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Conservation efforts based on local ecological knowledge: The role of social variables in identifying environmental indicators

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ABSTRACT

The incorporation of local ecological knowledge in monitoring processes has been one of the great challenges of conservation initiatives worldwide. Therefore, it is essential to use indicators as local evaluation tools of the conditions of a species in order to support conservation actions. Local populations observe the environment, climate change and the influence of these factors on the species they use. However, their observations and perceptions may vary depending on different social factors. We used as model two species of economic importance involved in sociobiodiversity product chains to evaluate the role of social variables in the identification of conservation indicators for this plants. The species studied were: *Caryocar coriaceum* Wittm. (locally known as pequi), and *Himatanthus drasticus* (Mart.) Plumel (locally known as janaguba). We also registered which indicators are perceived as the most important and what they are measuring. Our results show that the knowledge among collectors is homogeneous and that, generally, the social factors do not affect the knowledge on local indicators. Age and extraction time were factors that influenced the knowledge on climate indicators and population structure only for *C. coriaceum*. In the communities studied, collectors not only monitor the biological characteristics of the species, but also the environmental and climatic phenomena that are threatening the sustainability of the species. These results can help to improve our ability to manage information about natural resources, incorporating local ecological knowledge in the scientific process of evaluation and monitoring of biodiversity.

1. Introduction

In the last three decades scientific evidence has shown an acute decline in biodiversity due to habitat degradation (Rapport and Hildén, 2013) and the consequent loss of essential natural resources for humanity (Butchart et al., 2010; Cardinale et al., 2012). To remedy this situation, important measures have been implemented globally, such as the creation of protected areas (García-Frapolli et al., 2009) and the employment of monitoring systems (Danielsen et al., 2000). Monitoring systems are defined as a process of systematic collection of data on the conditions of a system and the possible changes over time (Yoccoz et al., 2001), usually applied by trained professionals with the main goal to inform actions of management (Danielsen et al., 2000; Nichols and Williams, 2006).

To assist in monitoring the use of indicators is being increasingly practiced, because they are important tools for decision-making (Jørgensen et al., 2013). Generally, an indicator is a measure that provides information about the state of a resource (eg. population size of a species) (Heink and Kowarik, 2010), a phenomenon (Jørgensen et al., 2013), or evaluate if pre-set targets are being accomplished (e.g. Millennium Development Goals) (Heink and Kowarik, 2010). In the context of environmental monitoring there are environmental indicators that report on the impacts of human actions on the environment, for example, measuring the environmental quality (air and water) (Jørgensen et al., 2013). In turn, the environmental indicators are used to measure the characteristics of the structure, composition or

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function of ecological systems (Niemi and McDonald, 2004) evaluating, holistically, emergent properties such as resilience of ecosystems (Jørgensen et al., 2013).

The observation of species and the environment have always been part of the interrelationship of the first humans with the environment (Rapport, 1992). Studies show that local populations in diferente parts of the world, such as hunters (Danielsen et al., 2014b), fishermen (Alves and Nishida, 2002; Turvey et al., 2014) and plant collectors (Khan et al., 2014; Monroy-Ortiz et al., 2009) observe local indicators, such as the migratory movements of animals (Niemi and McDonald, 2004), flowering of plants (Lantz and Turner, 2003), changes in the morphology of animals (e.g. weight and body size) (Bender et al., 2013), in the population density of plants (Khan et al., 2014) and environmental changes (Johnson et al., 2015). In addition, people observe atmospheric phenomena (Fernández-Llamazares et al., 2015a) and variations in climatic conditions and how these changes affect the distribution and interaction of species of animals and plants (Savo et al., 2016; Weber, 2010). In this study, we defined as local indicators the observations of the local populations to evaluate the status of conservation of the species and the future trends of the natural resources important for their subsistence. These continuous observations are part of the local ecological knowledge developed over the generations through the intimate contact of people with the environment (Berkes et al., 2007; Tengö et al., 2014).

In this scenario, many studies support the need to integrate the local ecological knowledge and the local indicators to improve monitoring of species and ecosystems (La Torre-Cuadros and Arnillas-Merino, 2012; Sheil and Lawrence, 2004; Sutherland et al., 2014; Tengö et al., 2014), because monitoring systems conducted only by researchers external to a location have limitations, because they are considered expensive and often are not performed systematically (Danielsen et al., 2014a, 2009). Similarly, the indicators used are developed by researchers who previously define what they consider most relevant to be monitored, which is considered a reductionist approach of the phenomena being measured (Santana-Medina et al., 2013).

Local ecological knowledge represents the knowledge based on the accumulated experience of interactions with the local environment and the observations of people who depend directly on natural resources (Turvey et al., 2014Brook and McLachlan, 2008). Many authors have shown that knowledge and the use of natural resources, as well as people's perception of environmental changes, may vary according to some factors, such as gender, age and time of exposure to the environment in the search for resources (Albuquerque et al., 2011 Campos J. et al., 2015;Campos L. et al., 2015; Hanazaki et al., 2013; Martins et al., 2014; Quinn et al., 2003).

There are few studies that address how knowledge about indicators is distributed among users of natural resources and what indicators are perceived as most important for assessing the state of conservation of species. In this study, we tested the hypothesis that social factors such as age, gender and the length of experience of extractivists influence the amount of indicators they observe. Therefore, the aim of this study was to answer the following questions: (1) Do age, sex and length of experience in extractive activity influence the number of indicators observed? (2) Among the mentioned indicators, which are perceived as the most important to monitor and evaluate the state of conservation of the species?

2. Material and methods

2.1. Study area

The study was conducted at the Araripe-Apodi National Forest (Flona Araripe), located at the southern end of the state of Ceara, northeastern Brazil. The Flona Araripe is a sustainable use conservation unit with 38,262.32 ha and is included in the Environmental Protection Area of Chapada do Araripe (Fig. 1). The climate is considered hot humid tropical according to Köppen classification, with an annual average of 1019 mm of rainfall and average annual temperature between 24 and 26 °C (IBAMA, 2004).

The communities of Belmonte, Horizonte and Macaúba located around the Flona Araripe, with an average distance of 28 km from each other, were selected for this study. These communities were selected because they have a long history of extraction of various non-timber forest products (Campos J. et al., 2015; Campos L. et al., 2015; IBAMA, 2004; Lozano et al., 2014), essential for the complementation of income of the populations, highlighting the collection of the fruit *Caryocar coriaceum* Wittm. (locally known and hereafter referred to as pequi), and latex obtained from *Himatanthus drasticus* (Mart.) Plumel. (locally known and hereafter referred to as janaguba). These species are the main sources of income for many families living in the surroundings of Flona Araripe, which is the case of the communities included in this study (Baldauf and Santos, 2013; Silva et al., 2017, 2015).

In the Horizonte community, the collection of fruits of *C. coriacem* is the main source of income for most families (IBAMA, 2004; Silva et al., 2017). The pulp of pequi fruits is used in the preparation of regional dishes (Sousa et al., 2013) and appreciated for its nutritional value (Sena et al., 2010); In addition, the fruits are processed to produce the pequi oil used for medicinal purposes to treat many disorders, such as skin inflammation, respiratory affections, ulcers and contusions (Saraiva et al., 2011). In the Horizonte community, most families in the communities surveyed make a living from subsistence agriculture and government subsidies, with incomes between half a minimum wage and two minimum wages (Cavalcanti et al., 2015). A study by Silva et al. (2017) showed that during the pequi harvest, between January and April, the sale of fruits and pequi oil can generate an average income between US$ 500.00 and US$ 3000.00, while the average annual income from subsistence agriculture is approximately US$ 60.00. The collection of this species is not prohibited, and the increased demand in regional trade along with the low regeneration rates of pequi populations are identified as a possible cause of the decline of natural populations of pequi, suggesting that this species is threatened with local extinction (Almeida, 2014; Santos et al., 2016).

In turn, *H. drasticus* presents a different picture. This species occurs in high densities in the Flona Araripe and its collection occurs predominantly in the Macaúba and Belmonte communities (IBAMA, 2004). The latex of janaguba, know as janaguba milk, is extracted from the removal of the bark and is used in local medicine for the treatment of inflammatory processes, ulcers, gastritis and tumors (Colares et al., 2008; Lucetti et al., 2010; Ribeiro et al., 2014). The scientific confirmation of its pharmacological properties (Mousinho et al., 2011) has led to increased sales of latex and extraction pressure, threatening the sustainability of the species (Baldauf and Santos, 2014). For this reason, the Chico Mendes Institute for Biodiversity Conservation (ICMBio), the agency responsible for the management of the Flona Araripe, began to regulate the extraction of latex. The collectors need to be registered and pay a fee for the collection (Baldauf et al., 2014; Baldauf and Santos, 2013). This regulation created an informal market, so there is no updated data on the income generated by the sale of the milk of janaguba.

2.2. Collection of ethnobotanical data

Data collection began with the identification of extractivists that visit the forest daily during pequi harvest periods and that participate in the pequi harvest every year. Just as janaguba latex collectors who are authorized to collect and visit the forest weekly for latex extraction. Pequi collectors who make sporadic collections or are frequently absent from communities to work in cities, as well as janaguba collectors who do not have permission for latex extraction, were not included in the samples.

The selection of informants was performed using the technique known as snowball (see Albuquerque et al., 2014). The interviews were conducted at the residence of the informants, with heads of families,