Ethnoecology for the control of *Hovenia dulcis* in the deciduous seasonal forest Santa Catarina, Brazil

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Research

Abstract

Background: The Deciduous Seasonal Forest (DSF) is one of the most abundant phytophysiognomies in Santa Catarina State / Brasil. However, it is severely impacted by fragmentation and introduction of invasive exotic species. In this scenario, the *Hovenia dulcis* is a species with a high degree of biological invasion, including in protected areas as the Fritz Plaumann State Park/Santa Catarina. Our objective was to understand the history of introduction of this invasive species in the park area, as well as to identify plant species with the potential to replace *H. dulcis*.

Methods: Semi-structured interviews were carried out with informants residing in the Park's Buffer Zone (BZ). As base data for analysis, we use citations of use and the potential replacement species. For the complementary analysis, the consensus value or level of fidelity for the uses was estimated. To investigate the introduction history of the species in the study region, a literature search was conducted on the use of *H. dulces*.

Results: Twenty-four informants were interviewed. The uses related to *H. dulcis* comprised thirteen citations. In the analysis of rapid ordering, firewood (23.25) was the most cited use. A total of thirty-four cited species with the potential to replace *H. dulcis* was obtained. The species' introduction history confirmed the technical indication as one of the main stimulators of the species' expansion in the region.

Conclusions: Results demonstrate that the species is considered, by farmers, technically suitable for cultivation in the BZ of the Park. Hence the importance of highlighting other species with a greater or equal level of biological characteristics to replace *H. dulcis*.

Keywords: Invasive alien species; ethnobotany, protected areas

Resumo

Antecedentes: A Floresta Estacional Decidual (DSF) é uma das fitofisionomias mais abundante no Estado de Santa Catarina/Brasil. Contudo, é severamente afetada pela fragmentação e introdução de espécies exóticas invasoras. Neste cenário, a *Hovenia dulcis* é uma espécie com um alto grau de invasão biológica, inclusive em áreas protegidas como o Parque Estadual Fritz Plaumann/Santa Catarina. O nosso objetivo foi compreender a história da introdução desta espécie invasora na área do parque, bem como identificar espécies vegetais com potencial para substitui-la.

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Métodos: Foram realizadas entrevistas semi-estruturadas com informantes residentes na Zona de Amortecimento do Parque (ZA). Como dados de base para as análises utilizamos citações de uso e de espécies com potencial de substituição. Para a análise complementar, foi estimado o valor consensual ou o nível de fidelidade para os usos. Para investigar o histórico de introdução da espécie na região de estudo, foi conduzida busca bibliográfica sobre o uso da *H. dulces*.

Resultados: Foram entrevistados vinte e quatro informantes. Os usos relacionados com *H. dulcis* compreenderam treze citações. Na análise de ordenamento rápido, a lenha (23,25) foi a utilização mais citada. Foi obtido um total de trinta e quatro espécies citadas com potencial para substituir a *H. dulcis*. A história de introdução da espécie confirmou a indicação técnica como um dos principais estimuladores da expansão da espécie na região.

Conclusões: Os resultados demonstram que a espécie é considerada, pelo agricultores, tecnicamente adequada para o cultivo na ZA do Parque. Daí a importância de destacar outras espécies com maior ou igual nível de características biológicas desejáveis para substituir *H. dulcis*.

Palavras-chave: Espécies exóticas invasoras; etnobotânica, áreas protegidas

Background

The Deciduous Seasonal Forest (DSF) has two well-defined climatic seasons and about 50% of the plant species are deciduous (Gasper *et al*. 2013). In Santa Catarina (SC), mainly in the west of the state, the predominant forest formation is the DSF, with an extension of 16% of forest remnants (Vibrans et al. 2012).

However, in the state of Santa Catarina, the DSF is severely degraded. This impact was caused by the occupation of the territory between the 1920s and 1960s, by the arrival of immigrants, who started the extractive activity for the timber sector, predominant converting the forest into areas for livestock or agriculture (Ruschel *et al*. 2003). Besides fragmentation, another impact on this forest formation has been the introduction of invasive exotic species, especially the *Hovenia dulcis* Thunb. (Rhamnaceae), with its origin in Asia. This deciduous species reach up to 25 meters high with a spheric crown. Its fruits are capsules in fleshy peduncles, attractive to fauna (Carvalho 1994, Dechoum *et al*. 2015).

H. dulcis has a large distribution in southern Brazil, especially due to introductions in degraded areas. However, this species tends to form dense clusters hindering the development of native species (Carvalho 1994, Mundeleski *et al*. 2008). Nonetheless, through technical recommendations, the species was indicated for introduction in agricultural properties as a form of shading in aviaries, besides having good timber contribution, especially for firewood (Cardoso *et al*. 2013).

Because *H. dulcis* is considered an invasive exotic species, bringing damage to biodiversity. Also, it has been considered a problem in several locations in the midwest of Santa Catarina, such as in Fritz Plaumann State Park (PAEFP) located in the municipality of Concórdia/SC; where it is estimated that 50% of the total area of this protected area (PA) is occupied by the species (Fatma 2014). This PA is the only one that protects the DSF in Santa Catarina, besides being home to several native species that are economically valuable, such as **grápia** (*Apuleia leiocarpa* (Vogel) J.F. Macbr.), but whose populations are declining due to logging in previous decades (Ruschel *et al*. 2003, Fatma 2014).

Strategies are being considered for controlling the species in this unit, for example, the gradual removal of specimens of *H. dulcis*, conducted especially under the supervision of the Institute for the Santa Catarina Environment Institute (IMA). However, the Buffer Zone (BZ) properties still use the species in the productive context. Thus, for the control activities to be effective, offering producers alternative replacement species is necessary.

Given the diversity of native species that occur in the region, especially due to the presence of the DSF, there are potential species known to farmers that could replace *H. dulcis*, thus reducing the pressure of this species on native populations while meeting the needs of farmers. Additionally, the Convention on Biological Diversity (1992) suggests establishing public policies that encourage the use of alternative species, restricting the practice of indicating invasive exotic species.

In this context, the study's main hypothesis is that farmers know local species that can act as substitutes for *H. dulcis*. Suppose the existence of these genetic resources and the knowledge associated with the use and

management of these species is proven. In that case, it could be possible to reduce the pressures on natural ecosystems gradually. Additionally, the work seeks to promote discussion about the economic and especially ecological impacts of agricultural activities, favoring a careful look at the complexity of the inter-relationship between agricultural and natural ecosystems.

In this scenario, the challenge of this study arises. It aims to understand the history of the introduction of *Hovenia dulcis*, in the Buffer Zone of Fritz Plaumann State Park in Concordia/SC, characterize the diversity of uses of the species, and to identify non-invasive species with similar attributes that can reduce the pressure of *H. dulcis* on the DSF.

Material and Methods

Study area

The study area comprised the Buffer Zone (BZ) of Fritz Plaumann State Park, a protected area located in the municipality of Concórdia, Santa Catarina, Brazil, with South latitude 27°17'26" 28 and West longitude 52° 05'15"61 (Fig. 1).

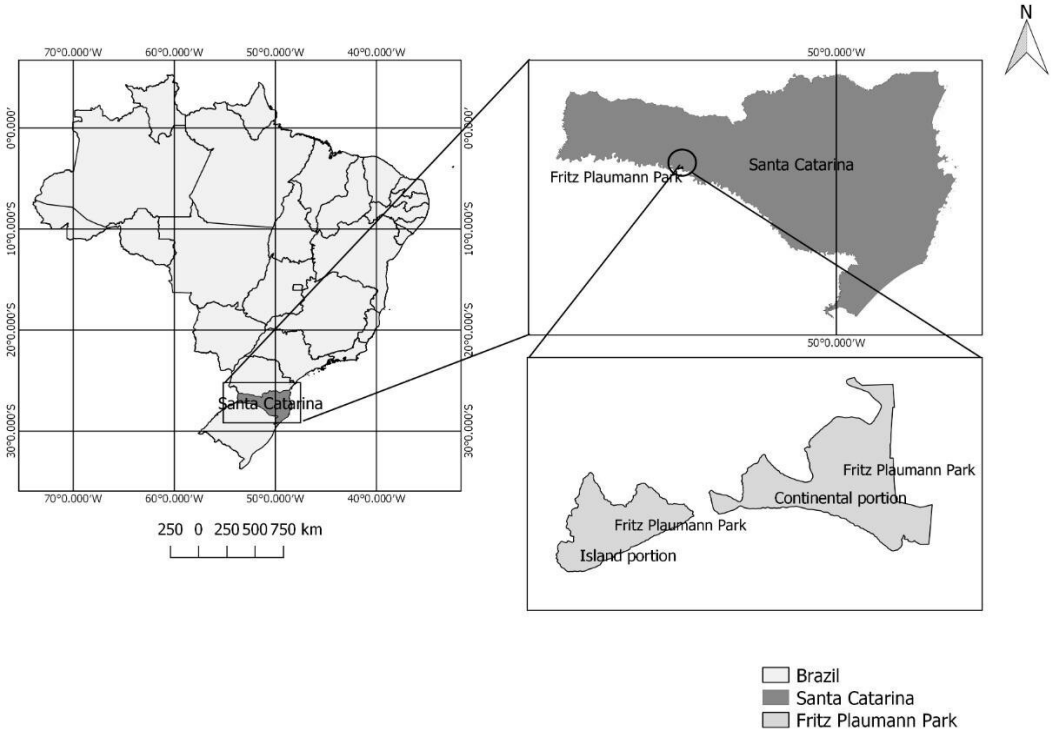

Figure 1. Study area.

The BZ covers an area of 1,778.95 hectares within a 29.31 km² perimeter. These surrounding areas are home to three rural communities: Sede Brum, Porto Brum, and Linha Laudelino, totaling approximately 70 rural properties with activities focused on pig farming, cattle farming, poultry farming, sheep farming, citrus farming, viticulture, and yerba mate plantations (Fatma 2014). The study sites included farms in Sede Brum and Porto Brum, which have *H. dulcis* specimens and where farmers were willing to participate.

Data collection took place from Jan/2017 to Apr/2017, covering two rural communities in the BZ, Sede Brum and Porto Brum.

Planning of the study

The participating farmers were contacted based on the non-probability intentional sampling technique "snowball" (Bernard 1994), where each farmer/informant indicates another possible informant who possesses the target attributes of the study (i.e., being in the Park's BZ and having *H. dulcis* specimens on the property). The farm was considered the unit of analysis.

Our research focused on a qualitative approach and consisted of two stages. The first stage relied on a semi-structured questionnaire (Bernard 1994, Viertler 2002) to collect data from the farmers. This questionnaire identified information mainly about uses, history of introduction of the species in the region, and tree species that could be used as substitutes for *H. dulcis*. The second stage consisted of a bibliographic survey on, i) the history of *H. dulcis* introduction through a timeline; ii) recommendations for its use; iii) a survey of potential species to replace *H. dulcis*; iv) and verification of regulatory issues on the use of invasive alien species in BZ. We used databases such as Google Scholar, Web of Science, Scielo, Scopus, Brazilian Digital Library of Theses and Dissertations (BDTD) and institutional repositories. As main search expressions were used: "technical recommendation", "uses of *H. dulcis*", "invasive alien species", "tree species of the Deciduous Seasonal Forest".

Analysis of the collected data

A content analysis was carried out (Franco 2005) through a literature review on the themes addressed for confirmation and/or discussion of the data. Additionally, the literature review stage sought to investigate the period and form of introduction of *H. dulcis* in the region.

The rarefaction method (Barros 2007, Miranda & Hanazaki 2008) was applied to verify the sampling sufficiency using the software *Estimates* (Estimates 2018). For this analysis, the statements about use and potential species for replacement were used (Albuquerque *et al*. 2010).

The Rapid Ordering Analysis (RIR) was also calculated; it considers the sequence in which a particular piece of information is cited, giving higher scores to those cited first and lower scores to those cited last.

For the complementary data analysis, the consensus value or fidelity level (FL) for the uses that farmers mentioned was estimated (adapted from Monteiro *et al*. 2006, Albuquerque *et al*. 2010). Being:

FL: (lp/lu)x100%,

where:
lp= number of informants who mentioned the main use of the species.
lu= total of informants who mentioned the species for any purpose.

The survey of species that could replace *H. dulcis* was based on interviews conducted with farmers and a literature survey. In order to list a preference index for each substitute species mentioned, an estimate was made by rapid ordering (Albuquerque *et al*. 2010).

Results

Twenty-four informants were interviewed, ranging in age from 36 to 86 years (mean= 48 years). The interviews were carried out in family units with the couple's participation (man and woman) on 16 occasions: only the man on six occasions and only the woman on two occasions.

For 22 family units, most property residents were reported as farmers, highlighting citrus production, annual crops, animal husbandry. In two family units, the informants and family members have a relationship with the agro-industry regarding yerba mate processing.

The rarefaction curve presented in Figure 2 (A) shows that the sampling effort (24 informants) was sufficient to cover the diversity of uses for the species known by the community. The curve shown in Figure 2 (B) indicates the potential for mentioning new tree species with economic and ecological characteristics similar to *H. dulcis* if there were new interviews. However, the stabilization for this indication would only occur after 50 interviews. This result is possibly due to the diversity of species present in this forest formation and to the profile of the informants who have a direct relationship with the rural environment and its landscape.

The uses related to *H. dulcis* comprised 13 mentions (Table 1), where the uses with the highest consensus rates were: firewood (100%), wood for internal use (66%), wood for external use (46%), cachaça/grappa (46%) and furniture manufacturing (38%).

In the Rapid Ordering Analysis shown in Table 1, it is possible to observe the preference of the informants regarding the uses mentioned. The 12 uses mentioned were listed by ranking them from 6 - "least important use" to 12 - "best/most important use". As a result, firewood (23.3) was the most frequently mentioned one, followed by wood for internal use (14.3), wood for external use (9.2), cachaça/grappa (8.2) and shadow (7.4). Thus, it can be observed that the RIR and the level of consensus were similar where firewood stands out, followed by woods for improvement and cachaça, differing only for shadow in the RIR, and in the FL for furniture.

Regarding the potential species to replace *H. dulcis*, a total of 34 species were mentioned, distributed in 18 botanical families (Table 2). The species with the highest number of references among the informants through the level of consensus were: **canela** (*Ocotea sp.*) (44%), **angico vermelho** (*Parapitadenia rigida* Benth.) (44%), **eucalyptus** (*Eucalyptus sp.*) (41%) and **grápia** (*A. leiocarpa*) (35%), in that order, respectively.

Table 1. Use mentions for *H. dulcis* followed by the level of consensus and rapid ordering stated in the interviews conducted in the Buffer Zone of Fritz Plaumann State Park/Concórdia-SC.

Uses	Fidelity level (FL) %	Rapid ordering (RIR)
Firewood	100	23.25
Wood for internal use	66	14.25
Wood for external use	46	9.16
Cachaça/Grappa	46	8.16
Furniture	38	7.08
Shadow	33	7.41
Honey	21	3.33
Fruit	13	2.66
Wine	13	2.66
Food (*in natura)*	8	1.50
Vinegar	4	0.66
Reforestation	4	0.66

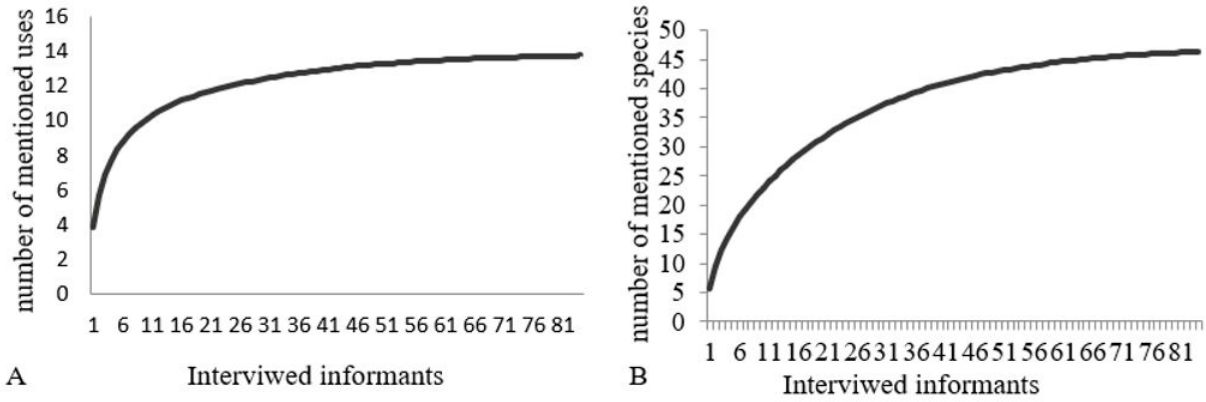

Figure 2. (A) Rarefaction curve referring to the mentioned uses for *Hovenia dulcis* in the Buffer Zone of Fritz Plaumann State Park/Concórdia-SC. (B) Rarefaction curve for tree species that can replace the *H. dulcis* according to informants from the Buffer Zone of Fritz Plaumann State Park/Concordia-SC.

The Rapid Ordering Analysis (Table 2) shows the preference of informants regarding tree species to replace *H dulcis*. There were 34 species mentioned, ranked from 23 - "less important species" – to 34 - "better/more important species." The species that presented priority in the informants' statements were respectively: **angico vermelho** (*P. rigida*) (14.5), **canela** (*Ocotea* sp.) (12,2), **grápia** (*A. leiocarpa*) (11,29), and **eucalyptus** (*Eucalyptus* sp.) (10.91). It is also observed that the RIR and FL were similar for the four species listed before, emphasizing that not only are they mentioned by most of the producers, but that they are more important, according to what they say. It is because the plants mentioned first are generally the most relevant to the farmers.

Table 2. Species with potential replacement of *H. dulcis*, followed by their respective botanical families, the fidelity level and the rapid ordering value obtained in the interviews conducted in the Buffer Zone of Fritz State Park/Concordia-SC.

Family	Common Name	Scientific Name	Fidelity level (FL) %	Rapid ordering (RIR)
Fabaceae	Angico vermelho	*Parapitdadenia rigida* Benth.	44	14.50
Lauraceae	Canela	*Ocotea* sp.	44	12.20
Myrtaceae	Eucalyptus	*Eucalyptus* sp.	41	10.91
Fabaceae	Grápia	*Apuleia leiocarpa* (Vogel) J.F. Macbr.	35	11.29
Meliaceae	Cedro	*Cedrela fissilis* Vell.	32	10.14
Araucariaceae	Araucária	*Araucaria angustifolia* (Bertol.) Kuntze	26	8.44
Fabaceae	Cabreúva	*Myrocarpus frondosus* Allemão	26	7.23
Malvaceae	Açoita Cavalo	*Luehea divaricate* Mart.	18	5.50
Fabaceae	Rabo de bugio	*Lonchocarpus campestris* Mart. ex Benth	12	1.85
Boraginaceae	Guajuvira	*Cordia americana* (L.) Gottschling & J.S. Mill.	12	3.35
Lauraceae	Canela Sassafras	*Ocotea odorifera* (Vell.) Rohwer	8	2.53
Pinaceae	Pinus	*Pinus.* sp.	8	1.88
Lauraceae	Canela Amarela	*Nectandra lanceolata* Ness	8	2.82
Fabaceae	Angico Branco	*Albizia polycephala* (Benth.) Killip ex Record	6	1.97
Platanaceae	Platanus	*Platanus* sp.	6	1.68
Myrtaceae	Guabiroba	*Campomanesia xanthocarpa* (Mart.) O. Berg	6	1.62
Lauraceae	Canela Branca	*Ocotea spixiana* (Nees) Mez	6	1.67
Meliaceae	Canjarana	*Cabralea canjerana* (Vell.) Mart.	6	1.56
Verbanaceae	Tarumã	*Citharexylum myrianthum* Cham.	6	1.70
Fabaceae	Bracatinga	*Mimosa scabrella* Benth.	3	1.00
Myrtaceae	Araçá	*Psidium cattleianum* Sabine	3	0.91
Myrtaceae	Pitanga	*Eugenia uniflora* L.	3	0.88
Myrtaceae	Cereja do Rio Grande	*Eugenia involucrate* DC.	3	0.85
Lauraceae	Canela preta	*Ocotea catharinensis* Mez	3	0.68
Lauraceae	Canela do brejo	*Ocotea pulchella* Nees & Mart	3	0.94
Cannabaceae	Grandiúva	*Trema micrantha* (L.) Blume	3	0.85
Bignoniaceae	Ipe	*Handroanthus* sp.	3	0.82
Aquifoliaceae	Yerba mate	*Ilex paraguariensis* A. St.-Hil.	3	0.97
Sapotaceae	Vassourinha	*Chrysophyllum marginatum* (Hook. & Arn.) Radlk.	3	0.94
Moraceae	Ficus	*Ficus* sp.	3	0.76
Sapindaceae	Maria preta	*Diatenopteryx sorbifolia* Radlk.	3	0.97

We also asked the farmers if they had observed animals feeding on *H. dulcis* on their properties during the interviews. For this data, the results were that, in 100% of the interviews (24 informants), they had observed fauna feeding on *H. dulcis.* When asked about which animals they observe the most, 24 species were mentioned (Table 3).

Regarding the introduction of *H. dulcis* in the activities of the BZ, based on the level of consensus among the informants, 12 of them stated that they had not received an indication for the use of the species; 10 of the informants received indications for planting from technical indications coming from public and private research and extension agencies; two informants received indication from other farmers.

When asked about the occurrence of the species on their property, 13 of the informants reported that the species occurs spontaneously. At the same time, nine had already planted the species once, but nowadays, it remains spontaneously. In one case, the informant reported that he does not maintain the species on the property, and, in case of incidence, it is controlled by grubbing it up at the seedling stage. According to the informant, this practice would avoid shading his plantation areas. And finally, one of the informants reports that he maintains the species even through planting and eventually buying it from neighbors to use as firewood.

Table 3: Fauna mentioned as consumers of *H. dulcis* fruits in the Buffer Zone of Fritz Plaumann State Park, Concordia/SC.

Order, Family Genus or Species mentioned by the interviewee	Number of informants that mentioned the species (N=24)
Passerines	21
Bovine	19
Sapajus spp.	11
Canis lupus familiaris	07
Ramphastidae	07
Penelope obscura	06
Nasua nasua	05
Cerdocyon thous	04
Ovine	03
Mazama spp.	03
Swine	02
Didelphis albiventris	02
Leopardus tigrinus	02
Eira barbara	01
Mustela putorius furo	01
Dasypodidae	01

Discussion

Introduction History

The introduction of *H. dulcis* in the region is commented by Lima *et al.* (2021) who report that the occurrence of the species has been present since the 1980s. In addition, some producers still deliberately cultivate the species in degraded areas or on the edges of dams, with a tendency to form dense clusters preventing the development of native species (Carvalho 1994, Mundeleski *et al.* 2008).

Additionally, through a timeline constructed together with the informants (Figure 3), milestones in the history of the introduction of *H. dulcis* can be verified. The timeline was divided into decades, highlighting the information reported by the informants and contrasting it with the data available in literature.

In 1930, the informants reported that before the arrival of the hydroelectric plant of Ita, some of them already lived in lands that belonged to Rio Grande do Sul State (RS). At that time, there were already, in small quantities, specimens of **uva do Japão** (*H. dulcis)*.

In 1944, there was an expansion of poultry farming and meat processing in the municipality of Concordia (SC). As reported by informants, some farmers were advised to plant the species around their poultry for shade. The integration system indicated to producers which actions could be performed to improve the productivity of farms (Gandolfi 2017).

In 1980, there was an intensification of deforestation of native forests (MMA, 2008). In addition, the use of agricultural techniques not compatible with the local soil and low productivity promoted the rural exodus (Silva *et al.* 2003). However, the informants' reports point out that even in the same decade, invasive exotic species, such as *H. dulcis*, were indicated for reforestation of degraded areas, aiming to reduce deforestation.

In 1994, Carvalho (1994) mentions that experimental plantings of *H. dulcis* were carried out in the South, Southeast and Central-West of Brazil. Concórdia appears as an experimental site. In addition, informants reported that in 1994, the government-financed green areas, in which 200 seedlings of *H. dulcis* should be planted.

In the 2000s, a study developed by Medrado (2000) suggests planting *H. dulcis* for Agroforestry Systems (SAFs). Moreover, Cardoso (2013) indicates that *H. dulcis* leaves could be included in hay for cattle. However, the informants themselves report too much intoxication in cattle using this type of silage.

Such background demonstrates that the invasive potential of the species and its ecological damage in the region has been overlooked. Nevertheless, farmers' reports highlight that "where the animals excrete, only **uva do Japão** (*H. dulcis*) grows, no other species come." When asked why, they reported that *H. dulcis* is like a "pest and weed". Additionally, it is noteworthy that in two interviews, the perception that the species was considered native to the region was reported, demonstrating the lack of information regarding the place of origin of the species.

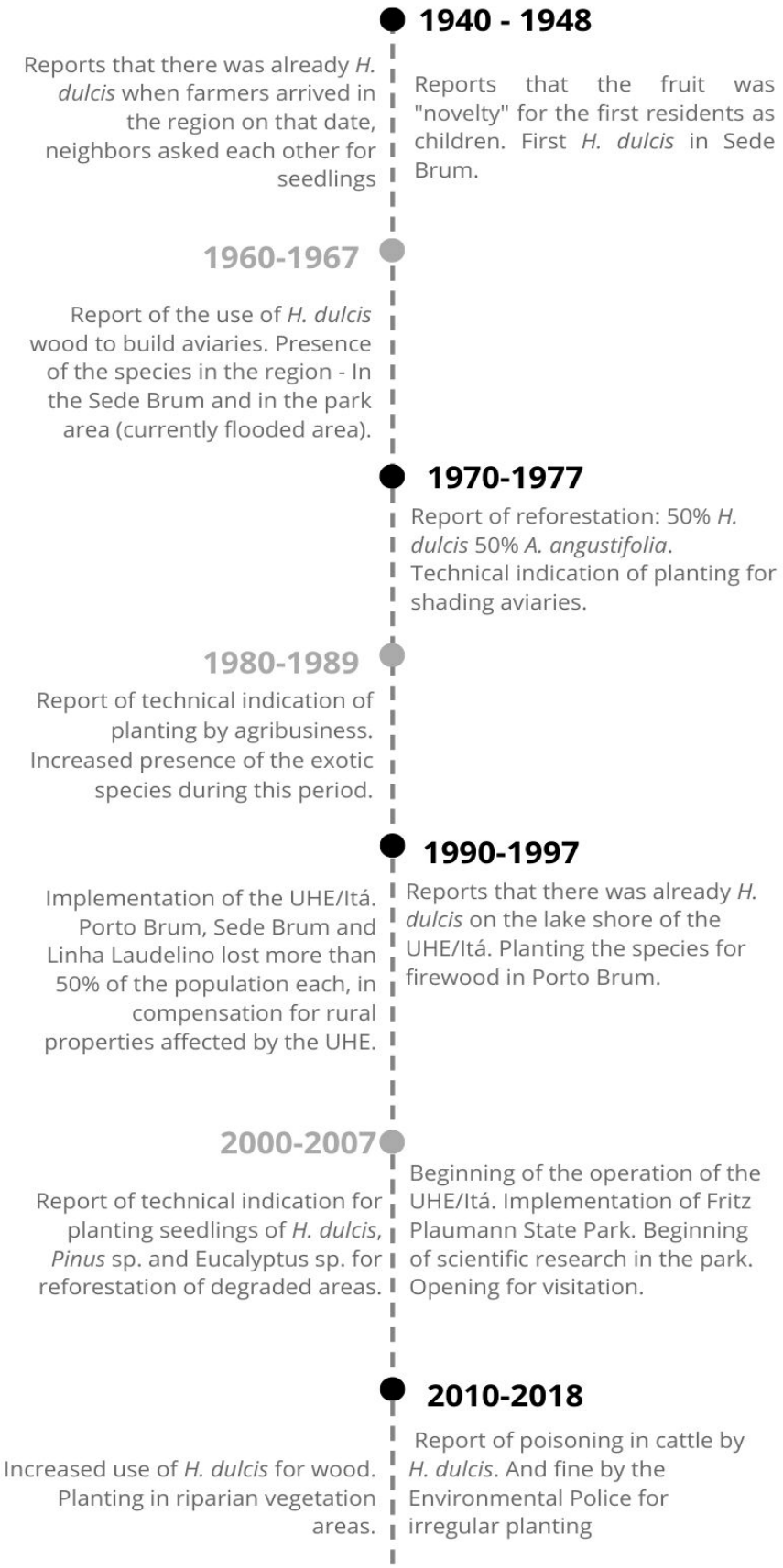

Figure 3. Milestones in the history of the introduction of *H. dulcis*

It is evident that *H. dulcis* has become a relevant species for the productive context of the communities, but the technical indication should be much more than just analyzing productive potentials; the indication should be made analyzing a whole post-installation context of any crop. The economic return may have been interesting when the first indications were made. Nevertheless, knowledge about the damage and impacts that this species is causing many years after its introduction is still embryonic.

The example of *H. dulcis* is an alert for the professionals/technicians of the agricultural area to keep in mind different factors regarding the indication of species for agricultural use. Often, the lack of knowledge about the range of genetic resources that can be used may be related to the limitation of integration between professionals from different backgrounds or even the disqualification of local knowledge held by local and traditional communities. In the latter case, attention to the different knowledge may favor the resilient use of our "own" biodiversity.

Possibly the ecological damage caused by this invasive alien species cannot be reversed. Still, it can be mitigated through coherent technical indications, such as the indication of non-invasive or native species with similar potentials.

Use of *H. dulcis*

The activities performed by the informants are closely related to the regional economic situation, which is based on agriculture and livestock with a focus on livestock production (pigs, poultry and dairy cattle). Additionally, a herbal company (which processes leaves of *Illex paraguariensis* A.St.-Hil) uses 15% of the raw material from its own cultivation in the Park's surroundings. The rest is acquired from producers in the Park's surroundings, encouraging the planting of yerba mate as a source of income. In this context, the use of *H. dulcis* as firewood for use in the processing of yerba mate or for domestic use has been noted.

The use of the species for firewood, according to the interviewees, is because it grows fast and has no impediment to cutting (because it is an exotic species). Additionally, the interviewees reported that *H. dulcis* firewood is preferably used for drying yerba mate because it does not leave a strong "taste" in the herb, preserving the aroma and flavor properties of the plant.

Additionally, according to Andrade *et al.* (2019), in an experiment conducted to evaluate the performance of *H. dulcis*, pinus and Eucalyptus for firewood; *H. dulcis* showed similar performance to the other standard species, and it was also indicated to meet the requirements for use in the industry.

As for the use of external and internal wood, in a study on the composition of wood panels, Napoli *et al.* (2013) showed that the mixture of *H. dulcis* and Eucalyptus wood in the proportion of 1:1 showed better stability in swelling and thickness. Furthermore, when comparing data from the mixture of **bracatinga** (*Mimosa scabrella* Benth.) wood, there is a direct relationship with water absorption. In contrast, the wood of **uva do Japão** and **eucalyptus** showed an inversely proportional relationship (Napoli *et al.* 2013).

The use of *H. dulcis* for producing cachaça/grappa with the fruits of *H. dulcis* is discussed by Cancelier (2013), who analyzed which were the influences in the process of obtaining fermented-distilled beverages from the fruits of **uva do Japão**. The author characterized that the pH of the solution does not change with increasing temperature, making it a viable alternative in the production of a fermented-distilled beverage or as a raw material for the production of bio-alcohol.

There are no studies on manufacturing furniture from *H. dulcis* wood that tests its resistance and quality. Still, it is possible to verify the indication of utensils made with this wood in regional commerce, such as beds, chairs, stools, and tables.

This set of uses indicates the challenge of replacing *H. dulcis*, which is already being inserted in different productive chains in the region.

Potential species to replace *H. dulcis*

As a proposition, there are species with similar potential to *H. dulcis* that can be recommended through a management plan. Species such as **angico vermelho** (*P. rigida*), **açoita cavalo** (*Luehea divaricate* Mart.), **canela guaicá** (*Ocotea puberula* Rich.), **canela lageana** or **canela do brejo** (*Ocotea pulchella* Nees & Mart.), **canela**

amarela (*Nectranda lanceolata* Ness), **grápia** (*A. leiocarpa*), **cedro** (*Cedrela fissilis* Vell.), **cabreúva** (*Myrocarpus frondosus* Allemão), **guajuvira** (*Cordia Americana* (L.) Gottschling & J.S. Mill.), **tarumã** (*Citharexylum myrianthum* Cham.), **angico branco** (*Albizia polycephala* (Benth.) Killip ex Record), and **canjerana** (*Cabralea canjerana* (Vell.) Mart.), which are indicated for mixed plantations, thus avoiding the attack of pathogens, as is the case with *Ocothea* spp trees and *C. fissilis*. Furthermore, as shown in Table 4, the species have similar uses reported by the producers as internal-use wood, external-use wood, cachaça/grappa, and furniture manufacturing.

The growth rates indicated for each species can help farmers to establish crops in areas where there is *H. dulcis*, the species **rabo de bugiu** (*Lonchocarpus campestris* Mart. ex Benth.), **guabiroba** (*Campomanesia xanthocarpa* (Mart.) O.Berg), **bracatinga** (*M. scabrella*) also mentioned, have potential for timber production and can be efficient in the production of firewood and charcoal. Moreover, the majority of species mentioned contain fruit for feeding the fauna, alleviating the problem of the lack of it.

Of the four species with the highest level of consensus (Table 2), three are native to the Atlantic Forest Biome. The references to the species are mainly due to the constant contact with them, for being integrated with the knowledge acquired over the years, and the farmers' way of life (Albuquerque & Andrade 2002).

Canela (*Ocotea* sp.) was one of the most commonly mentioned. Nonetheless, many informants did not specify which Canela species they were referring to. It was mentioned in the interviews that in 1948 there were two distilleries of sassafras/safrol oil, extracted from the **canela sassafras** (*Ocotea odorifera* (Vell.) Rohwer), in Sede Brum. This oil was and is important for the food, chemical, and pharmaceutical industries. In Santa Catarina, between 1940 and 1980, thousands of trees were transformed into sassafras oil through a steam process. With this exploitation, **canela sassafras** (*O. odorifera*) is found on the 2008 Official List of Species of Brazilian Flora Threatened with Extinction of the state of SC. Such a situation results in the loss of biological diversity, leading to the extinction of the species in local populations (MMA 2008).

The study conducted by Lorenzi (1992) clarifies that **angico vermelho** (*P. rigida*) is used and recommended for heterogeneous reforestation in degraded areas. However, according to Gasparin (2012), germination tests for **angico** plants are considered fundamental due to the delay in seed birth and because there are few studies on the species. Otherwise, their potential could be further explored, compromising its cultivation.

Due to the exploitation of its wood, the **cedro** (*C. fissilis*) is also on the Official List of Species of Brazilian Flora Threatened with Extinction of 2008 in the state of Santa Catarina, Brazil. Besides, there are photographic and spoken records that indicate that the cedar was exploited in the 1950s.

According to Zuchiwschi *et al.* (2010), a study developed in Anchieta-SC, also an area of occurrence of DSF, the species mentioned are similar to the present study where i) **canela** (*Ocotea sp.*) was mentioned as having a good contribution for sawn timber, firewood, and flooring wood; ii) **angico vermelho** (*P. rigida*) could be used for sawn timber, flooring wood, medicinal bark, firewood, and fence posts; iii) **grápia** (*A. leiocarpa*) was used for flooring wood, fence posts, and sawn timber and; iv) **cedro** (*C. fissilis*) for furniture and sawn timber.

One of the greatest obstacles described by the informants for the replacement of *H. dulcis* is the delay in the growth of native trees. Moreover, there's Law No. 9.605, of February 12, 1998, which does not allow cutting native species without permission from the responsible agencies to use species.

The informants also characterize that the absence of an adequate forestry policy is an obstacle to the use and commercialization of native species. As a result, the potential of native species is only exploited by a very small and restricted number of companies in the timber sector. The policies developed in the form of legislation only increase the list of what is not allowed (Fantini & Siminski 2011).

In contrast, among the mentioned species with greater consensus (41%), the **eucalyptus** (*Eucalyptus sp.*) stands out, which is an exotic species. According to Angeli *et al.* (2005), this species is used to meet the demands of both industries and small producers, because it grows fast and presents desirable silvicultural characteristics. Based on this, there is a concern that with the suppression of the *H. dulcis* on the properties, instead of replacing it with native species, the planting of Eucalyptus or other fast-growing exotic species will be carried out.

Table 4. Native species mentioned and their phenological, general characteristics, and growth habits with potential for replacing *H. dulcis*, BZ of Fritz Plaumann State Park. Concórdia-SC

Species	General Characteristic	Phenology	Growth
Angico vermelho (*Parapitadenia rigida*)	Native. Used in construction, woodwork, carpentry, landscaping, and mixed reforestation	Blooming season November-January, fruiting season June-July	Fast
Açoita cavalo (*Luehea divaricata*)	Native. Used in furniture structures, civil construction, framing, landscaping, and mixed reforestation in preservation areas	Blooming season December-February, fruiting season May-August	Fast
Canela-guaicá (*Ocotea puberula*)	Native. Used in construction, woodwork, carpentry, landscaping, and mixed reforestation	Blooming season July-August, fruiting season November-December	Fast
Canela lageana (*Ocotea pulchella*)	Native. Used for covering roofs, floors, walls, bridges in general, landscaping, and mixed planting in degraded areas	Blooming season November-December	Moderate
Canela amarela (*Nectranda lanceolata*)	Native. Used for civil construction, internal renovation, ornamentation, and mixed reforestation in degraded areas	Blooming season September-December, fruiting season January-March	Fast
Grápia (*Apuleia leiocarpa*)	Native. Used as wood for internal and external use, conservation reforestation.	Blooming season August-September, fruiting season January-February, but the fruits remain on the trees for many months	Slow
Cedar (*Cedrela fissilis*)	Native. Used for plywood, civil construction, reforestation of degraded areas	Blooming season August-September, fruiting season July-August	Fast
Cabreúva (*Myocarpus frondosus*)	Native. Used in construction, furniture, and ornamentation	Blooming season September-October, fruiting season November-December	Fast
Rabo-de-bugiu (*Lonchocarpus campestris*)	Native. Used for indoor rural constructions, firewood and charcoal, urban afforestation	Blooming season October-December, fruiting season June-July	Moderate
Guajuvira (*Cordia americana*)	Native. Used for constructions, exposed works, landscaping, and reforestation	Blooming season September-October, fruiting season November-December	Moderate
Angico branco (*Albizia polycephala*.)	Native. Used for covering roofs, floors, walls, bridges in general, internal use in construction, ornamental for shading, heterogeneous planting of degraded areas	Blooming season November-December, fruiting season May-June	Fast
Guabiroba (Campomanesia xanthocarpa)	Native. Used for making tool handles, firewood, and charcoal	Blooming season September-November, fruiting season November-December	Fast
Canjerana (*Cabralea canjerana*)	Native. Used in furniture, sculpture works, construction, landscaping, heterogeneous reforestation of preserved areas	Blooming season September-October, fruiting season August-November	Slow
Tarumã (Citharexylum myrianthum)	Native. Used for covering roofs, floors, walls, bridges in general, light artifacts, planting of degraded riparian areas	Blooming season October-December, fruiting season January-March	Fast
Bracatinga (*Mimosa scabrella*)	Native. Used for civil construction, plywood, firewood, charcoal, and ornamental purposes	Blooming season June-August, fruiting season November-January	Fast

Conclusions

The analysis of the history of the introduction of the species confirmed the technical indication as one of the main stimulators for the expansion of *H. dulcis* in the region, with more than 50% of the informants mentioning the technical indication for use on farms around the Park. Moreover, the statements are corroborated by the literature survey that showed studies and technical indications, promoting the use of the species.

As for the uses found for the species *H. dulcis*, it can be seen that firewood was the most present use in all interviews due to the species being of rapid growth and cutting allowed because it is an exotic species.

As potential species to replace *H. dulcis* in the study area, the **angico vermelho** (*P. rigida*) and **eucalyptus** (*Eucalyptus sp.*), a native and an exotic species, respectively.

As for the consumption of *H. dulcis* fruits by native fauna, 100% of the interviewees mentioned observing the animals consuming them. Particularly the order passerines were the most frequently observed.
These data, corroborated by other scientific research, demonstrate the importance of controlling *H. dulcis* in the study area. However, it is important to emphasize that the species were technically indicated for their cultivation in the Park's BZ. Therefore, other studies showing the gradual replacement of this species by others with a greater or equal level of biological characteristics are of paramount importance for controlling *H. dulcis* in the study area.

Declarations

List of abbreviations: Not applicable.
Ethics approval and consent to participate: The study was submitted to the authorization of the CEPSH (Committee for Ethics in Research with Humans) according to the Federal University of Santa Catarina regulations, with the Certificate of Presentation for Ethics Appreciation number 63202516.3.0000.0121. The research proposal was presented to each farmer, and an informed consent form was delivered, which marked the possibility of giving up at any time during the research without any risk or harm.
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Authors' contributions: Karine Petter da Silva did the preliminary work, semi-structured interviews, and revision of the manuscript. Carolina Novicki did the field survey, reviewed the literature, analyzed data sources, drafted and revised the manuscript. Karine Louise dos Santos did the field survey, defined the ethnobotany methodology, drafted and revision of the manuscript. Alexandre de Oliveira Tavela did the verification and revision of the manuscript.

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