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Ethnobotanical study of selected medicinal plants used for the treatment of respiratory diseases in Southern Brazil

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This survey explored the ethnobotanical uses of selected medicinal plants; *Adiantum raddianum* C. Presl. (Pteridaceae), *Lippia alba* (Mill.) N. E. Brown (Verbenaceae) and *Coronopus didymus* (L.) Sm. (Brassicaceae) used for respiratory diseases in Southern Santa Catarina (Brazil). This is timely as the incidence of respiratory disease is increasing in this state. Information was obtained through both interviews using a semi-structured questionnaire administered to 368 people and evaluation of published literature on these plants from scientific peer reviewed journals. The age profile of participants ranged from 20 to over 89 years, with females representing 75% of interviewees. Regarding their use of the medicinal species, 53% reported being users of one of the three plants. Approximately, 52% of users preferred to utilize *L. alba*, 40% *C. didymus* and 8% *A. raddianum*. The primary respiratory diseases reported for use by the plants included cough, flu or cold, lung disorders, bronchitis and asthma. There was also more scientific literature available to support the use of *L. alba* for treatment of respiratory diseases. This study contributes to the documentation of the medicinal and popular uses of *L. alba, C. didymus* and *A. raddianum* in Southern Brazil, in ways that respect and support their conservation. Further studies are warranted to evaluate the biochemical and pharmacological activities of *C. didymus* and *A. raddianum*.

Key words: medicinal plants, *Coronopus didymus, Adiantum raddianum, Lippia alba,* respiratory problems, ethnobotanical survey.

INTRODUCTION

Respiratory diseases have remained a public health challenge throughout the world, with over 500 million cases being diagnosed in developing countries (Ministério da Saúde, 2010), where individual and

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environmental conditions predispose them to a high incidence. Respiratory diseases are pathological conditions that affect both the upper and lower airways, thus affecting air breathing. Most of these diseases for example, asthma, allergic rhinitis, and chronic obstructive pulmonary disease (COPD) are preventable (OPAS, 2017). According to the World Health Organization (2015), more than 3 million people died of COPD in 2012, which is equal to 6% of all deaths globally that year with more than 90% of COPD deaths occurring in low- and middle-income countries.

In some states of Southern Brazil, such as Santa Catarina, the incidence of respiratory disease is increasing (Ministério da Saúde, 2010). According to the Department of Health System Information (DATASUS, 2019a), respiratory problems were the second highest cause of hospitalization in the public health system in the state of Santa Catarina in 2019. In the city of Siderópolis, respiratory problems were also the second of such cause (DATASUS, 2019b).

These statistics may be related to air pollutants from coal mining extraction. The state of Santa Catarina has been known for its abundant and economically important coal beds since the beginning of the 20th century (Silva et al., 2011), being the second largest Brazilian coal producer and having about 3.2 billion tons of coal reserves (Belolli et al., 2002; CETEM, 2001). Coal extraction is used for the production of energy and contributes to the advancement of the economy. However, significant environmental impacts are associated with the practice, such as water pollution, deforestation, the release of toxic amounts of minerals and heavy metals into the soil, increased erosion and air pollution (Dontala et al., 2015). In order to reverse such damage, in some areas environmental remediation standards were created (Ação Civil Pública do Carvão, 2013, 2010). Air pollution also contributes to lung problems associated with the inhalation of coal dust, including fibrosis, emphysema, asthma (Laney and Attifield, 2010) and silicosis (Churchyard et al., 2004).

The practice of using medicinal plants to treat respiratory problems affecting the study population has been documented. For example, one study assessed the efficacy of the native plants of Brazil for the adjuvant treatment of pneumoconiosis caused by acute exposure to coal dust *in vivo*, and the results were positive (Jeremias et al., 2012).

In Brazil, researching medicinal plants, including ethnobotanical research is a promising strategy, as the country possesses significant biodiversity, and has a wealth of traditional knowledge accumulated by local people who have access to nature and the products of biodiversity (Albagli, 2001). Regarding ethnobotanical studies, it is important to record popular uses of species before such knowledge disappears. In many parts of the world, traditions are at risk of disappearing, and it is necessary to study knowledge systems and find alternative means to disseminate them to future generations (Hadjichambis et al., 2008). Furthermore, studies with medicinal plants may lead to finding new materials for the development of new drugs (Cakilcioglu and Turkoglu, 2010).

According to local knowledge transmitted orally, three native Brazilian plants, found in abundance in Santa Catarina are widely used by the local population for the treatment of respiratory diseases, namely *Adiantum raddianum* C. Presl. (Pteridaceae), *Lippia alba* (Mill.) N. E.Brown (Verbenaceae) and *Coronopus didymus* (L.) Sm. (Brassicaceae) (Fabio et al., 2007; Rossato et al., 2012). Utilization of these plants may potentially help the population and provide a resource for primary health care.

Considering this information and the high incidence of respiratory diseases in the region, this work evaluated the ethnobotanical uses of these plants for the treatment of respiratory disease. The uses of each plant and associated side effects in the city of Santa Catarina were documented to establish the extent of knowledge that the population has about these species. The usage information recorded was supplemented with a literature search, with the objective of corroborating, refuting or certifying the absence of information noted in the community.

METHODOLOGY

Study area

This research was conducted in the city of Siderópolis, which is located in the state of Santa Catarina, Southern Brazil, between geographic coordinates 28°36'S and 49°33'W. It comprises a total area of 2.089,37 km², corresponding to 2.23% of the total state. It is a city with a subtropical climate (Casan, 1995).

This area of study was chosen because the city has a high incidence of respiratory diseases (DATASUS, 2019b), and the climate has favorable characteristics for the development of *A. raddianum*, *L. alba* and *C. didymus*, which can all be found naturally in the region.

Adiantum raddianum is an herbaceous, rhizomatous fern, with flabeliform leaflets and bicurved ribs towards the apex. *C. didymus* is an annual and prostrate herbaceous plant with alternate pinatisect leaves, divided into segments that unfold in 2 to 5 lobes, flowers gathered in raceme inflorescences, tiny and whitish, and silique fruit (Rossato et al., 2012). *L. alba* is a sub-shrub with tetragonal branches, decussed, hairy leaves, with a serrated margin, with a coined to attenuated base, a capituliform inflorescence with blue-purple flowers and globular drupe fruit (Lorenzi and Matos, 2008).

The plants were collected at Albino Neoti, Vila São Jorge, Siderópolis. Voucher specimens were registered in the Herbarium Pe. Dr. Raulino Reitz at the Universidade do Extremo Sul Catarinense (UNESC) as CRI 10514 (*A. raddianum*), CRI 10511 (*L. alba*) and CRI 10306 (*C. didymus*).

Study population and sample size

In this study, convenience sampling was applied. This is a type of nonprobability sampling where members of the target

population that meet certain practical criteria (Freitag, 2018), e.g. geographical in this case, are used. The sample population consisted of adults living in Siderópolis, aged over 20 years and selected by knocking on their doors, and conducting an interview with a member of the household who had knowledge about medicinal plants. The colonization of Siderópolis began in 1891, with the arrival of Italian immigrants. Its economy is based on poultry production, in addition to agriculture and mining. The population is made up of 6.518 women and 6.480 men (IBGE, 2010). According to 2010 estimates, the population of Siderópolis aged over 20 years was about 9.301 inhabitants (IBGE, 2010). In calculation of the required sample size, the following formula was applied (Jesus et al., 2009; Silva et al., 2010), $n = Np(1 - p) / (N - 1)(d / z)^2 + p(1 - p)$; where n is the sample size, z (1.96) corresponds to the 95% confidence coefficient, d (0.05) sampling error, p (0.5) a ratio to be estimated and N (9.301) the total population, reaching a representative sample (n) of 368 people.

Data collection

Semi-structured interviews were conducted with local people, by applying an adapted questionnaire of Allabi (2011) and Silva et al. (2011), between July and August 2014. The research was carried out in either morning or afternoon, taking between 30 min to 1 h per interview. The questionnaire was composed of questions relating to socio-demographic characteristics of participants (address, monthly personal income, profession, gender, age, education, religion and civil status), and also ethnobotanical information about one of the three plants: *A. raddianum*, *L. alba* and *C. didymus* (part used, method of preparation, administration, among others). At the time of the interview, the researchers showed an example of these three medicinal species to the participants in order to confirm their recognition of the species. Then, the participants were asked which of the three plants were considered more relevant in the treatment of respiratory diseases (bronchitis, cough, flu, asthma, allergic rhinitis, and chronic obstructive pulmonary disease) and the questionnaire was applied with the chosen plant.

The interviews began after the participants gave informed consent, pursuant to Resolution No. 466 of December 12, 2012 of the National Council of Health (Conselho Nacional de Saúde, 2012). The implementation of this work was approved by the Research Ethics Committee of Universidade do Extremo Sul Catarinense, registered under No. 668.733.

All completed and signed interviews were collated, including those in which the participants reported not knowing or using any of the three plants.

Literature investigation of *A. raddianum, L. alba* and *C. didymus*

Literature was investigated from scientific journals in academic databases (Google Scholar, PubMed, Science direct and Scopus), including all papers published from 1989 up to November 2014, in order to find studies about *A. raddianum, L. alba* and *C. didymus* related to respiratory diseases. The main keywords used were: *A. raddianum, L. alba, C. didymus,* pneumoconiosis, bronchitis, lung, cough, anti-inflammatory, asthma and respiratory diseases. A survey of the species in the literature listed in the RDC No. 26 of May 13, 2014 (Ministério da Saúde, 2014) was also conducted.

Data analysis

Data analysis was performed using Microsoft Excel 2013. Average age of participants was calculated using a simple arithmetic mean and ethnobotanical information of the species were assigned using frequency of indication.

RESULTS

Sociodemographic characteristics of the informants

Our research was conducted with 368 people, with females (75%) representing the majority of interviewees. It was observed that the age profile ranged from 20 to 89 years, with 54.3% being over 50 years and 33.9% between 30 and 49 years. Regarding education, the majority of participants (65%) had completed primary education. In relation to their economic situation, the majority of users (85%) reported a monthly household income of no more than two minimum wages (U$ 190.08). When asked about religion, 79.0% (n=155) of users reported being Catholic, 15% Evangelic or Pentecostals and others declared no religion. In relation to origin of their plant knowledge, 84.7% said they had learned about the plants through their families. The majority of the participants (67.8%) reported knowing or using the species since their childhood.

Medicinal plant species

With regard to the study species, 18% (n=67) of participants did not recognise any of the named plants. Of the 82.0% (n= 301) familiar with them, 53.0% (n=196) reported being users of at least one of the three plants (*A. raddianum*, *C. didymus* or *L. alba*) as a medicinal species for the treatment of respiratory disease.

Among the participants using the study plants for the treatment of respiratory disease, 52.0% reported the use of *L. alba* (n=102), 40.0% (n=78) *C. didymus* and 8.0% (n=16) *A. raddianum.* Upon tabulating popular indications described by users, 16 folk uses were registered/documented according to the knowledge of the interviewees (Table 1). Participants were encouraged to mention more than one folk use if relevant, and the manner of use(s) was recorded exactly as mentioned, including signals and symptoms, body organs and health conditions in general. The majority cited popular medicinal use of *A. raddianum* and *C. didymus* to treat cough followed by flu while majority reported *L. alba* for flu followed by cough (Table 1). Among the three plants, *C. didymus* was the species most mentioned in the treatment of lung disorders, such as pneumoconiosis.

For each plant, its form of preparation, plant part used and the mode of administration were recorded as shown in Tables 2 to 4.

In relation to preparation of the extracts, a decoction in water was the most cited method by users of all plants (67.8%). Leaves were the parts most used, representing 52.0% of the users of *A. raddianum,* 66.0% (*C. didymus*) and 89.0% (*L. alba*), however the population reported more than one part of each plant as having medicinal

Table 1. Popular ethnomedicinal uses for *Adiantum raddianum, Coronopus didymus* and *Lippia alba,* and their respective number of citations against various respiratory disorders.

Popular medicinal use	Number of citations (%)		
	A. raddianum	***C. didymus***	***L. alba***
Throat allergy	-	2 (0.7)	-
Anti-inflammation of the lungs	-	4 (1.3)	1 (0.3)
Asthma	3 (1)	10 (3.3)	2 (0.7)
Bronchitis	1 (0.3)	5 (1.6)	3 (1)
Cough	12(3.9)	41 (13.5)	46 (15.1)
Mucolytic	-	11 (3.6)	1 (0.3)
Difficulty of breathing	-	2 (0.7)	4 (1.3)
Flu	7 (2.3)	29 (9.5)	74 (24.3)
Pneumoconiosis	1 (0.3)	17 (5.6)	-
Lung infection	-	7 (2.3)	-
Cold	1 (0.3)	3 (1)	9 (3)
Respiratory problems	-	1 (0.3)	-
Rhinitis	-	-	1 (0.3)
Sore throat	-	-	3 (1)
Throat infection	1 (0.3)	-	2 (0.7)

properties. Most of the prescription of the decoction was one cup taken 1 to 2 times a day for cough and flu with treatment lasting up to seven days.

When questioned about the safety of the plants, only one user of *A. raddianum* said that the plant should not be confused with other related species, like other ferns with similar morphology (*Adiantum poiretii* Wikstr). Approximately 6.0% of users of *C. dydimus* said that precautions with this species were needed in pregnant women and those with high blood pressure and allergic reactions. 8.0% of users of *L. alba* said that the plant is not recommended for children, in pregnancy or in those with allergic reactions. Largely, participants did not know about toxicity of these plants. In relation to the use of *A. raddianum, C. dydimus* and *L. alba* upon recommendation by health professionals, the users largely did not report using the plants on the advice of these sources.

Literature investigation

Upon literature review, we found no biological studies about *A. raddianum* related to respiratory diseases. Also, no information was found in the literature as determined by the RDC No. 26 of May 13, 2014 (Ministério da Saúde, 2014). In relation to *C. dydimus,* only pre-clinical studies in mice and rat were found. Works were found as shown in Table 5.

DISCUSSION

The sociocultural characteristics of the participants, e.g. female, in this study shows similarity with other published works. Ethnobotanical studies commonly demonstrate that use of medicinal plants predominates among the females (Liu et al., 2014; Parada et al., 2009; Rosas-Piñón et al., 2012). According to De La Cruz et al. (2014), women play a key-role in the management of health with medicinal plants. This may be related to the fact that herbal practice provides women with many useful herbal remedies for conditions of particular interest to them, especially to treat a number of reproductive health problems, such as menstrual problems, infertility, discomforts and dysfunctions of pregnancy and menopause (Beal, 1998; Hardy, 2000). Furthermore, women are associated with herbal healing because of their crucial role in plant diversity management and conservation at the household, village, and community levels (Braidotti et al., 1994). On the other hand, women traditionally also play an important role in the medical society inserted in places that perform health care (Raja, 2015). This could explain the results observed in this present study where 75% participants were women.

Age profiles of respondents in the present study match closely with those in the literature (Cakilcioglu et al., 2011; Cakilcioglu and Turkoglu, 2010) and reinforce the importance of age in the accumulation of knowledge. An ethnopharmacological study by Cakilcioglu et al. (2011) applied to 143 people, observed that 63 participants were between the ages of 51 and 60 years, with 42 over the age of 61 years. Cakilcioglu and Turkoglu (2010) observed a 31 to 103 age range, and a mean age of respondents of 67 years, again representing a similar age profile to this work. In addition, Menendez-Baceta et al. (2014) conducted interviews with 207 informants and

Table 2. Preparation, indications for popular uses, administration and mode of use of *Adiantum raddianum* C. Presl. (avenca).

Mode of preparation of part plant used	Indication	Mode of use/dosage
Decoction of the leaves	Cough, throat inflammation, flu/cold	Drink half glass 3 times a day for 3 days
	Asthma, bronchitis	Drink 1 cup 2 times a day for 1 week
Infusion of the leaves	Cough, flu	Drink 1 cup of infusion 2 times a day for 1 week
Infusion of the leaves and stalk	Cough	Drink 1 cup 3 times a day. Drink 15 days and pause. Repeat after 15 days
	Cough and flu	Drink 1 cup 2 times a day for 3-4 days
Infusion of the whole plant	Cough	Drink ½ cup once at night until disappearance of symptoms
Decoction of the whole plant	Cough, asthma, flu	Drink ½ cup 1-2 times a day until disappearance of symptoms
Infusion of the roots	Cough, asthma	Drink 1 cup once a day for 2-3 days

Mode of preparation: Infusion consists of pouring boiling water over the vegetable drug and then, if applicable, covering for a specified time. Decoction consists of boiling the vegetable drug in water for a specified time (Gruenwald et al., 2000). In this study, decoctions are made with water or milk while infusions are prepared with water. Note 1: Information about the parts of the plant used, methods of preparation, indications and methods of use present in this table are described as reported by the participants in this study. Note 2: *Adiantum raddianum* is a species of easy recognition in the field, with no possibility of confusing it with another species.

Table 3. Preparation, indications for popular uses, administration and mode of use of *Lippia alba* (Mill.) N.E.Br (erva-cidreira brasileira, falsa-melissa, sálvia).

Mode of preparation and part plant used	Indication	Mode of use
Decoction of the sprouts, whole plant	Flu, cough, mucolytic	Drink 1 cup/1 time daily until relieved
Infusion of the leaves	Flu, cough, shortness of breath, anti-inflammatory, cold	Drink 1 cup 1-2 times a day for up to 7 days/Drink 1 cup once a day for up to 5 days
Decoction of the leaves	Flu, cough, mucolytic, cold, sore throat, bronchitis, rhinitis, shortness of breath, asthma	Drink 1 cup once daily for 2 to 4 days/Drink 1 cup 2 to 3 times for 2 to 4 days/1 tablespoon 3 to 4 times for 3 to 4 days
Syrup of the leaves	Cough, asthma	Take 1 spoon every 3 h. Use only 1 day
Decoction of the leaves, stem	Flu, cough, cold, shortness of breath, bronchitis	Take 1 cup 1 to 3 times daily for 2 to 4
Decoction of the, leaves, flowers	Flu	Take 1 glass 1 time a day

Mode of preparation: Decoctions are made with water or water and honey or milk. Infusions are prepared through aqueous decoction. Syrups are prepared with water and sugar to gain consistency. Note: Information about the parts of the plant used, methods of preparation, popular indications and methods of use present in this study are described as reported by the study participants.

observed a mean age of the informants of 76 years. Older people have more information about herbs compared to younger ones (Silva et al., 2010). Ahmad et al. (2015) observed that when conducting research about medicinal plants used for hypertension, the younger generation felt shy and showed a lack of interest in plants while elderly people were pleased when asked about medicinal plants and their uses. The reason

Table 4. Preparation, indications for popular uses, administration and mode of use of *Coronopus didymus* (L.) Sm (mastruço, mentruz).

Mode of preparation and part plant used	Indication	Mode of use
Crush the leaves with liquids/vegetable oils	Asthma, bronchitis	Take 1 teaspoon 1 once daily for 3 days
Infusion of the leaves	Flu, mucolytic, cough, as anti- inflammatory	1 cup 2 to 3 times up to 7 days
	Pneumonia, asthma	1 cup 2 to 3 times a day for 3 months/1 cup 2 to 3 times a day for 15 days
Decoction of the leaves	Cough, as anti-inflammatory, bronchitis, cold, lung infection, pneumonia, asthma	1 cup 1 to 2 times a day for 1 to 3 days/ Drink 1 cup 1 to 3 times a day for 3 to 7 days
Maceration of the leaves	Lung Infection, bronchitis, and cough	1 tablespoon 1 time per day for up to 7 days/1 cup 1 once a day until relief of symptoms
Decoction of the leaves, stem	Flu, cough, cold, lung problems	1 cup 1 to 3 times a day from 3 days to 6 months as needed
Infusion of the leaves, stem	Cough, mucolytic, allergy throat	1 cup 1 to 3 times a day for up to 3 days
Syrup of the leaves, stem	Mucolytic	Drink 1 glass at night until symptoms are alleviated
Blend of the leaves, whole plant	Pulmonary problems, bronchitis	Drink 1 glass a day for 1 week
Decoction of the leaves, roots/ rhizomes	Flu, cough	1 spoon/3 times a day until better
Decoction of the whole plant	Flu, cough, lung problems, shortness of breath, mucolytic, allergy throat	1 cup 1-3 times from 2 to 7 days/Drink 1 cup per day for 1 month
Infusion of the whole plant	Cough, bronchitis, shortness of breath, lung problems, flu	Drink 1 cup, 1-3 times in 3 to 7 days

Mode of preparation: Crushing of leaves with liquids are prepared with olive oil and almond oil. Decoction is made with water or milk or milk and honey (Reference). Infusions are prepared through water or sugar-cane spirit (commonly known as cachaça) or milk. Macerates are prepared with water or milk. Syrup is prepared with water and sugar to gain consistency. Blends are prepared with water for 2 to 3 minutes. Note: Information about the parts of the plant used, methods of preparation, therapeutic indications and methods of use present in this Table are described as reported by the study participants.

that elders possess greater knowledge of medicinal plants is often attributed to their longer interaction with the environment (Albuquerque et al., 2014; Silva et al., 2011). Knowledge about use of plants is transferred from older to younger people orally, often from generation to generation (Rokaya et al., 2010). Thus, ethnobotanical research should continue (Uprety et al., 2010) to document the traditional and popular use of medicinal plants to avoid disappearance of such knowledge in the future (Bussmann and Sharon, 2006).

The main reasons recorded for the use of medicinal plants in the world are accessibility and cost (Albuquerque, 2014). In developing countries and in many rural areas, the population cannot afford access to modern medical care either because it is too costly or because there are no service providers (Goleniowski et al., 2006; Mahomoodally, 2013). The population of the present study, although having access to the services of the Sistema Único de Saúde (SUS) (Ministério da Saúde, Brasil, 2017), feel the need to complement their health care with medicinal plants. This again reflects use by a low-income majority.

It has been observed elsewhere that the use of medicinal plants for the treatment of respiratory diseases is more prevalent among people with lower educational levels (Kayani et al., 2014). This was also observed here, and was similar to comparable ethnobotanical work where a majority of participants were primary school graduates, with only 8% university graduates (Cakilcioglu and Turkoglu, 2010). The importance of religion and beliefs in the diffusion of traditional knowledge has been previously highlighted in some surveys (Pieroni et al., 2011; Rexhepi et al., 2013). According to Menendez-Baceta et al. (2015), in folk medicine many remedies feature plants having a symbolic role within a highly ritualized health process that can be essential to the perceived effectiveness of treatment. In the present work, the main religion was Catholic. However, the high incidence of Catholic people is probably not connected with the religious symbolism of the plants, but with the

Table 5. Biological activity of *Coronopus didymus* and *Lippia alba* related respiratory to diseases.

Biological activity/ part	Tested material/concentrations or dosages	Method	Results	Reference
C. didymus				
Antiallergic and antipyretic/whole plant	Aqueous/200 and 400 mg/kg	*In vivo.* Sheep serum induced mast cell degranulation method. Analysis of rectal temperature.	There was a significant dose dependent protection against mast cell degranulation with aqueous extract. The extract produced significant antipyretic effect in a dose dependent manner. The antipyretic effect noticed at a dose of 400 mg/kg.	Mantena et al. (2005)
Anti-inflammatory/whole plant	Ethanolic and aqueous extracts/200 mg/kg	*In vivo.* Paw edema model	Only the aqueous extract showed significant anti- inflammatory activity.	Prabhakar et al. (2002)
Anti-inflammatory/Whole plant	Ethanolic/200, 400 and 600 mg/kg	*In vivo*. Spectrophotometric analysis. Pleurisy and paw edema models	Phenolic and flavonoids compounds were identified. *Coronopus didymus* (200-600 mg/kg) caused a significant dose-dependent decrease in leukocyte migration and revealed a long lasting antioedematogenic effect.	Busnardo et al. (2010)
***L. alba* – Preclinical studies**				
Analgesic/Leaves	Hydroethanolic (50%)/1 g of extract solids per kg in a volume of 20 mL/kg	*In vivo.* Writhing test. Tail flick test.	Significant effects in both tests were produced by leaf extracts of *L. alba.*	Costa et al. (1989)
Analgesic and anti-inflammatory/leaves	Essential oil/ different doses in each test: Hot plate: 1, 10 and 50 mg/kg, i.p.; 10 and 50 mg/kg, p.o. Induced writhing: 0.5; 1 and 10 mg/kg, i.p., or 1 and 2 mg/kg, p.o. Formalin: 0.5, 1, 10 mg/kg, i.p., or 0.5, 1, 10 mg/kg, p.o. Paw edema: 1 and 10 mg/kg, i.p., or 10 and 50 mg/kg, p.o.	*In vivo*. Hot plate test. Acetic acid-induced writhing. Formalin test. Paw edema induced by carrageenan or dextran.	Latency time to the thermic stimulus as detected by the hot plate test was increased with limone-citral. Limonene-citral and limonene-carvone inhibited 80.5% of the writhing. In the formalin test, the two chemotypes inhibited the second phase of the response. A significant antiedematogenic effect was seen.	Viana et al. (1998)
Antiespasmodic/leaves	Essential oil/0.3, 1, 3, 10, 30, 100 and 300 µL EO/mL.	*In vitro.* Essential oils were analyzed by a gas chromatography. Contraction intestinal tissues with acetylcholine and Ca^{+2}.	Chemical composition of the essential oils from citral and linalool chemotypes were identified. The citral chemotype had five times more potency than linalool in inhibiting muscarinic contractions.	Blanco et al. (2013)

Table 5. Contd.

Anti-inflammatory/leaves	The animals were treated orally with extract of petroleum ether, chloroform and ethanol (500 mg/kg b.wt). The aqueous extract at a dose of 460 mg/kg b.wt.	*In vivo.* Carrageenan induced hind paw edema.	Chloroform and ethanol extracts possessed significant anti-inflammatory effects that may be mediated through inhibition of cell mediators such as bradykinin, and prostaglandins.	Haldar et al. (2012)
Anti-inflammatory/leaves	The extraction was carried out using petroleum ether, chloroform, ethanol and water in succession/ 500 mg/kg orally.	*In vivo.* Carrageenan induced paw edema.	The chloroform extract showed significant anti-inflammatory activity.	Saha et al. (2011)
Anti-inflammatory/leaves	Essential oil/ 0.01 to 0.2 mg/ mL	*In vitro.* Murine macrophages stimulated with bacterial lipopolysaccharide.	The sample altered the expression of inducible nitric oxide synthase (iNOS) and cyclooxygenase-2 (COX-2). The results suggest anti-inflammatory effect.	Sepúlveda-arias et al. (2013).
Anti-inflammatory and nociceptive	Essential oil: citral/50, 100 and 200 mg/kg de citral.	*Ex vivo.*Carrageenan induced peritonitis. Leukocyte migration. *In vivo.* Carrageenan induced paw edema. Acetic acid-induced writhing. Formalin tests.	Pretreatment with citral (100 and 200 mg/kg) significantly reduced paw edema. Formalin induced nociception was significantly protected only at higher dose (200 mg/kg). Treatment with citral (100 and 200 mg/kg) significantly reduced leukocyte migration. Citral might represent a tool for treatment of painful conditions.	Quintans-Júnior et al. (2011)
Antimicrobial/leaves	Hydroethanolic (88%)/ 500 mg/mL	*In vitro.* Microorganisms tested: *Staphylococcus aureus, Streptococcus pneumonia* and *Streptococcus pyogenes.*	The plant exhibited antibacterial activity against the three microorganisms.	Caceres et al. (1991)
Myorelaxant/leaves	Essential oil/ 10, 25, 50, 100 and 200 mg/kg.	*In vivo*. Rota-rod tests and also on rectal temperature.	A myorelaxant effect was observed at dose of 200 mg/kg of chemotypes II essential oil.	Vale et al. (1999)
***L. alba* – Clinical studies**				
Analgesic/Leaves	Hydroethanolic (70%)/ 1 drop of tincture per kilogram of body weight per day, twice a day.	*In vivo.* Twenty-one women received hydroethanolic extract orally.	More than 70% of patients experienced a minimum 50% reduction on pain frequency.	Carmona et al. (2013)
Analgesic/leaves	Hydroethanolic (70%) 1-1/ 5 drops of tincture per kilogram of body weight per day, twice a day.	*In vivo.* Longitudinal study, phase 2. The participants received hydroethanolic extract orally. Gas chromatography-mass spectrometry analysis of essential oil was performed	At least 80% of patients experienced a 50% or more reduction on both intensity and frequency of pain episodes after a median time of 54 days. The major chemical compounds detected in the essential oil were geranial (24.6%) and carvenone (20.9%).	Conde et al. (2011)

high prevalence of Catholics influenced by Italian colonization in the area surveyed (Zanini, 2007; IBGE, 2020). Other published ethnobotanical studies show a similar majority of participants as Catholic (68%) (Adia et al., 2014).

In the present study, we documented the mode of preparation of extracts of *A. raddianum, C. dydimus* and *L. alba* for the treatment of respiratory diseases/ disorders. In relation to the formulations, it was observed that among the many different forms of preparation, most users utilized a decoction in water (Tables 2 to 4). This method is most appropriate for parts of plants with a rigid consistency, such as bark, roots, rhizomes and stems (ANVISA, 2018). In the literature, many diverse ethnic populations also utilize mostly leaves for the preparation of herbal extracts (Giday et al., 2010; Gonzalez et al., 2010). This may be because leaves are gathered more effortlessly than other plant parts, such as seeds, fruits and flowers (Giday et al., 2010). In addition, leaves are active in photosynthesis and production of chemical constituents (Ghorbani, 2005). Plants contain diverse molecules, known as secondary metabolites, that may act individually, additively, or in synergy to promote human health (Leicach and Chludil, 2014). Moreover, these chemical constituents working together tend to increase therapeutic activity in the body (Mahomoodally, 2013).

In addition, it is interesting to exploit the study of medicinal plants to find new drugs (Cakilcioglu and Turkoglu, 2010), especially regarding native species, as we show in the present work. Studies with native plants from local ecosystems establish benefits to the integration of the people with the species and particularities of their region (Moro et al., 2014; Abendroth et al.,

2012). Furthermore, the study of these species contributes to environmental education, increasing people's interest in and understanding of the environment and conservation (Dearborn and Kark, 2010).

Regarding the plant species in the present study, *L. alba* was that mostly used by participants for respiratory diseases. *L. alba* is an aromatic native plant belonging to the Verbenaceae family, which is widely used in South and Central America for many purposes (Lorenzi and Matos, 2008). The plant is most commonly named in Brazil as cidreira (Hennebelle et al., 2008), but is known locally in the study area as salvia-do-rio-grande, erva-cidreira-brasileira and falsa-melissa. In relation to ethnobotanical investigations, works from different parts of the world include studies detailing *L. alba* as an antitussive, a decongestive, to treat sore throat and headaches (Scarpa, 2004), an analgesic (Toscano-Gonzalez, 2006) and an antimalarial (Vigneron et al., 2005). In other states of Brazil, this species was documented as medicinal. According to Oliveira et al. (2006), the plant is used in Pará for cardiovascular problems such as hypertension. In the state of Bahia it is utilized for flatulence (Rodrigues and Guedes, 2006) and stomach pain (Pinto et al., 2006). In other ethnopharmacological studies, *L. alba* is considered useful for respiratory ailments in general, for example to treat sore throat, flu (Franco and Barros, 2006), bronchitis, cough and colds (Di Stasi et al., 2002). In the present study, this was also observed, as many users utilized the plant for these ailments, mainly flu and cough (Table 1). Based on the historical use, It is possible that *L. alba* could be a useful plants for managing respiratory disorders.

L. alba produces an essential oil (Maynard et al., 2011; Viana et al., 1998) whose composition is variable, suggesting the existence of different chemotypes due to the growth of the plant in different environments they can alter the composition of secondary metabolites and, consequently, in the therapeutic action (Blanco et al., 2013). A study identified in the essential oil of *L. alba* 19 compounds, being geranial (48.58%) and neral (35.42%) the major constituents (Maynard et al., 2011).

According Fabio et al. (2007), essential oils are used to treat respiratory diseases such as pharyngitis, sinusitis and bronchitis. Also, in some respiratory ailments, bronchospasm may occur (Weiler et al., 2007) and *L. alba* has been studied for this purpose and found to be effective (Blanco et al., 2013; Vale et al., 1999). Various biological studies are shown in Table 5, suggesting that *L. alba* medicinal plant is effective for respiratory diseases that may support its popular use. In Brazil, *L. alba* is certified as an anxiolytic, mild sedative, antispasmodic and antidyspeptic (ANVISA, 2018).

The second species most utilized by respondents was *C. dydimus.* This species belongs to the Brassicaceae family and is native to South America, particularly the South and Southeast of Brazil, where it is known locally as mentruz or mastruço (Lorenzi and Matos, 2008). According to Rehman et al. (2014), the plant is used to treat asthma, malaria, cancer, emphysema and bronchitis. Another study reported that the leaves, as a decoction or infusion, are used in low doses for colds, bronchitis or pneumonia, and to lower blood pressure (Menendez-Baceta et al., 2014). In the present study, we documented similar popular therapeutic indications for this plant (Table 1) with some related to inflammation. Busnardo et al. (2010) concluded that the anti-inflammatory activity of *C. didymus* occurs through the inhibition of pro-inflammatory enzymes (myeloperoxidase, adenosine deaminase) and of nitrite/ nitrate concentrations.

C. dydimus is reported to contain various compounds, including benzyl cyanide (Inam- ul-haque, 1989), 1,8-dihydroxy anthraquinone (De Ruiz et al., 1994), and flavones, e.g. chrysoeriol, chrysoeriol-(6"-OAc)-4'-β-D-glucoside (Prabhakar et al., 2002), generally phenolics (gallic acid) and flavonoids (quercetin) (Busnardo et al., 2010). Other species from the Brassicaceae family, such

as *Barbarea vulgaris* and *Cardamine diphylla,* have been reported to contain glucosinolates (Van Leur et al., 2008; Montaut and Bleeker, 2013), which may be important components in the treatment of respiratory system disorders (Guarrera and Savo, 2013). However, for *C. dydimus*, more studies should be performed to confirm the popular medicinal uses reported in this study.

The other native plant of interest in this study was *A. raddianum*, popularly known in the region as avenca*.* This species belongs to the Pteridaceae family, and is widely distributed in Brazil, in the states of Minas Gerais, Rio de Janeiro, São Paulo, Paraná, Santa Catarina and Rio Grande do Sul (Silva et al., 2007). It is also found in other countries, from Mexico to Uruguay (Winter et al., 2011). We could not obtain any biological studies on *A. raddianum*, nor is it included in the monographs on herbal traditional use of the European Community (Community herbal monographs with traditional use) to justify the uses shown in Table 1, mainly to treat cough. However, this species is also mentioned in Peruvian traditional medicine for respiratory diseases, such as cold (De la Cruz et al., 2014). It is documented also to treat vomiting, stomach pain, as a female contraceptive and for gynecological problems (De la Cruz et al., 2014).

In the present study, only a minority of the users of *A. raddianumm, C. dydimus* and *L. alba* reported their use pursuant to recommendation from a healthcare professional. This may be due to the fact that a majority of respondents have acquired knowledge of these species through their families since childhood. The use of *L. alba* should be supervised by healthcare professionals as it has been included in the Herbal Formulary of the Brazilian Pharmacopoeia (ANVISA, 2018). According to this formulary, *L. alba* should be used with caution in people with hypertension. Doses higher than those recommended may cause gastric irritation, bradycardia and hypotension (ANVISA, 2018). The recommendation of the treatment of diseases with medicinal plants from a healthcare professional may be beneficial to the population due to ease of use, treatment efficiency, low cost and having minimal side effects (Yabesh et al., 2014).

Conclusion

It was found that the participants of this study utilized and recognized *L. alba*, *C. didymus* and *A. raddianum* as medicinal plants for the treatment of respiratory diseases. Regarding usage precautions, few participants reported known contraindications and adverse reactions.

Of the plants in the present study, *L. alba* had the most scientific works in the literature regarding biological activity related to respiratory disease. More studies should be considered on the biochemical or pharmacological activity of *C. didymus* and *A. raddianum,* and these medicinal plants should not be used before their certification in Brazil's regulations for medicinal plants.

This study contributes to the documentation of the medicinal and popular uses of *L. alba, C. didymus* and *A. raddianum* in Southern Brazil, in ways that respect and support the conservation of medicinal plants and the environment in general.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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