Détermination et caractérisation des espèces indicatrices

Des caractéristiques générales des peuplements d'acariens comme l'abondance et la richesse spécifique ont été abordées dans les chapitres précédents. On peut cependant s'interroger sur les facteurs explicatifs de la répartition de ces espèces en fonction des sites d'études. L'identification des espèces indicatrices est une pratique courante en écologie et en biogéographie. Elle permet en effet l'évaluation de l'état de santé des différents écosystèmes par la détermination des espèces caractéristiques. Les mesures directes de la biodiversité sont coûteuses en terme de temps et de dépense d'énergie, et par conséquent des mesures par des indications sont souhaitables. Le programme INDVAL définit par Dufrêne & Legendre (1997) a été retenue pour les différentes analyses. Les approches qui ont guidées ces analyses sont les suivantes : (1) les espèces indicatrices des milieux perturbés ou stables. (2) les espèces indicatrices des zones écologiques, des localités et des sites d'études. (3) les espèces indicatrices de litières ou de sol minéraux. L'idée de cette partie est d'établir une relation entre la richesse spécifique et le statut écologique de chaque site d'étude.

Chapitre 6

Indicator species in soil mites (Acari) from Ivory Coast

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Abstract

Indicators species are a needed tool to analyse ecosystem restoration and degradation. Our aim was precisely to identify indicator of soil state under different kind of forest management, from primary forest to teak plantation under tropical conditions. In that context, Lamto savannah (LAS), Oumé primary forest (OPF), teak plantation (OTK) situated in (Sudanese domain) and the Tai primary forest (TPF) (Guinean domain) were sampled twice in Ivory Coast. After a 1-week extraction in Berlese-Tullgren funnels, and description, 177 mite species were recorded. According to the indval software used to identified the indicators species, a first partitioning appaered between zones (2 climatic zones), localities (3) and study sites (4). A second partitioning opposed litter dwelling to mineral soil dwelling mites. 4 species are significative indicator of the Guinean zone (TPF). Moreover, 3 species were considered as indicator of the Sudanese zone and two species of the teaks (OTK). Fiftheen mites were indicator species of OPF. Three oribatids are species indicator of litter in TPF while only a single gamasid is indicator of litter in OTK. In mineral soil, a single Actinedida is indicator of OTK. The number of indicator species rises to 5 in LAS and to 16 in OPF.

Key words: Acari, forest, savannah, litter, mineral soil, indicator species.

Introduction

Value of biodiversity conservation has been recognized worldwide (Bonn and Gaston 2005; Humphrey, 2005), notably because the erosion of biodiversity elements can cause impoverished ecosystem functioning (Mertz et al., 2007). However biodiversity indicator are still needed to asses changes due to ecosystems management and global change. Several indices have been developed to measure the biological diversity (Shannon 1962; Whittaker 1972; Pielou 1969), however they present some bias such as overestimating or underestimating the role of rare species. In that context, (Dufrêne and Legendre 1997) renewed the notion of indicators by combining the relative abundance of a species with its relative frequency of occurrence in defined groups of site. For instance, the maximum value of index is obtained when all individual of a species are found in one kind of site (i.e. Primary forest) and if all these site contains that species. In that case, the indicators value of a species is independent of other species abundances and thus of their relative rarity. This approach seems particularly sounds to monitor soil ecosystem changes and biodiversity conditions because it is cost-effective, indicators are easily and reliably identified, they represents eco-functionally important species, and respond differently to disturbance regimes (Pearce and Venier, 2006). A lot of definitions have been attributed to the notion of indicators (Maleque et al. 2009). Nevertheless the indicators are recognized as being a variable that describes the state or the health of a system (Ferris and Humphrey 1999; Walz 2000; Burger 2006). Direct measurement of soil biodiversity is expensive, and therefore a substitution of measurement by indication is desirable (Ekschmitt et al. 2003).The different properties of soils animals which can be potentially used as indicators of soils quality was listed by Linden et al. (2004). These include: single organism level characteristics (behavior, developpment), community characteristics (species richness, trophic groups, functional groups) and characteristics of the biological process (bioaccumulation, soil modification).

From this point of view, Oribatida and Acaridida species and species assemblages offer several advantages for assessing the quality of soil ecosystems (Behan-Pelletier 1999). Most of soil mite live in the organic horizons, play an essential role in organic matter decomposition, but also represent a trophically heterogenous group with predators, detripagous and lmycopagous species, etc.. Previous study showed that Oribatida dominate the forest soil while Trombidiformes were more abundant in the savanna soil (Ryke, 1965 ; Ryke et Loots, 1967). In contrast to the anaerobic process of fermentation and putrefaction causing an increase of Acaridida, a best porosity of the soil promotes the development and emergence of Oribatida (Ducarme et al. 2004b).

The identification of characteristic or indicator species is a current pratice in ecology and biogeography. Field studies describing sites or habitats usually mention one or several species that characterize each habitat. However,there is a clear lack of data concerning the African soil mesofauna. Our aim saw to provide a first insight in this field by extraction potential indicator species of a completely new set of data sampled in well contrast ecosystems.

Materials and methods

Study sites

Four sites in Ivory coast Lamto savannah (LAS), Oumé primary forest (OPF), teak plantation (OTK) situated in (Sudanese domain) and the Tai primary forest (TPF) (Guinean domain) were sampled twice at differents depth (0-5 cm, 5-10 cm, 10-15 cm, 15-20 cm, 20-25 cm, 25-30 cm, 30-35 cm, 35-40 cm), with a steel corer (∅ 3.5 cm). The mesofauna was then extracted during 1-week using a Berlese-Tullgren system, only mites were considered for this study. More details concerning the site and the sampling were given by N'Dri and André (submitted 1).

Data analyses

The approach outlined by Dufrêne & Legendre (1997) was followed. It is based on the specificity $A_{ij} = N_{ij}/N_i$; the fidelity $B_{ij} = S_{ij}/S_j$; and the index $IndVal_{ij} = A_{ij} * B_{ij} * 100$.

IndVal is an Indicator Value of species *i* in site group *j*. A_{ij} measure the specificity of a species "I" at a site "j" where, N_{ij} is the mean number of individuals of the species *i* across the sites of group *j*, while $N_{i.}$ is the sum of the mean numbers of individuals of species *i* over all groups. The group level makes reference to the level of the study which is of interest, for example all the samples of the primary forest of Oumé. We use the mean number of individuals in each group, instead of summing the individuals, because this removes any effect of the number of sites in the various site groups, and of differences in abundance among sites belonging to the same group. A_{ij} is maximum when species *i* is only present in group *j*. In the formula for B_{ij}, which is a measure of fidelity, S_{ij} is the number of sites in group *j* where species *i* is present, while $S_{.j}$ is the total number of sites in that group. B_{ij} is maximum when species *i* is present in all objects of group *j*. For the Indval index, quantities A and B must be combined by multiplication because they represent independent informations about the species distribution. Final multiplication by 100 produces percentages. Hierarchical classification of samples was used for data analysis. Level of signification was 5%.

The fidelity reflects the presence of species *i* on all sites from to a cluster *j* , while specificity reflects the frequency. A best indicator species should be primarily in a single group of the typology and be present at most sites from this group (high fidelity). Indicator species generally give an ecological function to a typology of sites.

A first partitioning was made between zones (2 climatic zones = two groups), then localities (3) and finaly study sites (4), i.e. between macrohabitats. A second partitioning opposes litter dwelling to mineral soil dwelling mites (microhabitat). This approach has been recommended and used in soil biology (Nahmania et al. 2006).

Results

Identification of species

In all, 177 soil mites species were identified, but not named according to the Code of Zoological Nomenclature because the lack of taxonomic information for African soil mites (LAS: 85 species, OPF: 98, OTK: 51 and TPF: 66). Species were delineated on morphological characters and respective photographs were treated with Auto-Montage and classified in a database. Reference collection and database were deposited in the African Museum of Tervuren, Belgium. In the absence of African keys, the hierarchy was maintained at a very simple level: each species, whatever the stase, was placed in Oribatida (in the traditional sense), Gamasida, Actinedida and Acaridida.

Species indicator of macrohabitats

On 66 species of the Guinean zone (TPF), only 4 species, 3 oribatids and 1 uropodid, can be considered as significative indicator of that zone (TPF). In contrast, 3 species are indicator of the Sudanese zone despite a richness estimated at 149 species (Table 1).

Nine species, 4 oribatids and 5 gamasids, are indicator of the savannah, LAS. A single oribatid, MERISP1, is indicator of the locality of Oumé.

Two species, a gamasid, GAMASP3 and an acaridid, RHYZOSP1, are indicator of the teaks (OTK). 15 mites are indicator species of OPF (Table 1).

Table 1 : Species indicator of a macrohabitat: zone, locality or study site. Only species acronyms are indicated. (P<0.05). Indval index (IV) are descending in the last column.

	2 zones			3 localities			4 sites	
Group	Species	IV	Group	Species	IV	Group	Species	IV
Sudanese	GAMASSP2	76.56	Oumé	MERISSP1	41.11	OPF	ORIBSP19	69.50
	UROPOSP2	42.22	Lamto	TORPASP1	66.67		GALSPP10	61.11
	RHYSODUP	35.56	(LAS)	TRACHSP3	49.93		TRACHSP2	59.77
Guinean	ORIBASP7	32.14		MYCROSP1	46.67		LARGASP2	53.33
(TPF)	ORIBSP48	31.03		GALSPP11	24.56		MESOSPP1	48.00
	ORIBSP47	20.00		GAMASP14	24.56		ORIBSP18	45.71
	UROPOSP1	13.33		ORIBSP50	24.24		ORIBSP26	44.33
				EVIMIURO	20.51		UROPOSP3	39.11
				MACROSP1	20.00		GALSPPP5	38.62
				ORIBSP49	20.00		OPPIASP3	33.33
							MIXASPP1	32.73
							ORIBSP33	30.56
							PHTHISP6	29.09
							ORIBSP41	25.64
							SPHAESP2	25.00
						OTK	GAMASSP3	30.00
							RHYSOSP1	26.67

Species indicator of microhabitats

A second partition in 2 microhabitats, litter vs mineral soil, was made in all sites (data from all site was pooled). A single oribatid is an indicator species of litter, ORIBASP7. In contrast, an oribatid (RHYSODUP) and 2 gamasid, GAMASSP2 and UROPOSP2, are indicator species of mineral soil. These species were particularly generalist, because they were observed on all 4 study sites.

If sites are considered, i.e. if all samples are partitioned into 8 groups, the list of species indicator of microhabitats is much longer (Table 2). Three oribatids are species indicator of litter in TPF while only a single gamasid is indicator of litter in OTK. In mineral soil, a single Actinedida, ACTISPP8, is indicator of OTK. The number of indicator species rises to 5 in LAS and to 16 in OPF. There is no indicator species of litter in OPF and LAS, neither of mineral soil in TPF.

Table 2 : Species indicator of a microhabitat, litter vs.mineral soil, in the 4 study sites. Only species acronyms are indicated. ($P<0.05$). Indicator Values (IV) are descending in the last column.

	LITTER			MINERAL SOIL	
Group	Species	IV	Group	Species	IV
OPF -1	-	-	OPF - 5	GAMASP2	27.91
				MESOSP1	25.00
				GALSPP10	22.92
				GALSPPP5	21.15
				ORIBASP26	18.67
				ORIBASP19	17.87
				TRACHYSP2	17.70
				ORIBASP18	15.56
				OPPIASP3	11.11
				UROPOSP3	10.11
				ORIBASP56	10.00
				ORIBASP33	9.72
				MERISP1	9.11
				PHTHISP6	9.09
				SPHAEROSP2	8.33
				LARGASP2	7.41
TPF - 2	ORIBASP9	12.69	TPF - 6	-	-
	GALSPPP4	8.65			
	ORIBASP48	6.06			
LAS - 3	-	-	LAS - 7	TRACHYSP3	16.84
				MACROSP1	10.00
				TORPASP1	9.52
				MYCROSP1	9.26
				GAMASP14	7.14
OTK - 4	GAMASP3	11.67	OTK - 8	ACTISPP8	7.37

Discussion and conclusions

Species identification

Delineating species boundaries correctly is crucial to the discovery of life's diversity because it determines whether or not different individual organisms are members of the same entity (Dayrat 2005). Parataxonomy and the sorting of specimens to recognizable taxonomic units (RTU's) are common approaches to invertebrate biodiversity studies worldwide (Ward & Stanley, 2004) and have been proposed recently to sort the springtail and mite specimens collected from the field (Alberta Biodiversity Monitoring Program 2006). Digital photography greatly enhances the ability of parataxonomists to efficiently recognize morphospecies (Basset et al. 2000). However, recognizing, naming, and identifying species is not an easy task, requiring experience or at least knowledge of all the taxon-specific pitfalls caused by variation and similarity (Krell 2004). Mites and other organisms whose length is less than one millimeter do not escape from the difficulty and necessitate skilled eyes to go on studying the richness of the soil (André et al. 2001).

If parataxonomy does not fulfill the criteria of a scientific method as claimed by Krell (2004), it can be a heuristically valuable tool to find out strange specimens and determine indicator species. By this way, it is possible to sort species and to set apart those which will require deep studies, naming as suggested by the International Code of Nomenclature and subsequent descriptions.

Indicator species

The methodology aiming at defining indicator species is reviewed by Carignan & Villard (2002) who conclude that each study presents arguments on the suitability of each taxon as a potential indicator.

On 177 species representing a important data set quite difficult to interpret this kind of approach allows to extract the essential information. We showed that only 7 mite species are sufficient to discriminate between climatic zones. More species are to be taken into account (17 indicator species) if we considered the study site (Table 1). The 15 indicator species in the Oumé primary forest characterize a relatively stable ecosystem, whereas in teak plantation (OTK), only two indicators species (GAMASSP3, RHYSOSP1) can be proposed, both not belonging to Oribatida. It will be wothful in the future to determine if these two species are also present in other kind of a disturbed sites.

Soil-dwelling species are more often sorted as indicator (OPF : 16 species, LAS : 5 species and OTK : 1 species) compared to litter dwelling species (OTK : 1 species, TPF: 3 species). The Taï forest seems to be a particular case, as in our study we mixed the climatic difference and the type of vegetation, and for instance,

no indicator species was observed in TPF soil-dwelling mites.

This preliminary studies gives a first insight on the potential use of some defined species of soil fauna in characterizing the ecosystems of West Africa, of their climatic influence, their soil depth and composition and the level of anthropic perturbation or restoration. It highlight the needed for a deep taxonomic work for this very unknow compartment of biodiversity.

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Appendix: Signification of acronymes

Acronymes	**Name of the species**
EVIMIURO	*Evimirus uropodinus*
GALSPP10	*Galumna sp10*
GALSPP11	*Galumna sp11*
GALSPPP4	*Galumna sp4*
GALSPPP5	*Galumna sp5*
GAMASP14	*Gamaside sp14*
GAMASP2	*Gamaside sp2*
GAMASP3	*Gamaside sp3*
LARGASP2	*Larve de Gamaside sp2*
MACROSP1	*Macrochelidae sp1*
MERISP1	*Meristacarus sp1*
MESOSP1	*Mesoplophora sp1*
MIXASPP1	*Mixacarus sp1*
MYCROSP1	*Mycrogynium sp1*
OPPIASP3	*paralopheremaeus sp1*
ORIBASP18	*Lamellobates sp1*
ORIBASP19	*Oribatulidae sp1*
ORIBASP26	*Oribate sp26*
ORIBASP33	*Dolicheremaeus*
ORIBASP48	*Protonymphe*
ORIBASP56	*Oribate sp56*
ORIBASP7	*Oribate sp7*
ORIBASP9	*Oribate sp9*
ORIBSP41	*Oribate sp41*
ORIBSP47	*Oribate sp47*
ORIBSP49	*Oribate sp49*

ORIBSP50	*Damaeidae sp3*
PHTHISP6	*Sabahtritia sp1*
RHYSODUP	*Rhysotritia duplicata*
RHYSOSP1	*Rhysoglyphus sp1*
SPHAEROSP2	*Malacoangelia sp1*
TORPASP1	*Dendracarus sp1*
TRACHYSP2	*Trachyuropodide sp2*
TRACHYSP3	*Trachyuropodide sp3*
UROPOSP1	*Uropodide sp1*
UROPOSP2	*Uropodide sp2*
UROPOSP3	*Uropodide sp3*