f865177d45c94490bf6f14c5d79977a1.pdf
21. Szumik C, Molina A, Rajmil J, Aagesen L, Correa C, Pereyra V, et al. The Wonderful World of Animals and Plants of the Puna. Miguel Lillo Foundation. 2016.
22. Administration of National Parks Argentina. (N/A) Biodiversity Information System. Biodiversity Information System. https://sib.gob.ar/buscar?q=*polylepis*
23. Frangi L. Note on the Root System of Some Puna Plants. Bull Argent Bot Soc. 1973;15:35-50.
24. Digilio AP, Legname P. The Native Trees of the Province of Tucumán. Opera Lilloana. 1966;15:1-107. https://www.jstor.org/stable/41411833
25. Zardini EM. The Native Genera of Rosaceae in the Argentine Republic. Bull Argent Bot Soc. 1973;15:209-228. https://botanicaargentina.org.ar/wp-content/uploads/2018/09/209-228008.pdf
26. Grau A, Malizia LR, Brown AD. Arboretum Calilegua: Native and Exotic Trees of Northwestern Argentina. Ed Subtrópico; 2016. Available at: https://www.academia.edu/36779192/%C3%81rboles_nativos_y_ex%C3%B3ticos_del_noroeste_argentino
27. Krussmann. *Polylepis* australis, A Winter-Hardy Shrub from Argentina. Dtsch Baumsch. 1972:58-59.

https://doi.org/10.61577/jec.2024.1000011

28. Martínez SM, editor. Guide to Native Trees of the Province of Salta: Northwestern Argentina. Secr Cult Prov Salta; 2006.
29. Segovia AD, Speranza FC, Malizia LR. Forest Survey in Quebrada de Humahuaca and Puna, Province of Jujuy. Final Consultancy Report. Prov Dir Biodivers; 2012.
30. Guzmán GF, Wayar C, Speranza FC. Complementary Report on the Survey of Forested Areas in the Pre-Puna, Puna, and Altoandina Regions of the Province of Jujuy. Tech Rep. 2017.
31. Arnal H, Sampson A, Navarro G, Palomino W, Ferreira W, Romoleroux K, et al. Pan-Andean Map of Priority *Polylepis* Forests for Conservation. Am Bird Conserv. 2007. http://dx.doi.org/10.5281/zenodo.4174838
32. Legname P. The Native Trees of Northwestern Argentina. Opera Lilloana. 1982;34:1-226. https://www.jstor.org/stable/3496315
33. Ponessa G, Tereschuk ML, Abdala LR. Leaf Morphology of *Polylepis* australis Bitter (Rosaceae) in the Tafí Valley, Tucumán, Argentina: Some Considerations on the Flavonoid Complex. Lilloa. 1998;39: 147-155. https://www.lillo.org.ar/journals/index.php/lilloa/article/view/1280
34. Asesor C. *Polylepis* australis Queñoa. In: Scrocchi GJ, Szumik C, editors. Universo Tucumano. 2019:1-10. http://lillo.org.ar/revis/universo-tucumano/2019/2019-ut-v30.pdf
35. Cuyckens GAE, Ochoa-Vilca ST, Marquéz SE, Renison D. Structure and Regeneration of a Little-Known Queñoa Species (*Polylepis* crista-galli). Book Abstr Virtual Event. 2021:18. https://www.conicet.gov.ar/new_scp/detalle.php?keywords=&id=50784&congresos=yes&detalles=yes&congr_id=9804678
36. Fernández J. *Polylepis* tomentella and Recent Orogeny. Bull Argent Bot Soc. 1970:14-30. https://botanicaargentina.org.ar/wp-content/uploads/2018/09/14-30022.pdf
37. Bonaventura SM, Tecchi R, Vignale D. The Vegetation of the Puna Belt at Laguna de Pozuelos Biosphere Reserve in Northwest Argentina. Vegetatio. 1995;119:23-31. https://doi.org/10.1007/BF00047368
38. Ruthsatz B, Movia CP. Relevamiento de Las Estepas Andinas Del Noreste de La Provincia de Jujuy. Fund Educ Cienc Cult. 1975. https://www.sidalc.net/search/Record/cat-unco-ar-11932/Description
39. Guzmán GF. Influencia Del Pastoreo En La Regeneración Del Bosque de *Polylepis* tomentella (Quéñoa) En La Puna de Jujuy, Argentina. UIA; 1999. https://fca.unju.edu.ar/media/revista_articulo/trabajo3_Salazar_y_otros.pdf
40. Alonso R. La Puna Argentina: ensayos geológicos, históricos y geográficos de una región singular. 3rd ed. Mundo Ed; 2013. https://revistas.unc.edu.ar/index.php/FCEFyN/article/view/28659
41. López VL, Cellini JM, Cuyckens GAE, et al. Influencia del micrositio y el ambiente en la instalación de *Polylepis* tarapacana en los Altos Andes. Neotrop Biodivers. 2021;7:135-145. https://doi.org/10.1080/23766808.2021.1902251
42. López VL, Cellini JM, Colque R, Acebal Y, Alberti MA, Pérez Flores M, et al. Facilitating Microenvironments for the Regeneration of *P. tarapacana* in Its Southern Distribution. Book Abstr. 2019:49. Available at: https://www.researchgate.net/publication/337772061_Microambientes_facilitadores_de_regeneracion_de_P_tarapacana_en_su_distribucion_austral
43. Guzmán GF. Influence of Grazing on the Regeneration of Queñoa Forests (*Polylepis tomentella*) in the Puna of Jujuy, Argentina. Book Abstr Cochabamba. 2000:70. https://e8392e22-ac2a-45dc-889a-504528ea9f34.filesusr.com/ugd/dc197f_f865177d45c94490bf6f14c5d79977a1.pdf
44. Cuyckens GA, Hensen I, López VL, Cellini JM, Renison D. Germination of High Andean Treeline Species of Contrasting Environments and Along Elevational Gradients in Northwest Argentina. Neotrop Biodivers. 2021;7:111-120. https://doi.org/10.1080/23766808.2021.1906137
45. Medina DE, Guzmán GF, Humano CA. Structure of *Polylepis* Forests in Jujuy, Argentina. Book Abstr Quito. 2019:73.
46. Braun Wilke HR. Three Woody Resources: Queñoa, Churqui, and Tola. In: García Fernández JJ, editor. The Laguna de Pozuelos Biosphere Reserve: A Pastoral Ecosystem in the Central Andes. PER-INBIAL UNJu/UNESCO; 1991:43-50.
47. Braun Wilke RH, Picchetti LPE. Disappearance of Queñoa Forests in the Jujuy Puna (N.O.A.). Book Abstr Potosí. 1999.
48. Cuyckens GAE, Mazzini F, Julián R, Medina DE, Guzmán GF. Effect of Livestock on Regeneration of Queñoa (*Polylepis* australis Bitt.) Forest in the Southern Andean Yungas of Northwestern Argentina. Rev Chapingo Ser Cienc For Ambient. 2021;27:215-228. https://doi.org/10.5154/r.rchscfa.2020.05.035
49. Julián RF. Effect of Livestock on a Queñoa (*Polylepis* australis, Rosaceae) Forest in the Montane Forest of the Yungas (Jujuy, Argentina). National University of Jujuy; 2018. https://doi.org/10.5154/r.rchscfa.2020.05.035
50. Alcon P, Flores FF. Comparison of Herbaceous Biodiversity in a Queñoa Forest Between a Site with Livestock Access and Another Without Access, in the Provincial Park Potrero de Yala (PPPY), Jujuy, Argentina. Book Abstr San Salvador. 2016:98. https://e8392e22-ac2a-45dc-889a-504528ea9f34.filesusr.com/ugd/dc197f_b12ccb4f0d55423b91d3475795c5027a.pdf
51. Corcuera J. Firewood from the Highlands. Vida Silvestre. 1995:17-20.
52. Baied CA. Human Activity or Climate Change? Environmental History of the Genus *Polylepis* in the Central-Southern Andes: Notes for Its Protection and Conservation. Book Abstr Cochabamba. 2000:43.
53. Cuyckens GAE, Christie DA, Domic AI, Malizia LR, Renison D. Climate Change and the Distribution and Conservation of the World's Highest Elevation Woodlands in the South American Altiplano. Glob Planet Change. 2016;137:79-87. https://doi.org/10.1016/j.gloplacha.2015.12.010
54. Baied CA. Historical Ecology of *Polylepis* in the Central Andes. Book Abstr San Salvador. 2001.
55. Zutta B, Rundel P. Modeled Shifts in *Polylepis* Species Ranges in the Andes from the Last Glacial Maximum to the Present. Forests. 2017;8:232. https://doi.org/10.3390/f8070232
56. Braun Wilke RH. Ecological Productivity of "Queñoa" (*Polylepis* tomentella Wedd.) in the Puna of Jujuy. Book Abstr Santiago del Estero. 1988.
57. González Arzac E. Use and Availability of Firewood in Tuite, La Redonda, and Muñayoc. Fed Invest Counc. 1995:88.
58. Chocovar N. Measurement of Growth in Some Native and Naturalized Woody Species of the Montane Forest (Dept. Dr. Manuel Belgrano, Prov. of Jujuy) Between 1600 and 2300 m.a.s.l. Book Abstr EDIUNJU. 2016:38-44. https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://fca.unju.edu.ar/media/publicaciones_cientificas/libro-resumen-x-jct-fc_ppSB18E.pdf&ved=2ahUKEwidkaGp1biJAxWSHbkGHduBH1QQFnoECBQQAQ&usg=AOvVaw1u2jQXMB7aLQsqthLwelN8
59. Picchi CG, Chocovar AN. Estimation of the Age of Two Species of Queuñoas: *Polylepis* australis in the Montane Forest and *P. tomentella* in the Puna, Province of Jujuy. Book Abstr La Paz. 2006.
60. Albeck ME. Pueblo Viejo de Tucute: Sorcuyo Revisited—a New Version of a Classic Site in Northwestern Argentina. Chungara. 1998;30:143-160. https://www.jstor.org/stable/27802082
61. Angiorama CI, Becerra MF. As there have never been mines in it... Mining and Metallurgy in the Puna of Jujuy during Late Pre-Hispanic Times. Relac Soc Argent Antropol. 2014;39:1-20. Available at: https://www.academia.edu/11670582/_Como_en_ella_jam%C3%A1s_ha_habido_minas_Miner%C3%ADa_y_metalurgia_en_la_Puna_de_Jujuy_durante_momentos_prehisp%C3%A1nicos_tard%C3%ADos
62. Becerra MF, Nieva N, Angiorama CI. Characterization of Archaeological Smelting Wastes: Colonial Metallurgy at Smelting Site 2, Rinconad, Jujuy. Rev Cienc Tecnol. 2014;16:58-64.

https://doi.org/10.61577/jec.2024.1000011

https://ri.conicet.gov.ar/bitstream/handle/11336/31611/CONICET_Digital_Nro.31b7e5ac-591d-4f5d-aec0-57d91eda52d9_A.pdf?sequence=2&isAllowed=y
63. Parker J. A Thousand Medicinal Plants of the Argentine Republic and South America. AYMI. 1973.
64. De Lampasona MEP, Catalán CAN, Gedris TE, Herz W. Oleanolic and Ursolic Acid Derivatives from *Polylepis* australis. Phytochemistry. 1998;49:2061-2064. https://doi.org/10.1016/S0031-9422(98)00408-7
65. Cantero JJ, Núñez CO, Bernardello G, Amuchástegui A, Mulko J, Brandolín P, et al. Plants of Economic Interest in Argentina. 1st ed. UniRío Editora; 2019.
66. Kessler M, Kühn A, Solís Neffa VG, Hensen I. Complex Geographical Distribution of Ploidy Levels in *Polylepis* australis (Rosaceae), an Endemic Treeline Species in Argentina. Int J Plant Sci. 2014;175:955-961. https://doi.org/10.1086/677649
67. Peng Y, Renison D, Hensen I. The climatic oscillations of the pleistocene, and not recent human alterations, determine the pattern of genetic diversity in *Polylepis* tarapacana. Book Abstr San Salvador. 2016:30.
68. Bellis LM, Rivera L, Politi N, Martín E, Perasso ML, Cornell F, et al. Latitudinal Patterns of Bird Richness, Diversity, and Abundance in *Polylepis* australis Mountain Forest of Argentina. Bird Conserv Int. 2009;19:265. https://doi.org/10.1017/S0959270909008491
69. Asiar F, Caldano S, Colina U. Survey of Birds, Mosses, Lichens, and Ferns in the *Polylepis* australis Forest of Potrero de Yala Provincial Park, Jujuy. Book Abstr San Salvador. 2016:99. https://e8392e22-ac2a-45dc-889a-504528ea9f34.filesusr.com/ugd/dc197f_b12ccb4f0d55423b91d3475795c5027a.pdf
70. Iturralde C. The Queñoa, the Sacred Tree with Healing Properties. Argent Mountain Cult Center. 2021. Available at: https://www.culturademontania.org.ar/articulo/646cc8cffc0d3efac6f6e572
71. Carrizo A, Comas MI. The Jujuy Manual. Yuchán Ed. 2005.
72. Teves A. Queuña Haiku. Painting. San Salvador de Jujuy. 2022.
73. Osacar M. Queuña. Mural Painting. San Salvador de Jujuy. 2009.
74. Florae Peruvianae et Chilensis prodromus, sive, Novorum generum plantarum Peruvianarum et Chilensium descriptiones, et icons. 1794;80:150. https://doi.org/10.5962/bhl.title.11759
75. Simpson BB. A Revision of the Genus *Polylepis* (Rosaceae, Sanguisorbaeae). Smithson Contrib Bot. 1979:1-62. https://repository.si.edu/bitstream/handle/10088/7018/scb-0043.pdf
76. Rafinesque-Schmaltz CS. *Quinasis* RAF. Sylva Tellur Mantis Synopt. 1838. Available at: https://www.biodiversitylibrary.org/page/404558#page/169/mode/1up
77. Govaerts R, Nic Lughadha E, Black N, Turner R, Paton A. The World Checklist of Vascular Plants, a Continuously Updated Resource for Exploring Global Plant Diversity. Sci Data. 2021;8:215. https://doi.org/10.1038/s41597-021-00997-6
78. Boza Espinoza TE, Kessler M. A Monograph of the Genus *Polylepis* (Rosaceae). PhytoKeys. 2022;203:1-274. https://doi.org/10.3897/phytokeys.203.83529
79. Quispe-Melgar HR, Llacua-Tineo YS, Ulloa Arias NE, Kessler M. A New Species of *Polylepis* (Rosaceae) from Santuario Nacional Pampa Hermosa, Peru. Phytotaxa. 2024;653:165-174. https://doi.org/10.11646/phytotaxa.653.2.5
80. Valenzuela Gamarra L, Valdivia MIV. A New Species of *Polylepis* (Rosaceae) from the Bosque de Protección Pui-Pui, Peru. Phytotaxa. 2024;655:97-104. https://doi.org/10.11646/phytotaxa.655.1.8
81. Pollice J, Marcora P, Renison D. Seed Production in *Polylepis* australis (Rosaceae) as Influenced by Tree Size, Livestock, and Interannual Climate Variations in the Mountains of Central Argentina. New For. 2013;44:233-247. https://doi.org/10.1007/s11056-012-9313-0
82. Acosta JM, Moroni P. *Polylepis* Ruiz and Pav. Fl Vasc Rep Argentina. 2023:381-386. Available at: https://www.conicet.gov.ar/new_scp/detalle.php?keywords=Czajkowski&id=23172&capitulos=yes&detalles=yes&capit_id=11736917
83. Picchetti LPE, Guzmán GF, Villafañe BS. Dos Nuevas Especies de *Polylepis* (Rosaceae) Para La Argentina. Book Abstr San Salvador. 2001.
84. Instituto de Botánica Darwinion. Flor Argentina. 2021. Available from: https://buscador.floraargentina.edu.ar/species/searchbyscientificname
85. Braun Wilke HR, Picchetti LPE, Guzmán G. Disappearance of Queñoales in the Jujuy Puna. Agraria. 2003;2:73-76.
86. Ancibor E. Anatomical Study of the Vegetation of the Puna of Jujuy. I. Anatomy of *Polylepis* tomentella Wedd. (Rosaceae). Darwiniana. 1975;19:373-385. Available at: http://www.jstor.org/stable/23215548.
87. López VL, Bottan L, Martínez Pastur G, Lencinas MV, Cuyckens GAE, Cellini JM. Characterization of *Polylepis* tarapacana Life Forms in the Highest-Elevation Altiplano in South America: Influence of the Topography, Climate, and Human Uses. Plants. 2023;12:1806. https://doi.org/10.3390/plants12091806
88. Sparacino J, Renison D, Devegili AM, Suarez R. Wind Protection Rather than Soil Water Availability Contributes to the Restriction of High-Mountain Forest to Ravines. New For. 2020;51:101-117. https://doi.org/10.1007/s11056-019-09722-z
89. Morales MS, Villalba R, Grau HR, Paolini L. Rainfall-Controlled Tree Growth in High-Elevation Subtropical Treelines. Ecology. 2004;85:3080-3089. https://doi.org/10.1890/04-0139
90. Salariato DL, Zanotti C, Zuloaga FO. Threat Patterns and Conservation Status of Endemic Vascular Flora in Argentina: A Quantitative Perspective. Phytotaxa. 2021;520:21-39. https://doi.org/10.11646/phytotaxa.520.1.2
91. Consejo Federal de Medio Ambiente. Declaration of Cofema. 2016. Available at: https://repositoriocurricular.educacion.gob.ar/handle/123456789/1568
92. Bonino N, Cossíos D, Menegheti J. Dispersal of the European Hare, Lepus europaeus in South America. Folia Zool. 2010;59:9-15. https://doi.org/10.25225/fozo.v59.i1.a3.2010
93. Carranza AV. Study of the Diversity and Structure of the Tree and Shrub Layers of the Forest and Mountain Jungle in Yala (Province of Jujuy, Argentina). Univ Press. 2005.
94. García LC. The Three Kingdoms in Azul Pampa (Humahuaca, Jujuy). In: The Three Kingdoms: Gathering Practices in the Southern Cone of America. Inst Archaeol Museum Miguel Lillo. 1999. http://repositorio.filo.uba.ar/handle/filodigital/14809
95. Julián RF, Arzamendia Y, Vilá BL. The Link Between *Polylepis* Forests and the Indigenous Community of Quebraleña, Jujuy - Argentina. Rev Etnobiol. 2021;19:154-169. https://ri.conicet.gov.ar/handle/11336/157866

https://doi.org/10.61577/jec.2024.1000011