Chapter 16
Edible Ectomycorrhizal Mushrooms in South America

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16.1 Outline

Edible mushrooms have been part of the human diet almost worldwide since prehistorical times, many of them are formed by mycorrhizal species (Pérez-Moreno et al. 2021). A comprehensive treatise on edible ectomycorrhizal mushrooms from a global perspective, but with special focus on some American countries, has recently been edited by Pérez-Moreno and coauthors (2020). Earlier, a checklist of saprobiotic, parasitic, and mycorrhizal fungi with edible sporomas has been published by Garibay-Orijel et al. (2010) for Mesoamerica and South America. In this chapter, we present a more specific and updated review of habitats, diversity, management, and conservation of ectomycorrhizal edible fungi (hereafter EEMF) in South America, especially in the Andean-Patagonian region of Argentina and Chile.

At species level, many ectomycorrhizal fungal symbionts are characterized by specific requirements in terms of vegetation type and climatic and edaphic conditions (Lilleskov and Parrent 2007); having co-evolved with their respective tree host, their geographical distribution is often more sharply defined than in case of less specific, saprobiotic species. Contrasting the dominance, high diversity, and wide extension of ectotrophic forests in the northern hemisphere, especially in the temperate and boreal zones, South America is characterized by only rather few autochthonous ectomycorrhizal tree taxa in disjunct areas (Singer and Morello 1960; Nouhra et al. 2019). Most of those areas coincide with cool temperate climate zones delimited by altitude or latitude, such as the high Andean oak forests in Colombia, the *Alnus acuminata* belt along the northern to central Andean slope, and the Andean Patagonian *Nothofagus* forests of Southern Chile and Argentina. Especially the more extensive woodlands with the presence of Fagales trees bear a considerable variety of autochthonous fungi, which produce edible mushrooms, although the mycophytosociological background of the respective *Quercus* and *Nothofagus* forests, which are geographically isolated from each other, is very different: The *Q. humboldtii* ectotroph in Colombia shows affinity to Central and Southern North America, whereas the ectomycorrhizal community associated to *Nothofagus* is of Gondwanan origin (Nouhra et al. 2019).

The scarce historical records indicate that collection and consumption of EEMF have a long tradition in local and regional indigenous populations (Coña *apud* Moesbach 1930; Molares et al. 2020). Although mushroom hunting has hardly been as popular among a broader public in South America as it is in many countries of the northern hemisphere (Commandini and Rinaldi 2020; Niveiro et al. 2009), a growing interest in EEMF can be observed in more recent times, as well with a commercial as a recreational background and evidently boosted by increased use of social media via Internet.

Among the most notorious anthropogenic changes of landscape and vegetation in many parts of South America during the last 50+ years is the large-scale replacement of native forests with timber trees, mostly conifers and eucalyptus (Echeverría et al. 2006). An increasing number of adventitious ectomycorrhizal fungal species forms part of these alien ectotroph communities, among them edible taxa, such as *Suillus* or *Lactarius*, which are not compatible with native ectomycorrhizal trees but often grow in large numbers in their monoculture habitat, making them a sought-after non-timber forest product not only for local and regional trade but also for food industry and exportation (Silva-Filho et al. 2020).

Finally, attempts have been made to culture introduced EEMF, such as truffles (Reyna and García-Barreda 2014), or to boost production of certain species in their natural habitat through enrichment of substrate with selected inoculum, a technique of mycosilviculture, which is increasingly applied worldwide (Wang and Chen 2014).

In this chapter, we did not include those wild EEMF from the region, which have either occasionally been categorized as being edible in the sense of being nontoxic and palatable but of low quality, such as *Laccaria* spp., or which represent rare and/or insufficiently known species, but we rather focused on those taxa that are regularly harvested and consumed and/or that have a market potential at local, regional, or international scale.

16.2 Edible Ectomycorrhizal Mushrooms in Native Forests

A detailed taxonomic inventory of ectomycorrhizal macromycetes growing in Colombian *Quercus* forests, which represent the second most important natural ectotroph area in South America, has been provided recently by Vargas and Restrepo (2020). The authors mention 37 edible species for the area. Previously, Peña-Cañón and Enao-Mejía (2014) published a list of 16 edible taxa known and harvested by rural communities of the Northeastern Colombian Andes, of which 11 are ectomycorrhizal, nine of them belonging to the genus *Ramaria*, and one to each, *Tylopilus* and *Russula*.

Although around 1000 species of macrofungi have been described from Andean-Patagonian *Nothofagus* forest (Mueller et al. 2007), only few species are regularly collected and consumed by local populations. Among EEMF, *Ramaria* spp. named "changle" or "chandi" in Southern Chile and Argentina (Coña *apud* Moesbach 1930; Sanchez-Jardón et al. 2017) are most commonly offered at local markets during the season. Species, often sold in mixed collections, have been named as *R. flava* (Schaeff.) Quél., *R. botrytis* (Pers.) Bourdot, *R. patagonica* (Speg.) Corner, and *R. subaurantiaca* Corner, among others, in the literature (Singer 1969; Lazo 2016; Barroetaveña and Toledo 2016); however, taxonomy of the South American Ramariae requires revision as species concepts applied at present are poorly defined (Valenzuela 2003) and date back to publications from the 1950s and 1960s (Singer 1969), lacking input of molecular and morphological data by advanced standards as proposed by Christan and Hahn (2005).

Autochthonous Boletes show low diversity in the *Nothofagus* region: a mere five species of Boletaceae are reasonably known so far from Southern Chile (Horak 1977; Garrido 1988; Riquelme et al. 2019), of which only *Boletus loyo* Phillippi and *B. loyita* E. Horak are considered good EEMF and regularly collected; both species are restricted to Mediterranean and temperate *Nothofagus* forests between the Pacific coast and the Andean foothills, from approximately 35° to 41° s.l.

B. loyo, named accordingly to its indigenous mapuzungún name "loyo" (Coña *apud* Moesbach 1930), resembles the king bolete *Butyriboletus regius* (Krombh.) D. Arora & J.L. Frank from the Northern hemisphere, but a comprehensive taxonomic study in order to justify a reclassification of *B. loyo* at genus level is still pending. Loyo is a rare regionally endemic species, but due to the impressive size of its basidiomata, which can reach 40 cm in diameter, it is easily spotted in the forest and regularly sold at local markets between Valdivia and Concepción, Chile.

Another regionally frequent EEMF in Chilean *Nothofagus* forest is *Cortinarius lebre* Garrido. Its main area of distribution is along the coastal cordillera, approximately between 36° and 39° s.l. (Arnold et al. 2012; Garrido 1988), although isolated records exist as far south as 44° s.l. (Salazar Vidal et al. 2020). A probable conspecificity with *Cortinarius purpurellus* M.M. Moser, E. Horak, Peintner & Vilgalys (syn.: *Rozites violacea* E. Horak), which was originally described from the Argentinian side of the Southern Andes (Moser and Horak 1975), remains to be verified. A specific and characteristic organoleptic attribute of fresh *C. lebre* is its strong and repugnant, naphthalene-like smell whose main component was identified as indol (Arnold et al. 2012) and which fades to a pleasant, perfume-like aroma during cooking. A similar species from the same area, although less frequent than *C. lebre* and with colors and smell strikingly similar to *C. camphoratus* Fr. from the northern hemisphere, is *C. contulmensis* Garrido, according to Garrido (1988) locally collected by the peasants of the Nahuelbuta coastal mountain range. Although *Cortinarius* is by far the most diverse genus of ectomycorrhizal fungi in South American *Nothofagus* forests (Moser and Horak 1975; Nouhra et al. 2013), only a few other common species, such as *C. magellanicus* Speg., are consumed locally (Gamundí and Horak 1994; Barroetaveña and Toledo 2016; Sanchez-Jardón et al. 2017). *Cortinarius austroturmalis* M.M. Moser & E. Horak; *C. effundens* M.M. Moser, E. Horak, & Singer; and a few other large-sized and gregarious Cortinarii described and gathered in the sect. *Xiphidipus* by Moser and Horak (1975) have been reported as edible and of good organoleptic quality by the same authors, but their culinary potential so far has been hardly appreciated, and there is yet no existing market for these attractive species although they are widely distributed. Salazar Vidal and Palfner (2015) calculated the seasonal yield of *C. austroturmalis* up to 7 kg fresh weight per ha for *Nothofagus* forest in the Maule region of Central Southern Chile.

At least two *Amanita* species, *A. diemii* Singer and *A. merxmuelleri* Garrido, have been traditionally collected and consumed in rural areas of Southern Chile (Salazar Vidal 2016a), but as adventitious toxic Amanitas, such as *A. phalloides* (Vaill. ex Fr.) Link and *A. gemmata* var. *toxica* Lazo, are becoming increasingly common in mixed woodlands where introduced trees, such as pines, oaks, or chestnuts are present (Valenzuela 1992), the harvest of *Amanita* spp. should nowadays be avoided due to the high risk of confusion and severe intoxication, especially for unexperienced mushroom gatherers.

Chanterelles (*Cantharellus* and related genera) and milk caps (*Lactarius*), not only common EEMF on the northern hemisphere but also found in Colombian oak forests, are absent in Southern *Nothofagus* forests, and only allochthonous *Lactarius* sect. deliciosi can be found in pine plantations, which today cover large areas previously occupied by native forest (see next section).

16.3 Edible Ectomycorrhizal Mushrooms Associated to Exotic Timber Plantations

Across South America, allochthonous timber tree species have long been introduced and are still expanding as monocultures or, more critically, becoming naturalized and invading native vegetation (Langdon et al. 2010). Although *Eucalyptus* spp. are probably most important in this context, the most relevant hosts for non-native EEMF are *Pinus* spp., which nowadays are spread across all climate zones, from the tropics to the subantarctic steppe (García et al. 2018). Pinaceae in South America are typically found to be associated to few but highly host-specific, adventitious EEMF, such as *Suillus* spp. and *Rhizopogon* spp., among others (Hayward et al. 2015). These low-diversity communities homogenize and simplify the landscape across a vast latitudinal gradient, not only replacing native ectotrophic communities like *Quercus* and *Nothofagus* forests (Simijaca et al. 2018; Palfner and Casanova-Katny 2019) but also establishing invasive alien ectomycorrhizal guilds in previously anectotrophic areas (García et al. 2018).

Although historically, *Suillus luteus* (L.) Roussel is by far the most important and widely distributed commercial species (Barroetaveña and Toledo 2016; Melgarejo 2014, 2015; Molares et al. 2020), less common species, such as *S. granulatus* (L.) Roussel and *S. bellinii* (Inzenga) Kuntze, are increasingly receiving attention by researchers and mushroom gatherers (Chung Guin-Po 2021; Niveiro et al. 2009).

After *Suillus* spp., *Lactarius* sect. deliciosi are the second most important EEMF retrieved from pine plantations in South America. The most commonly encountered milk cap was historically identified as *L. deliciosus* (L.) Gray (Mikola 1969) and reported from different countries (Singer 1969; Barroetaveña and Toledo 2016); however, more recent studies from Chile and Brazil (Chávez et al. 2015; Silva-Filho et al. 2020), backed by molecular, morphological, and ecological data, yielded evidence that this taxon should be correctly named *L. quieticolor* Romagn. and is probably distributed throughout large parts of the continent.

16.4 Putatively Mycorrhizal Edible Fungi: *Morchella*

Morchella ascomata are among the most demanded and high-prized edible mushrooms worldwide. Although there is still controversy about whether or which *Morchella* species are mycorrhizal or saprobiotic (Hobbie et al. 2017), we decided to include this genus in our review due to its extensive presence in South America and the evidently specific association of some species to ectotrophic forest.

Early mentions and descriptions of true morels from South America date from the late nineteenth and early twentieth centuries and were hence based on a eurocentric and today obsolete taxonomic concept. The first records of *Morchella* from Southern Argentina were published by Spegazzini (1909) and named as *M. conica* Pers., based on collections from the Southeastern Andes; later, records under the same name from Central and Southern Chile (Spegazzini 1918, 1921) were added. Espinosa (1929) reported *M. esculenta* (L.) Pers. from a market in Santiago de Chile. A single finding of the supposedly endemic *Morchella patagonica* Speg. by Spegazzini (1909) for Argentina still remains unrepeated and unconfirmed. Gamundí (1975) reported *Morchella elata* from Patagonia as representing a species complex; the same author later also mentioned records of *M. intermedia* and *M. semilibera* (Gamundí 2010) from Argentina. Only recently, taxonomy and phylogeny of *Morchella* in South America have been substantially updated, mainly based on molecular markers (Baroni et al. 2018; Machuca et al. 2021), indicating that probably most species names had been incorrectly applied before. Confirmed and new taxa published for the region are supporting the concept of coexistence of endemic and widely distributed species, and this is for Patagonia: *M. andinensis* A. Machuca, M. Gerding, & D. Chávez; *M. aysenina* A. Machuca, M. Gerding, & D. Chávez; *M. septimelata* Kuo; and *M. tridentina* Bres. (Machuca et al. 2021; Pildain et al. 2014) and for Ecuador, Perú, and Venezuela: *M. gracilis* and *M. peruviana* (Baroni et al. 2018). Furthermore, insufficiently identified *Morchella* spp. belonging to the "elata" and "esculenta" clades have also been reported from Bolivia (Melgarejo Estrada *pers. com.*).

A comprehensive treatise with up-to-date information about biology, diversity, ecology, and nutritional properties of *Morchella* spp. of the Patagonian Andes, together with guidelines for sustainable and environmentally friendly harvest as well as a market analysis, has recently been published by various authors (edited by Lobos and Icarte 2021).

16.5 Management and Culture of Native and Introduced Edible Ectomycorrhizal Fungi

16.5.1 Consumption and Trade Levels

As a common pattern, regionally endemic and/or infrequent species of EEMF are mostly collected, sold, and consumed in limited quantities and at a local scale, whereas widely distributed and/or frequent species tend to be commercialized across larger regions or even internationally, as in the case of *Morchella* spp. or *Suillus* spp., in some regions by technically and logistically rather advanced trade chains. However, there is only little published and updated information about commercial statistics of edible mushrooms in South America, especially of mycorrhizal species (Quiroz et al. 1996; Gysling et al. 2005; Albertó et al. 2010).

16.5.2 Mycosilviculture

Approaches toward sustaining, increasing, or diversifying production of EEMF in native forests or timber plantations are forming part of the concept of mycosilviculture (Savoie and Largeteau 2012; Wang and Chen 2014). Especially in managed, low-diversity, or degraded forest ecosystems, mycosilviculture can be an efficient tool for reinforcement or enrichment of mycorrhizal associations, with special focus on EEMF (Iwabuchi et al. 1994; Palma et al. 2021).

Mycosilvicultural methods aiming at increased productivity of EEMF are based on enrichment or boosting of natural production by inoculating compatible host trees in situ with spores or mycelium of selected species, previously produced under controlled conditions. In a study aiming at optimizing culture conditions for mycelial inoculum, Santelices et al. (2012) found differences in growth rates of geographically distant *Suillus luteus* strains from central Southern Chile. Successful formation and high colonization rates of mycorrhizal roots formed by *Pinus elliottii* Engelm. inoculated with spores of fresh *Suillus granulatus* were reported from Argentina by Nouhra and Becerra (2001). Pereira et al. (2014) induced mycorrhiza formation in seedling roots of *Pinus radiata* inoculated with mycelium of *Lactarius quieticolor* isolated in central Southern Chile and produced under optimized conditions in liquid medium. Also, inoculation trials of *P. radiata* with introduced *Boletus edulis* Bull. and *B. pinicola* (Vittad.) A. Venturi were reported for Chile by Chung et al. (2010); however, although formation of mycorrhizal roots could be observed in laboratory and nursery, no production of sporomata occurred.

A highly promising approach of enrichment of autochthonous EEMF in native *Nothofagus* forest by spore irrigation was recently realized by Palma et al. (2021) in Southern Chile, Valdivia Province: in a long-term collaboration project with a community of rural mushroom collectors and small land owners, spore inoculum of *Boletus loyo* and *Ramaria* spp. was brought out in previously monitored and prepared forest patches, accompanied by an information and training campaign for environmentally friendly EEMF harvest and adequate habitat management. During three consecutive years after spore irrigation treatment (2020–2022), at least one of the experimental sites showed continuously increasing production of *Ramaria flava* (changle) (Fig. 16.1), whereas the land owners reported that before the treatment, they had yielded very little or no harvest of this species from the same site. Although the results are still under evaluation, they provide important evidence that mycosilvicultural techniques can be powerful tools for sustainable use of native fungal resources and *Nothofagus* forest by local communities.

Fig. 16.1 Growth and harvest of edible *Ramaria* cf. *flava* basidiomata (lower photo showing EEMF gatherer Rosario Catripan Lincocheo from Caricuicui) in privately owned managed *Nothofagus* forest in Southern Chile (Valdivia Province) during May 2022, 3 years after spore irrigation treatment. Photo credit: Rodrigo Sagardía Parga, INFOR Valdivia

16.5.3 Truffle Culture in South America

Culture methods for *Tuber* spp., mainly for *T. melanosporum* Vittad. from Mediterranean Europe, were introduced in South America from around 2000 onward. Due to the Mediterranean to temperate climate required by *T. melanosporum* and other species of interest, like *T. borchii* Vittad. and *T. magnatum* Picco, Southern Chile and Argentina so far have proven to be the most adequate countries for truffle culture on the continent (Micofora 2018). First experimental assays with *T. melanosporum* were successfully performed and documented in Central Southern Chile by academic research teams (Pérez et al. 2007; Pereira et al. 2013). Results and perspectives of the attempts to introduce *Tuber magnatum* in truffle orchards in Chile have been recently summarized by Pereira et al. (2021). At present, private entrepreneurs provide a growing number of interested land owners with mycorrhizal tree seedlings inoculated in vitro, mainly with *T. melanosporum,* and, along with guilds of truffle growers, also offer technical guidance for successful management of truffle orchards in both countries (www.atchile.cl, www.trufasdelsur.com); harvests, as far as being documented in public media, have reached profitable levels within a few years (Micofora 2016). An interesting aspect of sustainable mycosilviculture has been the successful in vitro synthesis of ectomycorrhizas between *Nothofagus obliqua* and *Tuber melanosporum* (Pérez et al. 2007), which could open a new perspective for combining conservation and reforestation of native Fagales trees with truffle production, reducing the need of planting allochthonous host trees like *Quercus* or *Corylus*.

16.6 Mycogastronomy and Cultural Importance

During recent years, a rising interest in promoting wild mushrooms as part of local or regional gastronomy can be observed in various regions in South America, but scientific studies about this issue are still scarce. Fernández et al. (2021) recently published the results of an interview campaign performed with local chefs from the Cordillera de Chubut, Argentinian Patagonia, reporting EEFM being commonly offered in restaurants but only a low variety of species, led by introduced *Suillus luteus* and morels, whereas other, especially native fungi, only play a marginal role, mainly due to irregular and unpredictable supply as well as lack of knowledge about species or problems with their identification.

S. luteus is a neophyte in many regions of South America and, as mentioned above, even grows adventitiously in areas where no native EEMF existed before. Its harvest can therefore be an opportunity for local peasants to diversify crop sales and yield additional income, as has been shown for rural communities in Bolivia by Melgarejo Estrada et al. (2018). In central Chile, there exists even a traditional fair since 1988 in the village of Empedrado, dedicated to activities around *S. luteus*, called “Festival de la Callampa.”

Also in Chile, festivals or fairs held around native EEMF can be seen to be spreading along an increasing number of villages and urban areas: The "Changle" (*Ramaria*) Festival takes place in the town of Cañete every year since 2012, featuring cooking workshops by well-known national chefs, artistic shows, a mycological tour known as the "Changle Route," contests, gastronomy, and handicraft sales. In the town of Paillaco, located near the city of Valdivia, the Wild Mushroom Festival created in 2014 is organized during the month of April where dishes based on mushrooms, such as changle, loyo, lebre, among others, can be tasted, in addition to other activities linked to mushrooms. The Morel Festival has been held since 2015, in December, in Villa Ortega, located near the city of Coyhaique in Chilean Patagonia, which not only promotes sustainable harvesting of *Morchella* but also intends to raise awareness to increasing threats such as intentional burning of native forest and overexploitation. In this festival, art is presented together with dishes based on this gourmet edible mushroom. Another example is the "FungiFest" mushroom festival held in Valdivia since 2016, with scientific and popular talks on mushrooms, handicraft sales, photography, and cooking contests, highlighting characteristics and uses of a large number of species for a broad public.

For Argentina, Barroetaveña and Toledo (2016) mention high diversity of EEMF associated with Nothofagaceae in western Patagonia, some of which are little known and, therefore, not collected by the local and regional population; accordingly, the authors seek to promote the sustainable collection and consumption of these mushrooms as a novel non-timber forest product. In Chubut, wild edible and cultivated mushrooms have been incorporated into a gastronomic circuit called "Patagonia Fungi, trails and flavors," co-organized by public and private entities and based on experiences in foreign countries, mainly European, which promotes mycogastronomy and mycotourism. Activities include courses and workshops for collectors, flavor tastings with chefs from the region, gastronomic fairs, joint organization of tasting dinners of novel mushrooms, and the production of preserves and gourmet products (Fernández et al. 2021).

16.7 Nutritional Chemistry and Biological Activity

Edible wild mushrooms have been part of the human diet for centuries due to their attractive nutritional and organoleptic characteristics, such as flavor, texture, and aroma (Aisala et al. 2020). From a nutritional point of view, mushrooms are low in lipids but present high content in proteins, carbohydrates, fiber, vitamins, and minerals (Cheung 2010; Valverde et al. 2015). In addition to being recognized as a nutritious food, certain mushrooms are also an important source of biologically active compounds with medicinal potential, including phenolic compounds, polysaccharides, sterols, and triterpenes, among others (Wasser 2010).

Most chemical analyses of EEMF have been performed with species from the northern hemisphere, only some of which are adventitious in South America (Kalač 2013). For example, Ribeiro et al. (2009) characterized the lipid profile of European species, such as *Amanita rubescens* Pers., *Suillus bellinii*, *S. granulatus*, and *S. luteus*, which are also adventitious in South America (Valenzuela et al. 1998; Niveiro et al. 2009; Chung Guin-Po 2021). However, chemical and organoleptic analyses are generally still scarce for South American EEMF, especially for native and endemic species: High carbohydrate content and low fat/protein ratio was determined for *Boletus loyo* mushrooms from Chile by Schmeda-Hirschmann et al. (1999), as well as for *Cortinarius magellanicus* and *Ramaria patagonica* from Argentinian Patagonia by Toledo et al. (2016); in the latter study, the authors also detected high content of tocopherol in *C. magellanicus*, whereas *R. patagonica* stood out by its high antioxidant activity and phenol content. Barroetaveña et al. (2020) expose in detail the nutritional composition of common EEMF from *Nothofagus* forests as well as from pine plantations. Jacinto-Azevedo et al. (2021) provide not only nutritional data (moisture, protein, fat, ash, and carbohydrate content) but also biological activity (antibacterial, antifungal, and antioxidant) for four EEMF native to Chile and Argentina: *Boletus loyo, Cortinarius lebre, Ramaria flava*, and *R. subaurantiaca,* among which *R. flava* stands out by its high antioxidant activity.

16.8 Outlook: Global Change and Conservation Strategies

Following a worldwide tendency, changes in climate and soil use are putting increasing strain on many natural habitats of EEMF in South America. The most important factors, which negatively affect mycorrhizal trees and associated fungi in the region, are disturbance and deforestation of native woodlands as well as overharvesting of wild mushrooms in the remaining forests. Conservation measures for EEMF should include individual fungal species as well as their tree hosts and specific habitats. Protection should be implemented not only by improving environmental laws but also by recommendations for good practice and sustainable harvesting, made available to mushroom collectors. In Chile, the conservation status of fungi is classified according to IUCN criteria since 2012 by the Ministry of Environment, based on an annual public call for suggestions of species. To date, distribution and vulnerability of the important EEMF *Boletus loyo* (classified as endangered "EN") and *Cortinarius lebre* (classified as vulnerable "VU") have been assessed (MMA 2022). A proposal of classification of the respective ecosystems and phytosociological units by IUCN criteria has been published (Pliscoff 2015) but is awaiting legal status. However, protocols and recommendations for sustainable harvesting are being issued by governmental and scientific institutions as well as by NGOs (Salazar Vidal 2016b; Palma et al. 2021).

On the other hand, local invasion of native forest by ectomycorrhizal fungi, which were originally introduced with allochthonous timber trees but changed to autochthonous tree hosts, has been observed. For the special case of EEMF, there is the example of *Amanita rubescens* in Southern Chile, which, being locally adventitious in Monterrey Pine plantations, has also been reported from pure *Nothofagus* forest in the coastal mountains near Valdivia (Valenzuela et al. 1998).

Sustainable harvest of EEMF, especially in native forests, should be based on protection of fungal species (selective and careful extraction of sporomata, minimally intrusive treatment of substrate and mycelia) but also of the habitat (host trees, understory, water courses); in managed forests, grazing livestock should be excluded; on the other hand, pruning and selective cutting of trees may be considered in order to maintain canopy cover and tree density adequate for the respective EEMF taxa (Palma et al. 2021).

There is evidence that at least some of these good practices have been applied and passed on since ancient times by indigenous and rural communities, for example, in Southern Chile and Argentina; these often local experiences should be considered as a baseline for the development of regional, socially acceptable collector's guidelines and conservation frameworks for EEMF in South America (Tacón et al. 2006; Alvarado-Castillo and Benítez 2009; Toledo et al. 2014).

Finally, as outlined by Pérez-Moreno et al. (2021), sustainable use and management of EEMF based on local and regional cultures and traditions can have multiple positive effects on economy, ecology, and social structure, especially on a highly diverse continent like South America.

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