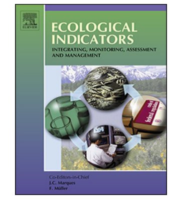
Ecological Indicators 95 (2018) 75–84

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind



Original Articles

Use of local ecological knowledge as phenology indicator in native food species in the semiarid region of Northeast Brazil

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ARTICLE INFO

Keywords:
Ethnobiology
Ethnoecology
Participatory methodology
Phenology
Phenological calendar

ABSTRACT

Phenological studies that aggregate local ecological knowledge on the expression of phenophases may be useful in the elaboration of management strategies of species that are important to a given local system. In this study, we seek to answer the following questions: 1) How do the different phenophases of two important native food species are expressed in the three phytophysiognomies of the Cerrado (Brazilian savannah) where they are collected? 2) How does rainfall influence the expression of the phenophases of these species on the evaluated phytophysiognomies? 3) Does the local ecological knowledge of the residents of the Araripe National Forest (hereafter FLONA) on the phenophases of native species of high importance correspond to what occurs in the three phytophysiognomies of the Cerrado? The phenological monitoring was executed monthly from January 2012 to December 2013. In order to retrieve the local knowledge about phenophases, key informants from three communities located around the FLONA were selected. Rainfall is a limiting factor for the expression of the reproductive phenophases of *Caryocar coriaceum*, differently from what occurs for the vegetative phases and for *Hancornia speciosa*. There were no significant differences between the local knowledge of communities that collect resources in the forest and most of the data collected in the phenological evaluation. In addition, there was no difference in the expression of the phenophases among the three phytophysiognomies, also corroborating with the local ecological knowledge. As for the community that collects in agroforestry yards, there were significant differences between knowledge and expression of phenophases. Thus, the use of local ecological knowledge of people who collect resources in the forest has proved to be reliable and may be promising mainly in rapid diagnoses of biodiversity.

1. Introduction

Local ecological knowledge is a product of the adaptation of human populations to the environment they live (Berkes et al., 2000). Considering that people have preferences regarding the resources that are available for their foraging (Albuquerque et al., 2005), it can be expected that they have greater knowledge about the ecological characteristics of locally widespread species (Lins Neto et al., 2013; Ochoa and Ladio, 2014). This may reflect the selective aspect of human memory, which seeks to store information that they consider socially relevant (Gardner et al., 2000).

In the case of native food plants, their phenological observation is a prominent activity, since it allows determining the periods of the year in which these species are available for collection. Most of the phenological studies attempt to describe the behavior of the vegetative and reproductive phases of the species, related to the variations of the environmental factors, with emphasis on the climatic issues (Amorim et al., 2009; Vasconcelos et al., 2010; Chambers et al., 2013). These studies are of great importance in forest extractive contexts because they provide valuable data on different forest responses to disturbances (Fayolle et al., 2014). In addition, in the semi-arid regions, where the availability of water resources is a limiting factor, rainfall response mechanisms are especially relevant (Valdez-Hernández et al., 2010), and the investigation of their influence on phenology is fundamental.

In addition to the importance of investigating the influence of environmental factors on phenological studies, we believe that local

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https://doi.org/10.1016/j.ecolind.2018.07.016
Received 13 March 2018; Received in revised form 6 July 2018; Accepted 9 July 2018

ecological knowledge may be relevant to identify phenological aspects of species that are important to local populations (Lins Neto et al., 2013; Ochoa and Ladio, 2014). This type of approach is necessary, since local communities have such a close relationship with the environment in which they live and with the resources present there. This may provide information on several ecological and ecophysiological aspects, such as phenology (Wezel and Lykke, 2006; Ruenes-Morales et al., 2010; Lins Neto et al., 2013). In addition, the people-resource relationship is important to understand some of the phenological responses of plants, since the forms of management adopted by the communities may alter the microclimatic conditions of the environment, which may shift in time the expression of some phenophases.

The record that people are able to recognize and identify such differences in the areas they manage suggests that the results from local knowledge studies on phenophases can be used as a tool for rapid diagnoses to identify periods of availability of a particular forest resource (Lins Neto et al., 2013), principally because it requires a great deal of evaluation time in order to understand the ecological patterns of certain species (Otero-Arnaiz et al., 2003).

Considering the aspects mentioned above, the present work aimed to clarify the following questions: 1) How do the different phenophases of two important food species widely used in the Araripe National Forest (hereafter FLONA), are expressed in the three phytophysiognomies of the Cerrado (Brazilian savannah) where they are collected? 2) How does rainfall influence the expression of the phenophases of these species on the evaluated phytophysiognomies? 3) Does the local ecological knowledge of the residents of the FLONA on the phenophases of native species of high importance correspond to what occurs in the three phytophysiognomies of the Cerrado?

2. Material and methods

2.1. Study area and species selection

FLONA was the first conservation unit of sustainable use created in Brazil in 1946 (IBAMA, 2004). It is considered a priority area for the conservation of the biodiversity of the Brazilian savannah. It is located in the southern region of the state of Ceará, Northeast of Brazil and comprises the following municipalities: Barbalha, Crato, Jardim, Missão Velha and Santana do Cariri (IBAMA, 2004).

In the FLONA area a mosaic of Cerrado phytophysiognomies is found, which are: Cerrado *sensu stricto*, composed mainly of herbaceous plants and shrubs; Cerradão, where it is possible to observe a larger quantity of large trees; and finally, Mata úmida (humid forest) area composed of large trees and with denser vegetation (IBAMA, 2004). The areas referring to the three phytophysiognomies were those managed by the local population where they were found, concomitantly with the two species selected in this study.

In order to verify if the local ecological knowledge on the phenophases of two food species correlates with the phenological data collected in the field, in the three phytophysiognomic domains listed above, we selected data from a previous study, the two food species that are generally preferred by three local communities of the region, which are: *Caryocar coriaceum* Wittm. (local name: pequi) and *Hancornia speciosa* Gomes (local name: mangaba) (Campos et al., 2016; Sobral et al., 2017).

Caryocar coriaceum Wittm. (Caryocaraceae) is a tree species that can reach up to 15 m high and is native to the Cerrado of the northeastern Brazil (Oliveira, 2008). In the harvest period, pequi attracts a large number of extractivists to the interior of the forest to collect the fruits that are traded, consumed *in natura*, and for the production of oil (Sousa-Júnior et al., 2013). In addition to having a high potential for food, pequi oil is also widely used in the treatment of certain diseases, especially those affecting the respiratory system, such as influenza and tuberculosis, as well as being used in the treatment of skin diseases and inflammation (Agra et al., 2007; Sousa-Júnior et al., 2013).

Hancornia speciosa Gomes (Apocynaceae) is a woody species with a height between four and eight meters and that inhabits preferably open areas (Moura, 2005). The mangaba is widely distributed, being found in different phytophysiognomies of the Cerrado and in restinga vegetations (Lederman et al., 2000). The fruits, consumed *in natura*, are considered rich in several types of nutrients and vitamins, mainly vitamin C. The latex is often used in the treatment of ulcers and gastritis and in the prevention of several types of cancer, mainly those associated to the gastrointestinal system (Pereira et al., 2006).

2.2. Phenological evaluation

The phenological behavior of the selected populations was estimated through the activity, intensity and synchronization of the vegetative stages (budding and leaf fall) and reproductive (flowering and fruiting) (Fournier, 1974) in the three phytophysiognomies of the Cerrado. The evaluated individuals were randomly selected, totaling 15 pequi and 10 mangaba individuals in each area. It is worth mentioning that the number of individuals for the two species was different because the mangaba population is quite small in the three phytophysiognomies.

The selected populations were evaluated monthly between January 2012 and December 2013, totaling 24 months. In order to quantify the phenophases described above, the method proposed by Fournier (1974) was adopted. It consists of a semi-quantitative scale composed of five categories (0–4), in which: 0 = absence of the phenophases; 1 = intensity between 1 and 25%; 2 = intensity between 26 and 50%; 3 = intensity between 51 and 75%; and 4 = intensity between 76 and 100%. For all phenophases of the two species the Fournier Index (FI) was calculated. It is presented in percentage values and calculated by means of the following equation:

$IF = \Sigma\ ei/im.100$, where ei = estimation of the intensity of the phenophase in the individual i; im = the maximum intensity reached by the population if all the individuals present maximum intensity of the phenofase.

In order to evaluate the variation in the synchronization of the phenological phases between the individuals of the same phytophysiognomy and among phytophysiognomies, the synchronization index was calculated (Augspurger, 1983). The synchronization for each phenophase (Xi) was measured separately for each of the individuals of both species used in this study, in each phytophysiognomy. Synchronization was calculated using the following formula: $[Xi = \Sigma ij/(N - 1) fi]$, where Σij is the sum of the number of months that each individual i and j showed synchronization in a phenophase; fi corresponds to the months in which the individual i exhibited a particular phenophase and N is the total number of individuals in a sample. The synchronization index for the species Z is calculated by the arithmetic mean of Xi, through the equation: $Z = \Sigma Xi/N$. This index ranges from 0 (no synchronization) to 1 (perfect synchronization) (Augspurger, 1983).

2.3. Characterization of communities

In order to access the local ecological knowledge about the occurrence of phenophases, we identified the informants, based in interviews, either male or female, who are more knowledgeable. We termed them key informants about native food plants (see Campos et al., 2016).

These key informants reside in three important extractive communities in the region, which are located near the FLONA. These communities are: Baixa do Maracujá, belonging to the municipality of Crato; Horizonte, located in the municipality of Jardim and Macaúba, located in the municipality of Barbalha. It is important to note that, although the three communities extract different native resources, they develop different strategies for this extraction.

The community of Baixa do Maracujá, for example, has as its main collection site the agroforestry yards, where a high diversity of native species is found. In Horizonte, the collection of native resources is