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Selecting Indicator Species Habitat Description and Sustainable Land Utilization: A Case Study in a Mediterranean Delta

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ABSTRACT

In this study, we have used an innovative method instead of the classical methods to understand whether species could be utilized as indicators for habitat description. The targeted insect groups, which have been found to have more likelihood to contain indicator species, were chosen among the species spending most of their life cycles in the soil surface layer in Çukurova river delta in the Adana province in southern Turkey. The experiments were conducted in both 2003 and 2004. The insect species, caught by pitfall traps, which were set up in five different biotopes, were tested using the Indicator Species Analysis to find out whether they have indicator values for habitat description. There are been seven insect species found that have statistical significance as indicator species for a habitat description.

Key Words: Pitfall trap; Sustainable land usage; Insect; Çukurova delta; Turkey

INTRODUCTION

It is easy to understand that bioindicators have proven to be useful tools for monitoring and detecting changes in the environment. Species have different ecological requirements and their reaction to environmental variation is different from one another. Therefore, some species are better indicators than others (Dufrêne & Legendre, 1997; New, 1998). Some species are generalists occurring in a wide range of habitats, while others are more specialized, requiring certain habitat characteristics.

The classifications of bioindicators are divided by McGeoch (1998) into three categories: (1) environmental (2) ecological and (3) biodiversity indicators. The basic difference among them is that environmental and ecological indicators are being used to detect changes in the environment, while biodiversity indicators reflect the overall diversity of the biota.

The main hypothesis to be tested is whether some characteristics of habitats are expressly required by insects, or habitat features have their own impacts on insect populations and on conditions of their absence/presence, as well as, finally, which one is more important than the other to be determined as indicator. The objectives of this study are (1) to test the usage of insects in habitat description and (2) to determine the sustainability of habitats. Thus, we determine how suitable insects are as bioindicators for habitat description.

MATERIALS AND METHODS

The study was carried out in five main biotopes (1) fixed grey dune, (2) salty mud, (3) salty meadow, (4) Pinus dune forest and (5) afforestation with *Eucalyptus* spp. from 15 localities overall within the Cukurova delta (southeastern Turkey, in the Adana province) after the classification of biotopes that was carried out as part of the Çukurova Delta Biosphere Reserve project funded by the EU LIFE program during 2003 and 2004.

The insects were sampled using pitfall traps comprised of plastic cups (15 cm in diameter, 20 cm in depth) buried into the soil, so that the upper rim of the pitfall trap was leveled up with the ground surface. The distances between pitfall traps were approximately 25 m at each sampling site and thus, a total of ten traps were placed at the margin and in the center of each of the fifteen fields (which makes the total of 150 traps). The sampling was performed annually through one week periods between April and September, which is the time of maximum arthropod abundance and diversity. The beetles were transferred using Falcon tubes (3×10 cm), which contained 70% ethyl alcohol, to the laboratory, where the trapped insect individuals were identified up to the species level.

The indicator species analysis (Dufrêne & Legendre, 1997) was done to explore the associated groups of species; we used the PC-ORD software package (version 4.14) for this analysis.

(1) . The proportional abundance of a particular species in a group was calculated relative to the abundance of that species in all groups. It was expressed as a percentage and the intermediate result was displayed.

Let:

A = sample unit x species matrix

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aijk = abundance of species j in sample unit (SU) i of group k

nk = number of sample units in group k

g = total number of the groups.

Firstly, the mean abundance xkj of species j in group k is calculated:

$$xkj = \sum_{i=0}^{nk} aijk / nk$$

Then the relative abundance RAkj of species j in group k is calculated:

$$RAkj = xkj / \sum_{k=1}^{g} xkj$$

(2) . The proportional frequency of species in each group was calculated (i.e., the percentage of sample units in each group that contain that species). It was also expressed as a percentage and the intermediate result was displayed.

Firstly, A is transformed into a matrix of presence-absence B:

$$bij = a_{ij}^{0}$$

Then relative frequency RFkj of species j in group k is calculated:

(3) . The two proportions calculated in steps 1 and 2 are combined by multiplying them. The result is expressed as a percentage, yielding an indicator value IVkj for each species j in each group k.

(4) . The highest indicator value (IVmax) for a given species across groups is saved as a summary of the overall indicator value for that species.

(5) . The statistical significance of IVmax by using the Monte Carlo method is evaluated. The SU's were randomly reassigned to the groups a large number of times (default=1000). Each time, IVmax was calculated. The probability of type I error is based on the proportion of times that the IVmax from the randomized data set equals to or exceeds the IVmax from the actual data set. The null hypothesis is that IVmax is no larger than it would have been expected by chance (i.e., that the species has no indicator value).

The Dufrêne and Legendre (1997) method provides a simple, intuitive solution to the problem of evaluating species associated with the groups of sample units. It combines information on the concentration of species abundance in a particular group of habitats and the faithfulness of existence of species in a particular group. It produces indicator values (InV) for each species in each group. These values are tested for statistical significance using the Monte Carlo technique.

RESULTS

During the first year of our study, we collected 175 species overall (31517 individuals) from 15 habitats selected from the five main biotopes: within the Cukurova Delta. During the second year of our study 109 species (20509 individuals) were collected from the same fields. During the second year (2004), there were found 14 species, which were not collected in the first year, while 95 species amongst those sampled in the first year could not be found during the second one.

Selecting the indicator species for different biotope types of biotopes

While selecting the indicator species for different biotypes, seven species viz., *Siagona europaea* Dejean, *Scarites planus* (Bonelli), *Acinopus megacephalus* (Rossi), *Pimelia bajula solieri* Mulsant and Wachandru, *Megacephala e. euphratica* Latreille and Dejean, *Zophosis dilatata* Deyrolle and *Scarites subcylindricus* (Chaudoir) were found to have a statistical significance as indicator species for biotope determination in the two sampling periods (Table I). Individual numbers of insect species sampled from different locations are given Table II

DISCUSSION

This study showed how environmental changes can affect indicator species through quantitative predictions. In the second year of the study, 95 species were missing among those that were sampled in the first year. The fragmentation of habitat exerts considerable influence on insect populations, but everyone knows that this fact is not widely recognized. Turin and den Boer (1988) found that, over the past century, majority of secondary carabid beetle species no longer occupied many localities in which they were previously found in the Netherlands; a pattern attributed to habitat fragmentation. Klein (1989) found that dung and carrion eating beetles of Brazilian rain forest-would not cross even narrow clear-cut barriers (less than 350 m wide). Both richness and abundance of the species declined significantly in this group in response to decreasing patch area just several years after the isolation. The select insect species are responsive to habitat fragmentation and therefore can be effective indicators providing early warnings to the ecological consequences of fragmentation. Thomas *et al.* (2004) said that butterflies experienced the greatest net losses, while disappearing from their previously occupied 10-km squares at about 13% rate on the average. If insects tend to show the similar sensitivity pattern everywhere in the world, we can conclude that there are found to be previously unrecorded parallels between the extinction rates of plants, vertebrates and invertebrates. Such a finding would support the hypothesis that the natural world is going through the sixth major extinction event in its history. With habitat destruction, indicator species may disappear before they are found. There is a need to investigate indicator, umbrella, flagship and keystone species before their habitats might be destroyed. This

Table I: The percentage indicator values (InV) of insect species predicted to be indicators in two sampling periods. Af, afforestation with *Eucalyptus* spp.; SW, salty meadow; SM, salty mud; and SD, sandy dune; F, *Pinus* dune forest

Year	Species	Indicator Species Analyses				
		% InV	Mean	SD	P	Biotope
2003	*Siagona europaea*	92.1*	38.2	17.21	0.0135	SW
	Scarites planus	88.7	43.3	15.93	0.0057	SW
	Acinopus megacephalus	96.7	40.9	16.23	0.0091	SW
	Pimelia bajula solieri	86.5	39.9	17.91	0.0336	Af
	Megacephala e. euphratica	80.5	33.1	14.31	0.0093	SM
	Zophosis dilatata	80.5	49.1	12.45	0.0083	SD
	Phtora reitteri reitteri	78.6	32.6	15.71	0.0227	SM
	Scarites subcylindricus	94.0	37.0	16.88	0.0135	SW
	Gonocephalum rusticum	60.7	41.2	11.14	0.0307	SW
2004	*Siagona europaea*	87.3	34.8	15.57	0.0105	SW
	Scarites planus	80.1	39.5	14.13	0.0105	SW
	Acinopus megacephalus	93.4	34.4	15.56	0.0105	SW
	Pimelia bajula solieri	79.1	36.0	17.79	0.0358	Af
	Megacephala e. euphratica	72.3	31.1	12.39	0.0127	SM
	Zophosis dilatata	72.4	49.8	9.81	0.0132	SD
	Erodius orientalis oblongus	55.1	34.9	9.26	0.0413	SD
	Myrmeleon sp.	61.0	35.9	12.33	0.0460	SD
	Scarites subcylindricus	95.3	37.3	15.91	0.0105	SW
	Zophosis p. punctata	60.6	33.0	11.64	0.0444	Af

*Indicator values (InV) significant at $P < 0.05$

research should be complimented by sustainable land utilization practices, by sound environmental management programs and by nature conservation studies. For better nature protection, it is highly important to use indicator species that show sensitivity to environmental changes. These species have to be utilized in nature conservation studies.

Commonly the studies of determine bioindicator species are carried for a long time. On occasions however, a two or three year study should be enough to find a good indicator provided the indicator value is functional. The indicator species should be utilized only under strict environmental conditions and used to detect healthy/unhealthy ecosystems (Arndt *et al.,* 2005; Aydin *et al.,* 2005; Aydın & Kazak, 2007). In order to find the bioindicator species in a short period, an alpha diversity (number of species within a single habitat type) and a beta diversity (difference in species composition between habitats) should be determined and thus the similar and dissimilar habitats must be compared to each others for species assemblages. Different species assemblages, because of different habitat types and/or environmental conditions should be observed and measured carefully using special methods to fund valuable species of bioindicators.

Scientists, environmental managers and the general public have a great need for ecological indicators. Such indicators have long since been used to detect changes in nature. Currently, indicators are mainly used to assess environmental conditions sending early warning signals about ecological problems and being used as barometers for various trends in ecological resources. Most of the surveys focus on response of the species to changes in environmental conditions, or to environmental management practices. The environmental indicators help track changes in the environment by addressing the critical changes in the environment, which may be physical, chemical, biological or socio-economic–that can be taken to provide much needed information about the whole system (Saunders *et al.,* 1998). By using indicators, it is possible to evaluate the fundamental condition of the environment without having to capture the full complexity of the system. The knowledge about bioindicators is a product of best scientific research that is currently available. We can use this knowledge to identify simple changes in the environment that are an evidence of more complex environmental trends.

We have tested two hypotheses in our study.

Hypothesis 1 was "*the species can not be used as indicators for different parts of the world because of the different biogeographic zones*". We agreed with Kremen *et al.* (1993) and Rainio and Niemela (2003) with that species suitable for monitoring are not always the best ones for inventory and vice versa. This is true because indicators appropriate for monitoring must be sensitive to anthropogenic disturbance, while indicators for inventory must identify biogeographic zones, areas of endemism and community types. Because species have different ecological requirements, some species are better indicators than others. If there is a species that cannot be used as indicator due to the differences in biogeographic zones, a new indicator species can be found for the area using the methods of this study.

Hypothesis 2 states that "*the species can be used as indicators for different parts of the world notwithstanding the different biogeographic zones*". No matter how the biogeographic zones differ from each other, the species, which are identified as specific, can be used as indicators for some determined factors globally. It is very essential to find a specific indicator species for same factor across the world (such as for determining habitat, environmental effect, etc.) so that they would not be affected by biogeographic zones for the purposes of program monitoring.

The selection of indicator species will supply early warning signals for ecological problems and will support the sustainable land usage in the areas of conservation. This is why this study is really a pioneering one in this respect.

In Çukurova delta, where the sustainable land utilization program has been carried on for sometime, it is possible to determine the habitat types for the specific indicator species (Aydin, 2006; Aydin & Kazak, 2007). It is very important to know, which species can be used as indicators either in different biogeographical regions or just locally. It is also possible to find similar and/or new methods identifying indicator species for habitat description and for sustainable land utilization.

Table II: Number of individual insects sampled from 15 localities altogether (3 of each habitat X under 5 biotopes)

Year	Species	Biotopes and species individuals from 15 localities altogether.				
		SD	**SM**	**SW**	**F**	**Af**
2003	*Siagona europaea*	- - -	4, 11, 3	14, 70, 126	- - -	- - -
	Scarites planus	- - -	24, 16, -	248, 114, 79	7, 2, 4	- - 3
	Acinopus megacephalus	- - -	4, 1, 1	37, 113, 84	- - -	1, - , 1
	Pimelia bajula solieri	- - -	- - -	- - -	- - , 23	135, 2, 11
	Megacephala e. euphratica	- - -	428, 342, 143	77, 86, 58	- - -	- - -
	Zophosis dilatata	979, 2519, 4589	6, 4, -	117, - , 3	93, 69, 332	566, 362, 405
	Phtora reitteri reitteri	- - -	18, 3 12	- - -	8, - -	- - , 1
	Scarites subcylindricus	2, 1, 1	- - -	33, 23, 7	- - -	- - -
	Gonocephalum rusticum	4, - -	22, 4, 2	57, 17, 17	- , 3, 7	3, 10, 4
2004	*Siagona europaea*	- - -	3, 13, 5	14, 64, 67	- - -	- - -
	Scarites planus	- - -	27, 19, -	141, 83, 46	11, 2, 2	- - 6
	Acinopus megacephalus	- - -	7, 1, -	29, 59, 53	- , 2, -	- - -
	Pimelia bajula solieri	- - -	- - -	- - -	- - , 24	79, 2, 10
	Megacephala e. euphratica	- - -	306, 230, 226	110, 115, 67	- - -	- - -
	Zophosis dilatata	512, 1192, 2633	5, 1, -	56, 1, 3	121, 150, 214	279, 328, 497
	Erodius orientalis oblongus	131, 411, 462	- - , 34	15, - -	46, 66, 109	209, 178, 162
	Myrmeleon sp.	25, 8, 14	- - -	- - -	1, 18, 2	4, 2, 3
	Scarites subcylindricus	1, 1, 1	- - , 1	35, 32, 15	- - -	- - -
	Zophosis p. punctata	4, - -	- - -	2, - -	40, 108, 35	100, 100, 91

Currently, humankind faces many critical ecological problems that are manmade such as global warming and climate change, environmental pollution, destruction of natural plant assemblages, lack of adequate protection measures to sustain biodiversity, erosion of soil, decreasing water resources, depletion of the ozone layer, atmospheric pollution, radioactive poisoning of the environment, spread of epidemics, extinction of different species, anthropogenic (industrial) effects, forest and stubble fires, urbanization in general, excessive grazing, all kinds of natural disasters, rapid growth of the world population, increase in agricultural land utilization etc., (Cepel, 2003). Therefore, the selection of indicator species affected by factors as mentioned above can provide early warning signals for vast ecological problems that nevertheless can still be preventable so that we humans, can protect our own habitat.

In crux, the fact is that the destruction of habitats is still going on due to anthropogenic impacts, but the humans do not seem to hear the persistent grievances of nature.

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