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REMOTE SENSING IN THE LEAF SPECTRAL CHARACTERIZATION OF THE *Hesperozygis ringens*, AN ENDANGERED SPECIES

Carlos Garrido Pinheiro[1*], Caroline Lorenci Mallmann[1], Waterloo Pereira Filho[1], Berta Maria Heinzmann[1]

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ABSTRACT - *Hesperozygis ringens* is a species that stands out for the production of essential oil. No reports on the leaf spectral characterization of the species have been found. This study aimed to determine the reflectance pattern of *Hesperozygis ringens* leaves with the aid of Remote Sensing. Therefore, a spectroradiometer that operates in the continuous spectral range from 400 to 900 nm of the electromagnetic spectrum was used, with a resampled precision of 1 nm. The reflectance measurement was collected *in situ*. Four records were obtained. A spectral curve was created from the means of measurements in each sample. In the blue region, reflectance values between 0.0116696 and 0.0399550 were found. In the red region, the reflectance oscillated between 0.0438487 and 0.1095826. In the green region, the reflectance values ranged between 0.0405677 and 0.1001319. In the near-infrared region, the oscillation of reflectance values occurred between 0.1163483 and 0.4655269. The results indicate the effectiveness of the use of geotechnologies to carry out the spectral characterization of the *H. ringens* leaf. Further studies are expected to identify and monitor plant populations with Remote Sensing.
Keywords: spectral curve, spectroradiometer, geotechnologies, reflectance.

SENSORIAMENTO REMOTO NA CARACTERIZAÇÃO ESPECTRAL FOLIAR DE Hesperozygis ringens, UMA ESPÉCIE AMEAÇADA DE EXTINÇÃO

RESUMO - *Hesperozygis ringens* é uma espécie que se destaca pela produção de óleo essencial. Não foram encontrados relatos sobre a caracterização espectral foliar da espécie. O presente estudo teve como objetivo determinar o padrão de reflectância das folhas de *Hesperozygis ringens* com auxílio de Sensoriamento Remoto. Para isso, foi utilizado um espectrorradiômetro que atua na faixa espectral contínua de 400 a 900 nm do espectro eletromagnético, com precisão reamostrada de 1 nm. A medida de reflectância foi coletada *in situ*. Foram obtidos quatro registros. Uma curva espectral foi criada a partir de médias das medidas em cada amostra. Na região do azul foram encontrados valores de reflectância entre 0,0116696 e 0,0399550. Na região do vermelho, a reflectância oscilou entre 0,0438487 e 0,1095826. Na região do verde, os valores de reflectância variaram entre 0,0405677 e 0,1001319. Na região do infravermelho próximo, a oscilação dos valores de reflectância ocorreu entre 0,1163483 e 0,4655269. Os resultados encontrados no presente estudo indicam a efetividade do uso de geotecnologias para a realização da caracterização espectral da folha de *H. ringens*. Espera-se que os resultados encontrados estimulem futuras pesquisas com o intuito de identificar e monitorar as populações da planta com Sensoriamento Remoto.
Palavras-chave: curva espectral, espectrorradiômetro, geotecnologias, reflectância.

INTRODUCTION

Geoprocessing or geotechnologies are terms that refer to the set of technologies used for collection, processing, and analysis activities, followed by the provision of information that contains a geographic reference (ROSA, 2005). Remote Sensing is part of geotechnologies and has portable sensors, also known as spectroradiometers, which are capable of performing reflectance sampling of targets in different bands of the electromagnetic spectrum (SOUZA FILHO; CRÓSTA, 2003). According to these authors, the sampling includes the wavelengths of the visible regions, as well as the near-infrared, short-wave infrared, and thermal infrared.

Part of the radiation that reaches the earth's surface and encounters vegetation is absorbed by the leaf, while part is reflected; being that these amounts vary between and within species (MALLMANN et al., 2015). The differentiation and the monitoring of vegetation types can be performed using characterized spectral profiles (LIRA et al., 2009). The use of Remote Sensing technologies for the spectral characterization of vegetation has been reported in the literature (PANDYA et al., 2013; MALLMANN et al., 2015; MARTINS; GALO, 2015).

Hesperozygis ringens (Benth.) Epling is an endangered species (GOVERNO DO ESTADO DO RIO GRANDE DO SUL, 2014), which can be found in populations located in municipalities of Rio Grande do Sul State (RS) (FRACARO; ECHEVERRIGARAY, 2006), as in Santa Maria (PINHEIRO et al., 2018a, 2018b). Studies have demonstrated the potential of *H. ringens* leaves for the

[1]Universidade Federal de Santa Maria (UFSM), Santa Maria, RS, Brasil. E-mail: pinheiro.gcarlos@gmail.com. *Corresponding author.

production of essential oil, as well as the chemical characterization and biological activities provided by the extractive (TONI et al., 2014; PINHEIRO et al., 2017; PINHEIRO et al., 2021).

In addition to producing essential oil characterized by the predominance of the oxygenated monoterpenoid known as pulegone, the *H. ringens* leaves also produce classes of constituents such as lipids, oil-resins, proteins, phenolic compounds, flavonoids, and alkaloids (PINHEIRO et al., 2018a). Additionally, the leaves stand out for their structural characteristics such as the presence of glandular and non-glandular trichomes (PINHEIRO et al., 2018b).

Although structural and histochemical characterizations of the *H. ringens* leaf have already been carried out (PINHEIRO et al., 2018a, 2018b), no studies on the spectral characterization of the species were found. Additionally, no reports of spectral characterization of representatives of the Lamiaceae family were found.

Therefore, this study aims to identify the reflectance pattern of *H. ringens* leaves using a spectroradiometer so that it is possible to evaluate the use of Remote Sensing for the identification of plant populations.

MATERIAL AND METHODS

To carry out this study, legal authorizations were obtained, such as the one acquired from *Sistema de Autorização e Informação em Biodiversidade* (SISBIO, number 74776-1) for the collection of plant material to carry out scientific activities with *H. ringens*. In addition, authorization for access to genetic heritage was also obtained from the *Conselho Nacional de Gestão do Patrimônio Genético*, linked to the *Ministério do Meio Ambiente* (SISGEN N. AB0C2C1), as well as a record of studies with *H. ringens*.

H. ringens leaves were analyzed *in situ*, in a population located in Santo Antão, Santa Maria municipality, RS. The analysis followed the method described by Durán et al. (2013). An Analytical Spectral Device Inc spectroradiometer, FieldSpec HandHeld VNIR model was used. This equipment operates in the continuous spectral range from 400 to 900 nm of the electromagnetic spectrum, in an interval of 1.6 nm and a resampled precision of 1 nm. This equipment operates in the visible region and partly in the near-infrared region. Among the components of the spectroradiometer are the detector unit, a tripod, a laptop, and a reference board, in addition to accessories such as a battery and cables for connection (DURÁN et al., 2013).

Since *H. ringens* is a shrub, for the plant analysis, the branches of one individual were grouped, so that the records were obtained only from the leaves, avoiding the reading of the soil. For leaf sampling, a reflectance measurement was collected at a height of 50 cm. Four records were obtained on the spectroradiometer. The data were reviewed to verify the dispersion of the spectral curves. For each sample, an average of the measurements was performed to create a spectral curve. The data processing, as well as the obtention of spectral curves, were carried out using the software RS3, FieldSpec, ViewSpec Pro Versão5.6, and Microsoft Excel (DURÁN et al., 2013).

RESULTS AND DISCUSSION

The lowest reflectance value found in the blue region was 0.0116696 at 400 nm, while the highest value was 0.0399550, detected at 499 nm (Figure 1). The reflectance increased in this spectral range and the average was 0.0285964. In the green region, an average reflectance of 0.0790069 was detected. The lowest value found was 0.0405677 at 500 nm, and the highest reflectance detected was 0.1001319 at 554 nm. Therefore, the reflectance in this spectral band showed an increase up to the wavelength of 554 nm and a decrease until the end of this spectral band.

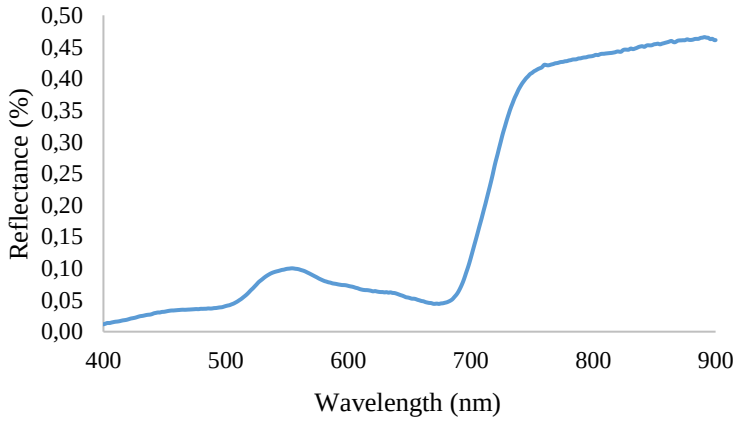

FIGURE 1 - Spectral characterization using a spectroradiometer of the canopy of one *Hesperozygis ringens* individual located in Santo Antão, Santa Maria municipality, Rio Grande do Sul.

The red spectral range showed smaller reflectances than the green and infrared bands (Figure 1). The smallest reflectance value detected in the red region was 0.0438487 at 674 nm, and the average reflectance in this region was

0.0595628. The spectral band of transition from red to infrared, called RedEdge, showed a marked variation in reflectance of approximately 0.36% of amplitude. In the near-infrared region, the minimum reflectance value was 0.1163483 at 700 nm, and the maximum value was 0.4655269 at 891 nm (Figure 1). The average reflectance found in this region was 0.4042686.

From the spectral characterization of the *H. ringens* leaf, the green region stood out in the visible range, where, in general, there was an increase in reflectance concerning the blue and red regions. The results suggest the effectiveness of spectroradiometrics for the characterization of the leaf of a Lamiaceae species. Using spectroradiometers, reflectance data can be collected *in situ*, which is especially important for endangered species. In addition to providing information about the spectral characteristics of the targets, *in situ* collection makes it possible to obtain physical values as well (MARTINS; GALO, 2015).

Regarding the spectral behavior of vegetation, chlorophyll absorbs solar radiation in the photosynthetic process and the reflectance is usually low in the visible region, while in the near-infrared region, the leaf tissue reflects solar radiation and the reflectance is usually high (LIRA et al., 2009). This behavior in the reflectance of the near-infrared region is in agreement with what was observed in our study since the referred region presented a highlighted average value.

Spectroradiometry can be used to analyze canopies of plant species. A study with soybean observed that the decrease in chlorophyll provides a decrease in reflectance in the bands from 450 to 520 nm, as well as from 630 to 690 nm (GROSS et al., 2016). In our study, among the regions of the visible range analyzed in *H. ringens*, the average green reflectance stood out, with the maximum value at 554 nm. This result is possibly related to the strong presence of chlorophyll in this region.

Our results may serve as a basis for further studies with *H. ringens*, such as the use of vegetation indices to analyze new characteristics of the leaves. Vegetation indices have been used in several studies to help achieve different goals such as measuring chlorophyll (LU et al., 2015), assessing water stress (DEJONGE et al., 2016), identifying diseases in plants (ODILBEKOV et al., 2018), and the monitoring of a deforested area (NERY et al., 2014).

Our study is the first report on the use of spectroradiometrics in *H. ringens* characterization. Future research is indicated, such as the analysis of more individuals of the species, as well as the study of other populations. These new studies could allow a comparison of characteristics between places of occurrence of *H. ringens* to identify the species with the aid of Remote Sensing. Geotechnologies can be applied in different fields of knowledge, and the use of satellite images enables the analysis of a geographic space, as well as the collection of information in distant environments considered difficult to access (FLORENZANO, 2005). The identification and distribution of plant species can be carried out with the help of Remote Sensing technologies, and methods such as vegetation indices (COELHO et al., 2016; GOERGEN et al., 2016). Since *H. ringens* is an endangered species, the use of Remote Sensing would enable the identification of occurrence areas and the monitoring of their populations, aiming at preservation.

CONCLUSIONS

The results suggest the effectiveness of geotechnologies for the spectral characterization of the *H. ringens* leaf, an endangered species. It is expected that this study motivates further studies on the species, with a larger sample number and in other geographic sites, aiming to detect and monitor populations of *H. ringens* with remote sensing.

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