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Identification of ecological indicators for monitoring ecosystem health in the trans-boundary W Regional park: A pilot study

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ARTICLE INFO

Article history:
Received 8 February 2007
Received in revised form
30 March 2007
Accepted 1 April 2007
Available online 23 May 2007

Keywords:
West Africa
Ecological indicators
Fruit-feeding insects
Transects
Human pressure
Mosaic landscape

ABSTRACT

The sustainable management of the W Regional park and its peripheral areas is based on a trade-off between conservation and the generation of economic income for local populations. This work is a pilot study for the identification of ecological indicators to monitor ecosystem health in Sudanian Savannah ecosystems. Ecological indicators are needed to warrant the efficiency of the protection measures, particularly in the mosaic landscapes of the peripheral areas. Two insect families (Coleoptera: Scarabaeidae (Cetoniinae) and Lepidoptera: Nymphalidae) were trapped along transects crossing landuse units submitted to various human pressures (none, hunting, traditional and intensive crops, grazing) in two countries (Burkina Faso and Bénin). Plant species richness was found to be correlated with the abundance of four fruit-feeding insect species and with the fruit-feeding butterflies species richness, but not with the Cetoniinae species richness. The abundance of Nymphalidae species generally dropped with human activities, but that of Cetoniinae species followed the intermediate disturbance theory. The likely impact of the various management practises on the general ecosystem health is discussed, as is the potential value of fruit-feeding insects as bioindicators and the points that still need to be clarified.

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1. Introduction

The W Regional park (Bénin, Burkina Faso and Niger) was recently classified as the first trans-boundary biosphere reserve in Africa by the UNESCO-MAB (November 2002). Thanks to the involvement of the neighbouring populations in the management and the exploitation of the peripheral areas surrounding the protected one, it is becoming a model of sustainable conservation for West-African Savannah ecosystems. To be sustainable, the conservation policies must

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0006-3207/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.biocon.2007.04.001

reconcile the conservation of the diversity with the generation of income for local populations of the peripheral areas (buffer areas, transition areas). Monitoring of the health of ecosystems appeared to be of critical importance while evaluating the various technical strategies involved in the project. To achieve this aim, the identification of ecological indicators, sensitive to slight ecosystem changes in a predictive manner, thus allowing the detection and measurement of the effect of various human pressures and activities, was of high priority. These indicators should fulfil two main attributes:

- be a tool to select the best management strategies to maintain the maximal biodiversity given the space available,
- be demonstrative for the local populations and environmental services, so that they can use it themselves and be encouraged to apply the conservation measures.

Our selection scheme (presented in Section 2) led to the choice of two fruit-feeding insect groups and to test the relation between their apparent densities at a species level, and the various landuse units encountered in the park periphery. Insects represent half of the global diversity and are influenced by many ecologic factors, like micro-climate, geology or vegetation structure (Ramos, 2000). Their relation to the ecosystem attributes are not still fully understood. Both bait-attracted insect families are taxonomically well-known and ecologically highly diversified (Allard, 1991; Sakay and Nagai, 1998; Larsen, 2006). Bait-attracted butterflies are well studied, as attested by the many references available and their recent classification in well-defined categories of habitat and distribution by Larsen (2006). Bait-attracted Cetoniinae are not as well studied, but we are preparing a similar classification than Larsen for this group (only the species of West-African Savannah areas), thanks to other trials in various localities in Burkina Faso, Niger and Bénin (Legrand et al., 2006).

The relations between ecosystem disturbance and insects in general (Holloway et al., 1992; Eggleton et al., 1995; Brown, 1997; Hamer et al., 1997), fruit-feeding butterflies in particular, have been investigated in tropical forests (Kremen, 1992; Beck and Schulze, 2000; Fermon et al., 2000; Ramos, 2000; Bobo et al., 2006). Fruit-feeding butterflies revealed themselves sensitive to disturbance and allowed an evaluation of the ecological impact of various conservation strategies (thinning, agroforestry, crops). However, the impact of disturbance on species richness is ambiguous, a slight disturbance or a border effect being able to increase local biodiversity (Lovejoy et al., 1986; Brown, 1997; Wood and Gillman, 1998), thus jeopardising the use of this parameter as a bioindicator. Authors generally agree that the use of species level parameters in well known environments is much more precise, provided that the sampling method can be standardised. This is particularly easy in the case of fruit-feeding insects that can be attracted to banana traps. All these studies were achieved in forest ecosystems and no data concerning the relation between disturbance and fruit-feeding butterflies or beetles densities is available in Savannah ecosystems. We chose to study both families together because their ecological roles and trophic levels of their larval stages (phytopageous and saprophytic) are completely different, thus ensuring a better indication of the global ecosystem health.

2. Materials and methods

2.1. *Selection of indicator taxa*

The selection of our indicator taxa is based on three reviews presenting the general properties of bio-indicator taxa and step-wise decision-making frameworks for the selection of indicator taxa (Noss, 1999; Hilty and Merenlender, 2000; Dale and Beyeler, 2001).

Authors generally agree that the first step is "to decide what ecosystem attribute indicator taxa should reflect" (Hilty and Merenlender, 2000). The activities considered as creating an income for local populations in the peripheral areas of the W Regional park are hunting, gathering, cropping and cattle grazing. Various crops have been developed, ranging from traditional crops (millet, sorghum, corn) to commercial crops using a lot of pesticides (especially cotton). The aim of this study was to compare the impact of various human activities on ecosystem health. The property of the environment to be monitored is thus its general health under various human pressures.

The second step was to "list all species in the area that best satisfy the baseline information criteria" (Hilty and Merenlender, 2000). Good information was already available about vertebrate taxa represented in the W Regional park (Lamarque, 2004), as opposed to most invertebrate taxa. During 3 years, 20 higher level insect taxa have been listed including Cerambycidae, Cetoniinae, Cicindelidae, Scarabaeidae, Reduviidae, Ascalaphidae, Myrmeleontidae, Papilionoidea, Hesperiidae, Saturniidae, Sphingidae, Lasiocampidae, Glossinidae, Tabanidae and Stomoxinae. These inventories are still being continued for some families and are about to be published for others. A new species of Sphingidae, a new species of Saturniidae, two species of Cerambycidae and four new species of Scarabeideae Ontophagini have already been described (Adlbauer and Sudre, 2003; Haxaire and Bompar, 2003; Adlbauer, 2004; Rougerie and Bouyer, 2005; Josso and Prévost, 2006). New species of Reduviidae and at least two other Cerambycidae species are to be described (J.M. Berenger and J. Sudre, com. pers.).

The third step was to "retain species that best meet the suggested niche and life history criteria" (Hilty and Merenlender, 2000). Because of their high mobility, most vertebrate species present in the W Regional park are not appropriate, nor are many invertebrate families (Sphingidae, Lasiocampidae, etc.). Despite the capacity to fly, less mobile invertebrates like butterflies were not removed at this stage since other studies revealed significant variations in their abundance according to degree of disturbance, even over short distances (Fermon et al., 2000; Ramos, 2000). The criterion "to be easily measured" further limited the list, leaving no taxa but the Glossinidae, Tabanidae, Stomoxinae, Cetoniinae and some Nymphalidae, especially the genus *Charaxes*. Actually, the authors understood the word "easy" as comprising a trapping technique that can easily be replicated. All active measures of density are too dependent of the operator to be standardized,

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