Agroforest Syst
https://doi.org/10.1007/s10457-024-00971-2

Benefits associated with traditional livestock systems in family sheep farms in the Chiloé Province, Chile

P. Lima de Lima · L. C. Pinheiro Machado Filho · M. J. Hötzel · E. V. Machado · F. L. D. D'Ávila

Received: 15 December 2023 / Accepted: 16 February 2024

Abstract The inclusion of trees in pastures have emerged in recent years due to the benefits they generate towards livestock ecosystems. In the province of Chiloé, Chile, family farmers still maintain different designs that integrate the tree component and grasslands. The objective of this papper is to identify designs that integrate forestry components in livestock in the Chiloé Province, Los Lagos Region, Chile, to know the functionality attributed to them by family sheep farmers, and to verify if the participation of farmers in agroecological networks influences their perception of the benefits of silvopastoral systems (SSP). The present work identified 5 types of traditional SSP, and 8 benefits were associated with them by sheep farmers. The forest patch system is the most widespread in farms. Sheep farms under agroecological management have had greater adoption of forest patch SSP in relation to those that are not agroecological. Shade is the benefit most cited by ranchers and native species predominate in their designs.

Keywords Silvopastoral system · Sheep farming · Agroecology

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10457-024-00971-2.

P. Lima de Lima (✉) · L. C. Pinheiro Machado Filho · M. J. Hötzel · E. V. Machado
Laboratório de Etologia e Bem-Estar Animal, Universidade Federal de Santa Catarina, Florianópolis, Santa Catarina, Brazil
e-mail: patricialima.agro@gmail.com

L. C. Pinheiro Machado Filho
e-mail: pinheiro.machado@ufsc.br

M. J. Hötzel
e-mail: maria.j.hotzel@ufsc.br

E. V. Machado
e-mail: elelan_machado@outlook.com

F. L. D. D'Ávila
Núcleo de Ensino, Pesquisa e Extensão em Agroecologia, Universidade Federal de Santa Catarina, Florianópolis, Santa Catarina, Brazil
e-mail: eng.agronomofernandodiniz@gmail.com

Introduction

Initiatives for afforestation in pastures have been studied in different parts of the world. When implemented intentionally, these systems are referred to as Silvopastoral Systems (SSP) (Montagnini et al. 2013; Chará et al. 2020). AFSs emerge with various objectives and at different scales, proving to be highly beneficial in enhancing livestock systems in ecological, economic, and animal welfare aspects (Barragán-Hernández 2019; Gomes et al. 2022; Mancera 2018; Broom et al. 2013). At a large scale, exotic species such as Pinus spp. and Eucalyptus spp. have been utilized for timber production, providing additional income to livestock activities, and sometimes integrating rotation and intercropping systems with

Published online: 17 April 2024

annual crops (Bosi et al. 2020; Barbosa et al. 2019). Preferred designs involve single-strip systems at a density that allows the growth of herbaceous species for livestock feed without compromising timber production (Paula et al. 2013; De Souza et al. 2023).

Increasing the functional biodiversity of these systems is important to enhance ecosystem services such as nitrogen fixation, habitat for fauna, production of non-timber forest products, and improvement in soil quality (Simioni et al. 2022; Sales-Baptista 2021; Kinneen 2023; Zin Battistti 2020). In Latin America, the integrated use of native tree-grasslands is a traditional practice, especially in areas with fragile ecosystems where intensive agriculture and livestock farming can not to thrive (Toro-Mujica and Riveros 2021; Toro-Mujica et al. 2019; Silva et al. 2013; Avilez et al. 2021).

Considering the climate crisis and anticipated economic uncertainties, the ability to produce food with minimal inputs in increasingly challenging environments is a trajectory to which animal science should aspire (Rockström et al. 2009). Traditional knowledge plays a crucial role in dialogue with science in the search for new alternatives for sustainable production and crisis management (Sun et al. 2013; Gómez-Baggethun 2012).

When discussing traditional knowledge, the idea of backwardness and purity must be abandoned. We refer to a type of knowledge that was locally developed, based on the real needs of communities, and has adapted over time to societal changes, incorporating other sources of knowledge such as scientific knowledge (Guerrero et al. 2019). Breaking the myth that traditional knowledge is outdated allows us to look at these systems, in our case, for the use and knowledge about the forest component, drawing several lessons to propose alternatives for agroecosystem afforestation (Santoro et al. 2020; Guadilla et al. 2019).

Considering the significance of family livestock farming in Latin America and the role of traditional knowledge in providing clues for local pasture afforestation, the objective of this study is to identify designs that integrate forest components into livestock farming in the Province of Chiloé, Los Lagos Región, Chile. The study aims to understand the functionality attributed by family livestock farmers and to determine whether their participation in agroecological networks influences their perception of the benefits of SSP.

Methods

Study area

The Chiloé Archipelago is located at Latitude: − 42.4667, Longitude: − 73.8, 42° 28′ 0″ S, 73° 48′ 0″ W, with a surface area of 9182 km^2. It is situated in the Los Lagos Region, Southern Chile, and comprises a formation of 26 islands. Chiloé's climate is defined as cold-temperate, without a dry season, with concentrated rainfall in winter (Alcayaga et al. 1963). The accumulated precipitation in the year 2020 was 1495.2 mm, with an average minimum temperature of 6.7 °C and an average maximum temperature of 14.6 °C (INIA 2020). The predominant original vegetation includes evergreen forest types, including alerce, as well as formations of *Nothofagus antarctica* and *Sphagnum magellanicum* moss, which contribute to forests of *Nothofagus nitida* in peat bog areas (Ramírez et al. 1996).

Establishments

A total of 83 family sheep farms distributed across 7 communes in the province of Chiloé, Chile, were analyzed. The establishments were categorized as family livestock farming due to low use of external inputs, extensive nature system, and the prevalence of family workforce (Porto et al. 2010). Active participants in rural extension programs, residing in easily accessible establishments, were chosen. All participants engaged in other complementary activities, with cattle farming, vegetable cultivation, and wage labor being the most mentioned. The herd size varied from 6 to 90 breeding ewes, with 69.88% stating that sheep farming was their main activity. Visits to each establishment were conducted between January and May 2023, with an approximate duration of 2 h each. In 96.6% of the establishments, naturalized grasslands with species adapted to temperate climates predominated (INE 2007). High-performance grasslands were characterized by the plant community *Holcus lanatus, Anthoxanthum odoratum, Trifolium pratensis, Trifolium repens,* and *Lotus curniculatus* (Dietl 2013). Areas with a predominance of *Agrostis capillaris* and broadleaf species indicated grasslands in the early stages of degradation. Establishments with higher levels of technological adoption implemented supplementary grasslands of *Lolium* spp*., Avena* spp*., and*

Trifolium spp. for direct grazing or storage in silage or hay formats. Family workforce was employed, with third-party hiring for specific activities such as shearing and health management.

SSP arrangements

During the visit, all types of tree formations present on the establishment were identified and described according to the observed arrangement and the classification attributed by the livestock farmer. An interview with open and closed-ended questions was conducted to determine the origin of the observed tree formation, whether planted or spontaneous, the attributed benefits and uses, the species used, and their management. Recognizing the family unit as a whole and the need for a gender and youth approach, preference was given, whenever possible, to the participation of women and young people during the interviews. After data collection, a classification of the observed arrangement types described by the livestock farmers was carried out. Those with a similar arrangement were grouped, and the frequency of each was calculated. Once categorized, the data were cross verified with satellite images using Google Earth software to finalize the classification. Participants were categorized based on their participation in ecological production networks, and a chi-square test was used to assess whether participation was related to the adoption of SSPs.

Results and discussion

SSPs descriptions

Five tree arrangements of SSPs were identified.

Forest Patches: Areas of natural vegetation, mostly forests with a high degree of intervention, containing individuals of different sizes, primarily those in the early stage of succession, including species such as *Rhaphithamnus spinosus*, *Drimys winteri, Gevuina avellana, Luma apiculata, Eucryphia cordifolia, Chusquea quila.* The reasons for maintaining these areas include wood extraction, protection of water resources, and animal shelter. These systems are referred to by farmers as “bosques” or “montes” and generally occur at the edges of paddocks. Some interviewees attributed forage value to this zone, using it as paddocks during winter periods of forage scarcity. Species reported for consumption by sheep belong to the Myrtaceae family, mainly during budding. Excessive browsing can affect native forest regeneration depending on browsing pressure. In Chile, some studies have shown that livestock are more detrimental to the regeneration of evergreen forest compared to selective logging (Zamorano et al. 2014), especially in plants below 1.5 m in height (Sotomayor 1989). Forest patches are areas where property water resources are found, requiring protection and planning measures to prevent degradation. Unconventional functionalities, such as veterinary medicinal use, are also mentioned, as in the case of Canelo (*Drimys winteri*), where the infusion of leaves and bark is used as an anthelmintic for sheep and goats.

Scattered Trees: Although they cannot be considered silvopastoral systems per se, some livestock farmers maintain large trees within paddocks. Despite being structurally and diversely simplified systems, they contribute various benefits to the overall system. In a carbon inventory conducted at the CET Chiloé center (Manual of Silvopastoral Systems for the Chiloé Province, unpublished), it was found that these specimens accounted for a significant percentage of carbon stock on a livestock property. Additionally, the commonly used species *Maytenus boaria* has the capacity to fix nitrogen, recycling the nutrient into the soil. This species is also widely recognized in traditional knowledge as a source of food for livestock, particularly as feed in the trough. During times of food scarcity, pruning is carried out, and the branches are offered to the animals for this purpose. The etymology of the scientific name “boaria,” derived from the Latin “boarius,” signifies an area of pasture for oxen or related to oxen. The *Nothophagus nítida* species also frequently appears in this design. Generally, these are mature trees exceeding 20 m in height, serving the exclusive purpose of providing shade to the animals. They represent the last arboreal individuals in the pastures, and their demise results in the complete disappearance of the arboreal component from the paddocks.

Windbreak Curtains: These are linear arrangements with trees exceeding 10 m in height. In most properties, windbreak curtains were implemented by the owners’ predecessors, and no recently implemented windbreak curtains were observed. They consist of both native and exotic trees, either mixed or

monospecific, with varying degrees of permeability. The planted species *include Pinus spp., Eucalyptus spp., Maytenus boaria, Popolus spp*., in single-species designs, mainly located near structures to protect infrastructure and, to a lesser extent, to shield paddocks from strong northern winter winds. Native species such as *Luma apiculata, Rhaphithamnus spinosus, Eucryphia cordifolia, Nothophagus nitida, Nothofagus alpina,* and the exotic *Alnus glutinosa* appear in formations that could be described as a mix of windbreak curtain and live fence, serving both to divide paddocks and protect against the wind. They are generally remnants of natural vegetation managed for this purpose. In sheep production systems, wind protection is crucial as it is directly associated with lamb survival (Obst and Day 1968). Windbreak curtains composed of trees, shrubs, or grasses can aid in reducing lamb mortality (Pollard 2006; Masters 2023). Considering the relative ease of implementation, this design appears to be quite promising for adoption in sheep farms.

Tree Shelters: Nuclei of native trees, not intentionally planted, selected during the conversion of forested areas to livestock farming. These dense designs, ranging in size from 5 to 10 m in diameter of nuclei, predominantly feature mature individuals with low natural regeneration. They are highlighted as a shelter for lambing during the autumn–winter months and mainly include species such as *Luma apiculata, Amomyrtus luma, Gevuina avellana, Amomyrtus meli, Drimys winteri, Rhaphithamnus spinosus, Aristotelia chilensi*s. In some cases, there are shelters exclusively with the species *Luma apiculata*. These designs are expressly attributed to animal protection, particularly during the winter lambing period. Ewes seek refuge in protected areas during lambing, favoring the direct survival of lambs (Val-Laillet and Nowak 2006), which seems to be well observed by breeders. Protection against predatory bird attacks, a common issue during the first days of lamb life, is a benefit associated with this type of system. Farmers refer to this arrangement as a "playground," implying that they attribute this place as a space for the welfare and rest of the animals.

Living Fences: Small-sized trees, not exceeding 5–8 m in height, predominantly species like *Luma apiculata, Amomyrtus luma, Salix babylonica*. Planting occurs from woody stakes, spaced at 1.5–2 m, used as posts for constructing paddock division fences. Implementation takes place in the winter season, from May to July, to ensure higher survival rates. Other aspects, such as the beveled cut on two sides and the use of biostimulants based on seaweed, are considered. Some families still consider lunar phases for stake planting, with the waning moon associated with higher rooting rates. In older living fences, plant density increases due to natural dissemination by birds or reproduction when no thinning is carried out. When analyzed over the long term, living fences present a higher Internal Rate of Return (IRR) and lower implementation costs compared to fixed wire fences (Queiroz et al. 2015). Given the local wood scarcity and high labor costs, this ancient technique could still be relevant. Newly implemented systems were observed during visits.

To better illustrate, the types of Silvopastoral Systems (SSP), adoption frequency among participants (%), and associated benefits are detailed in Fig. 1.

The forest patch design had the highest incidence on the properties, which can be associated with a greater number of benefits attributed by livestock farmers to this design compared to others and the ease of its maintenance. The study corroborates a preference among producers for managing natural forests compared to tree planting (Wilkens et al. 2022) Shade is the main recognized benefit, appearing in all types of designs. Although in a temperate climate during the summer, sheep may experience heat stress due to high air humidity, which often exceeds 90% on many summer days. Cold protection is also mentioned as a significant benefit of SSPs, even though most farmers have infrastructure to protect the herd. Some farmers mention that outdoor shelter is preferable because it reduces hoof problems and labor associated with barn cleaning.

The use of wood for on-site purposes, followed by the protection of water resources, are mentioned benefits. The archipelago relies exclusively on groundwater, and the pressure on this resource is discussed every year (Valdebenito 2012). However, direct livestock access has caused severe degradation, requiring guidance for restoration. Other motivations, such as conservation itself, medicinal use, and fruit collection, are attributed to a lesser extent.

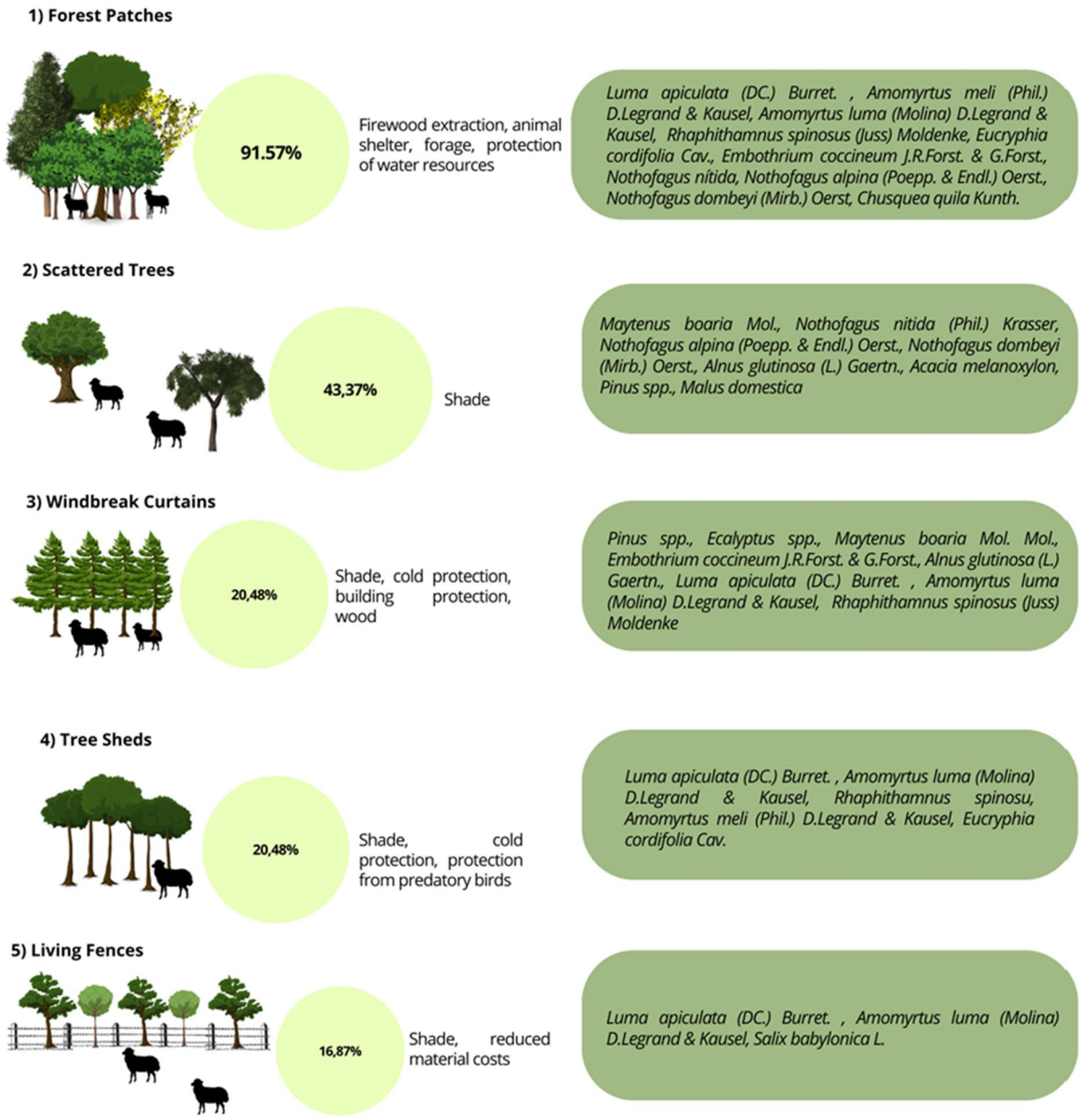

Fig. 1 Types of SSP, Adoption Frequency, Main Species, and Benefits Observed by Interviewed Livestock Farmers

Species used

In all the systems, a preference for native species is reported due to several advantages indicated by the livestock farmers, such as greater natural propagation, adaptability to climate and soil, and as a feeding option during the winter. When asked about planting within the property, the majority stated that they had not planted but had managed succession (57%), followed by the planting of exotic species (19%) (Fig. 2). Various factors may have led to this behavior, with one of them being the low availability of native plants in local plant nurseries, coupled with the incentive and donation of exotic seedlings, mainly of the genus Eucalyptus spp., in reforestation programs.

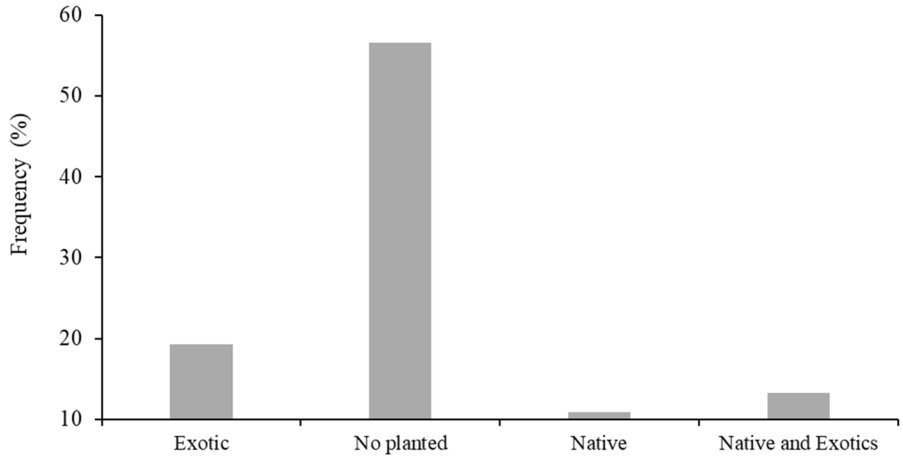

Fig. 2 Frequency of tree species planted by sheep farmers in Chiloé

When asked about which species are used by the animals for feeding o other, a total of 35 plants were cited. The most mentioned species was *Luma apiculata* (18), followed by *Chusquea quila* (10) (Fig. 3). Luma apiculata is a species quite present in productive systems due to its rapid growth and the possibility of using wood for fence construction. It has rapid natural dissemination in areas near fences or protected from livestock disturbance. *Chusquea quila* is a shrubby species of the Bambusoideae subfamily. It is an important forage source during the winter due to its high production of dry matter, although it has low nutritional value. In the following graph, the species mentioned during the interview as valuable for livestock systems, either for animal feed, shade, or wood, are presented (Fig. 3).

Participation in agroecological network

Seeking to understand initiatives that favor pasture afforestation, the interviewed farmers were categorized as Agroecological or Conventional based on their participation in networks or groups of organic/agroecological producers. The networks identified during the research were the Organic Producers Association, the SIPAM Producers Network, and the Agroecology and Silvopastoral Systems Network, the latter being informal. Some participants were part

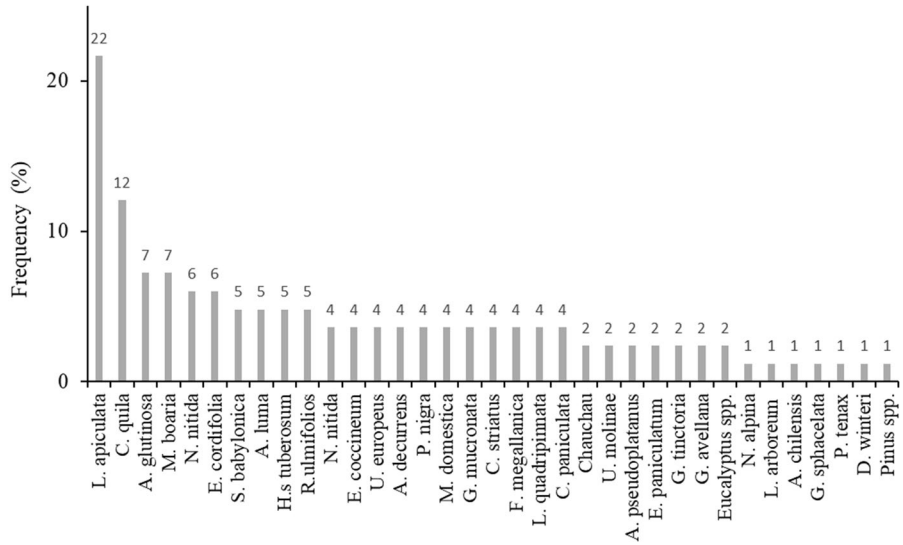

Fig. 3 Main species identified for use in sheep production systems

of more than one group simultaneously. Those categorized as agroecological represented 41.25% of the interviewed farmers. These farmers showed higher afforestation in the forest patch design compared to those who identified themselves as conventional ($p = 0.024$). For the other designs, there was no differentiation between them. In this sense, we can suggest that perhaps participation in these networks does not contribute to the adoption of new systems but does contribute to the maintenance of native forests with multiple uses. Nevertheless, directing strategies to promote the adoption of planted systems through these networks can be interesting for different reasons: (1) Exchange of knowledge about management practices in Silvopastoral Systems; (2) Exchange of genetic material, plants, and seeds; (3) Establishment of community nurseries to reproduce species of interest for use in Silvopastoral Systems.

Conclusion

- Shelter and cold protection are the benefits attributed to trees by livestock farmers, indicating a motivation for afforestation with a focus on animal welfare.
- Culturally, managing succession seems more interesting than planting trees, regenerative SSP with native species being an interesting alternative for this group.
- There is a wide range of species identified by farmers and the Myrtaceae family seems promising due to easy propagation and multiple uses.
- As expected, participants in agroecological networks demonstrate greater sensitivity to conserving native vegetation within their properties.
- The Forest Patch and Living Fence systems show recent regeneration or establishment. The other systems have not been surveyed and could be transformed as regeneration does not occur.

Acknowledgements We would like to express our gratitude for the funding received from CAPES, CNPQ, and UNIEDU to support the primary author and co-authors in the development of this research.

Author contributions The main text was drafted by PL, LCPMF, and MJH, while EVM and LFDA reviewed and contributed to the Spanish and English versions. Additionally, EVM and LFDA were responsible for the creation of figures and graphs. The final version was approved by all authors.

Data availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare no conflict of interest.

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