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Orginal Article

Effects of Anthropogenic Disturbances on the Diversity and Composition of the Acridid Fauna of Sites in the Dry Deciduous Forest of West Bengal, India

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Abstract

Acridids have been identified as important bio-indicators for assessing biodiversity and monitoring ecosystem responses to anthropogenic disturbance. The community structure of acridids plays vital role in functioning the forest ecosystem. A total of 25 sites are distributed among five habitat types based on different vegetation communities and degree of disturbances including five terrestrial weed dominant sites (WDS), five Oryza species dominant sites (ODS), five sal dominant sites (SDS), five road sites (RDS) and five rock sites (RS) in Chipkuthi forest, West Bengal, India. Total abundance, species richness and diversity of acridids were highest in undisturbed habitats and lowest in highly disturbed habitats. Acridid species appear to be negatively affected by anthropogenic disturbances. The analyses show significant positive correlation between undisturbed habitats and species diversity of acridids within the study area.

Keywords: *Acridids; Disturbance; Diversity; Dry deciduous forest; Indicator*

INTRODUCTION

Forest ecosystems are important habitats when considering local and global biodiversity. Biological diversity is now recognized increasingly as a vital parameter to assess global and local environmental changes and sustainability of developmental activities (Lovejoy, 1995). The most important task is to identify and to follow the changes of biota in space and time to prevent degradation and further loss of biodiversity. This includes the survey and comparison of different sites and the development of monitoring programs. The design of a survey or of a monitoring program is a multistep procedure, including the identification of aims, the selection of indicators and the designation of sampling scheme. The following criteria were suggested for indicators of temporal changes by two authors (Noss, 1990; Pearson, 1994): the indicator taxa should be (1) sensitive to changes, (2) widely distributed, (3) easily and cost-effectively measurable, collectable and identifiable (stable taxonomy), (4) able to differentiate between natural and anthropogenic variation, (5) relevant to ecological phenomena and (6) economically important. These criteria are valid not only for monitoring programs but also for many programs addressing environmental questions. It argues that acridid assemblages are good indicators because, first, the structure of communities is sensitive to environmental changes. Second, the acridids are habitat specific. Third, there is a simple sweep net sampling method, which can be standardized to obtain relative abundance data. Fourth, the identification is relatively easy, partly due to low number of species and their taxonomic stability. Fifth, they are one of the most dominant phytophagus insects, which play an important role in the functioning of forest ecosystem and potentially useful bioindicators for land disturbance.

The use of indicators is most effective when supported by a predictive understanding of the responses of target taxa to environmental stress and disturbance (Andersen, 1997). In addition, bioindicators present valuable information for nature conservation planning. Grasshopper diversity and bioindicator was studied by Andersen et al. (2001) in Australian tropical savanna and by Baldi and Kisbenedek (1997) of grassland naturalness in Hungary. de Wysieck et al. (2000) reported grasshopper diversity in North La Pampa, Argentina. Grasshopper species composition (Larson et al., 1999; Cigliano et al., 2000) and habitat association of grasshoppers was studied by Squitier et al. (2002) and Capinera et al. (1997). Fielding and Brusven (1993a, 1993b) showed that grasshopper species composition differed among disturbance categories on several scales in North American rangelands. In India Joshi et al. (1999) studied the different habitats with degree of disturbance by acridids in moist deciduous forest. The aim of this work is to address an important study to test the ability of acridid diversity to indicate habitat characteristic and different levels of anthropogenic disturbance on dry deciduous forest in India.

MATERIAL & METHODS

Study area

The present study was conducted in Chipkuthi forest (3 sq. km), a dry deciduous type, located near Santiniketan at approximately 23°29´N and 87°42´E with an average altitude of 58.9 m above sea level in West Bengal, India. During the study period temperature varied between 3.5°C (Feb. 2005) to 39.5°C (May 2006) and humidity ranged between 20% (Apr. 2005) to 96% (Jul. 2005) and rainfall varied between 0.00mm (Jan. 2006) to 98.5mm (Jul. 2005). Weather data were obtained from the Meteorological department at Sriniketan, Visva-Bharati University, 3 km away from the study area. A total of 25 sites are distributed among five habitat types based on different vegetation and degree of disturbance as follows five terrestrial weed dominant sites (WDS), five Oryza species dominant sites (ODS), five sal dominant sites (SDS), five road sites (RDS) and five rock sites (RS).

Terrestrial weed dominant site (WDS) was a dense population of terrestrial weed like V. ziginoides. This site was totally free from human interference and there were no grazing animals. Soil condition was very favorable for acridids because the place was very close to a Jheel (water body), which make the soil wet throughout the study periods. Oryza sp. dominant site (ODS) was a dense population of Oryza sp. It was very close to a paddy field. Sal dominant site (SDS) was a dense population of short and tall S. robusta. Both ODS and SDS habitats involved human disturbance like partly cleared and there were no grazing animals. But ROS and RS habitats received highly human disturbances like repeatedly cleared or slashed and grazing animals such as cow, sheep and goat. The soil condition of ROS habitat was dry and red colour silt like whereas RS habitat was dry sandy hard laterite layer varies from place to place with small pebbles and fossil woods.

Sampling

Acridids were surveyed a 10m2 area at each site at fifteen day intervals during July 2004 to June 2006 (two years separately) from 7.30 am to 10.30 am. From each sampling site the adult acridids were collected by sweep net sampling which is the most commonly used method to estimate grasshopper species composition (Joshi et al., 1999; Larson et al., 1999; Saha and Haldar, 2008). Twenty sweeps of a 30 cm diameter sweep net were taken from each area. All vegetation within an area was swept including tall grasses, herbs, shrubs and trees up to a height of 2 meter as almost the entire acridid species were found within this range. The acridids were collected and counted and brought to the laboratory for identification. The identified species were sent to Zoological Survey of India, Kolkata for confirmation.

Data analysis

Species diversity in each of the five habitat types was expressed using the Shannon-Wiener index (H') (Shannon- Wiener, 1949). This index was selected for analysis because it is the most commonly used to express the species diversity and it is moderately sensitive to sample size (Castrezana and Markow, 2001). Besides Margalef index (Margalef, 1958) (DMg = S-1/lnN) was also used for species diversity analysis. The probability values (Table 2) of each species over all sites within communities as a function of habitats was conducted using two way anova (S-PLUS 4.0 versions). Another statistical programme (MATLAB 6.0 versions) was used for studying the interaction between species and habitats (Table 4) on acridid populations.

RESULTS & DISCUSSION

Five investigated "habitat types" and there sites with disturbance effects and dominant plant (tree/shrub) species are represented in Table1. A total of 1412 and 1549 adult individuals of 21 and 20 acridid species were collected from 1st and 2nd year observation separately. Twenty one acridid species, belonging to two families (Acrididae and Pyrgomorphidae) and eight subfamilies (Acridinae, Hemiacridinae, Truxalinae, Oxyinae, Coptacridinae, Eyprepocnemidinae, Catantopinae and Pyrgomorphinae) and relative abundance percentage were recorded (Table 2). Family Acrididae was represented by 19 and 18 species, constituting about 95.2% and 93.8% while Pyrgomorphidae was represented by two species, constituting about 4.8% and 6.2% during 1st year and 2nd year separately. But only three species i.e. D. venusta (22.7%, 23.1%), O. abruptus (15.8%, 18.2%) and O. fuscovittata (16%, 13.9%) were the most dominant species of the total number of individuals of Acridoidea during 1st and 2nd years respectively. The community analyses between habitat disturbances and acridid variables (species composition and total abundance) are shown in Table 3. The G. afr. africanus was absent in all the habitats except RS habitat. All the collected species in the study area are considered as pest except E. sinetyi and G. afr. africanus. The species like D. venusta, O. abruptus, C. tra. trachypterus, E. sinetyi, and T. indica were widely distributed in all the habitats whereas G. punctifrons, H. banian and Oxya species were abundant in both ODS and WDS habitats. But G. afr. africanus and C. tra. trachypterus comprised markedly greater proportion of the acridid communities in highly disturbed habitats while P. panteli and T. varicornis were found only undisturbed habitat.

The ecological indices used to assess acridid community structure revealed marked differences among habitats (Table 4). The highest number of acridid was found in WDS (596, 605) while lowest in ROS (87, 105) during study period. The maximum and minimum acridid species were recorded from WDS (20) and ROS (6) during 1st year whereas WDS (19) and seven species from both ROS and RS habitat during 2nd year study respectively. The highest diversity value (0.98, 0.96) was recorded in WDS habitat in both the years whereas lowest in (0.64, 0.66) in ROS habitat. The Margalef index was also highest in undisturbed (WDS) habitat (2.97, 2.81) whereas lowest in highly disturbed (ROS, RS) habitats (1.11, 1.28).

All the cases we have seen the calculated F values (Table 5) are greater than the tabulated F values as followed $F1 > F\ \alpha;20,420\ 1.57$; $F2 > F\ \alpha;4,420\ 2.37$ and $F3 > F\ \alpha;80,420\ 1.27$ in the 1st year observation whereas $F1 > F\ \alpha;19,400\ 1.58$; $F2 > \alpha;4,400\ 2.37$ and $F3 > F\ \alpha;76,400\ 1.28$ in the 2nd year observation can inferred that the analysis show significantly differed between undisturbed and disturbed habitats of acridid diversity within the study area. It is also to be noted that the two factors interaction i.e. species and habitat have significant effect on acridid populations. These calculations have been done by using Matlab programme.

In present investigation the species richness, abundance and species diversity were highest in WDS habitat with no anthropogenic disturbance by human or grazing animals in both two years. Higher species diversity may be important in maintaining ecosystem functioning (Yachi and Loreaue, 1999; Chesson et al., 2002). The low acridid diversity was observed in ROS and RS habitats due to disturbance of human and grazing animals. Our observation suggests that total abundance, species richness and diversity of acridids were highest in undisturbed habitats. The similar patterns by Parmenter et al. (1991) and Joshi et al. (1999) were found that species richness and diversity were higher on undisturbed habitats. Fielding and Brusven (1993a) found that in North America rangelands the most disturbed sites had the lowest species richness and diversity. The acridid community indices clearly tracked the extent of anthropogenic disturbance. In particular, acridoid diversity was sensitive to grazing. Grasshopper presence and species richness are positively correlated to the number of plant species in different types of habitat (Kemp et al., 1990b). The change in vegetation community diversity can cause variation in the special pattern of grasshopper biodiversity (Guo, 2006). Vegetation strongly influenced the species composition (Fielding, 1995). These results suggest that food plants and their characteristic habitats influence the local distribution of these acridid species. Some species of acridids are capable of occupying many habitats while others apparently occur in one or more habitats. Only one species i.e. D. venusta was abundant all the habitats. This species which appears to prefer a mixed diet of vegetation is very common and widely distributed throughout the study area and to increase in its population in different habitats.

The species richness and abundance were highest in SDS habitat in comparison to ODS habitat field with water in most of the time. The species like G. punctifrons, H. banian and Oxya species were abundant in both ODS and WDS habitats which were partly boarded by agricultural land. Oxya, Heiroglyphus and G. punctifrons are adapted for life in standing water and paddy fields (O. sativa and O. ruphipogon). These species are indicated as pest of paddy plants. The similar pattern by Sanjayan and Muralirangan (1997) reported that Oxya, and Heiroglyphus are adapted for life in standing water and alluvial soil of paddy fields of rice (Oryza sativa L.). The majority of the collected species are pest according to the

Pictorial Handbook on Indian Short-Horned Grasshopper Pests (Acridoidea: Orthoptera) (Mandal et al., 2007). The Gastrimargus afr. africanus significantly indicated rock site which was also disturbed habitat whereas Gastrimargus muscicus indicated disturbed Savana site (Andersen et al., 2001). Baldi and Kisbenedek (1997) showed that grasshopper assemblages are more stable on undisturbed habitat. However, it lends support to the suggestion that acridids are potentially useful indicators of ecological disturbance associated with human land use. In addition to acridoid species that appear to be negatively affected by anthropogenic disturbance, some acridids benefit from human impacts. The present study reveals that species richness and diversity of acridids were highest in undisturbed habitat. The high acridid diversity and species richness may increase the more stable on the undisturbed habitat. Therefore, the acridids considered in this study could be successfully used for bioindication of the forest ecosystem disturbance.

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Table 1. Five investigated "habitat types" and there sites with disturbance effects and dominant plant species.

Sites	Habitat type	dominant tree	dominant herbs/shrubs species
WDS	No human disturbed and grazing animals	*Eucalyptus globossus* Labill	*Vetivaria ziginoides* (Linn.) Nash; *Chrysopogon aciculatus* (Retz.), *Cyanodon dactylon* L.Pers., *Saccharum bengalense* Retz., *Sporobolus diander* (Retz.)
ODS	Human disturbed, but no grazing animals	Not found	*Oryza ruphipogon* Griff. *Oryza sativa* Linn.
SDS	Human disturbed, but no grazing animals	*Shorea robusta* Gaertn.f.	*S. diander, S. bengalense, C. aciculatus, C. dactylon*
ROS	Highly disturbed by human and grazing animals	*E. globossus* Labill	*S. bengalense, C. aciculatus*
RS	Highly disturbed by human and grazing animals	*Acacia auriculiformis* Benth	*Sida cordifolia* Linn.

Table2. Species of acridids collected in Chipkuthi forest and their relative abundance percentage

Family/subfamily/Species	Relative abundance (%)	
	1st year	2nd year
ACRIDIDAE		
Acridinae		
Dittopternis venusta (Walker)	22.7	23.1
Oedaleus abruptus (Thunberg)	15.8	18.2
Aiolopus thalassinus tamulus (Fabricius)	1.8	1.8
Phlaeoba infumata Burnner	1.8	1.6
Gastrimargus africanus orientalis Sjostedt	1.5	0.9
Acrida exaltata (Walker)	0.7	0.9
Gastrimargus africanus africanus (Saussure)	0.8	0.4
Phlaeoba panteli Bolivar	0.3	0.1
Hemiacridinae		
Heiroglyphus banian (Fabricius)	7.7	7.6
Gesonula punctifrons (Stal.)	3.6	3.3
Spathosternum prasiniferum prasiniferum (Walker)	1.9	1.2
Truxalinae		
Truxalis indica (Bolivar)	4.1	3.8
Aulacobothrus luteipes (Walker)	1.3	0.7
Leva cruciata Bolivar	4	4.9
Oxyinae		
Oxya fuscovittata (Marschall)	16	13.9
Oxya hyla hyla Serville	7.9	7.2
Coptacridinae		
Epistaurus sinetyi Bolivar	2.8	3.7
Eyprepocnemidinae		
Tylotropidius varicornis (Walker)	0.3	0.4
Catantopinae		
Catantops pinguis innotabilis (Walker)	0.2	0
PYRGOMORPHIDAE		
Pyrgomorphinae		
Chrotogonus trachypterus trachypterus (Blanchard)	4.3	5.6
Atractomorpha crenulata (Fabricius)	0.5	0.6

Table 3. Community composition of acridid species in different habitats of Chipkuthi forest

	1st Year						2nd Year					
Species name	ROS	RS	ODS	SDS	WDS	P value	WDS	SDS	ODS	RS	ROS	P value
D. venusta	42	12	19	167	79	ns	89	189	22	13	46	ns
O. fuscovittata	7	0	64	0	155	ns	132	0	80	0	4	<0.001****
O. abruptus	12	26	10	61	114	<0.001****	139	69	17	42	13	<0.01***
H. banian	0	0	102	0	6	<0.05**	5	0	114	0	0	<0.1*
A. exaltata	0	0	2	0	8	<0.001****	12	1	0	0	0	<0.01***
A. crenulata	0	0	0	3	5	<0.05**	4	6	0	0	0	ns
A. luteipes	0	0	1	11	5	ns	2	9	0	0	0	ns
A. tha. tamulus	0	0	2	4	19	<0.001****	24	2	2	0	0	<0.01***
C. pin. innotabilis	0	0	0	2	1	ns	0	0	0	0	0	na
C. tra. trachypterus	13	24	2	10	13	<0.05**	8	16	0	37	25	<0.001****
O. hyla hyla	0	0	24	0	87	<0.001****	91	0	22	0	0	<0.001****
L. cruciata	0	0	0	42	15	ns	19	55	0	0	2	ns
G. puctifrons	0	0	34	0	17	<0.001****	13	0	37	0	0	<0.01***
T. indica	8	3	2	31	14	ns	16	33	0	5	6	ns
E. sinetyi	5	9	2	17	6	ns	8	26	2	11	9	ns
P. infumata	0	0	0	3	23	<0.01***	22	2	0	0	0	<0.05**
S. pra. prasiniferum	0	0	14	4	9	<0.01***	6	0	13	0	0	<0.05**
G. afr. africanus	0	11	0	0	0	<0.01***	0	0	0	6	0	<0.05**
G. afr. orientalis	0	9	0	2	10	ns	7	0	0	8	0	ns
T. varicornis	0	0	0	0	5	<0.05**	6	0	0	0	0	<0.05**
P. panteli	0	0	0	0	5	<0.01***	2	0	0	0	0	ns

WDS: Weed dominant site; SDS: Sal dominant site; ODS: *Oryza sp.* dominant site; RS: Rock site; ROS: Road site
Level of significance: 10%=*;5%=**;1%=***;0.1%=****

Table 4. Comparison of diversity index in different habitats in Chipkuthi forest

1ST Year						2nd Year				
ROS	RS	ODS	SDS	WDS	Ecological Units	WDS	SDS	ODS	RS	ROS
87	94	278	357	596	N	605	408	309	122	105
6	7	13	13	20	S	19	11	9	7	7
0.64	0.77	0.79	0.74	0.98	H’	0.96	0.72	0.74	0.71	0.66
1.11	1.32	2.04	2.13	2.97	D_{Mg}	2.81	1.39	1.66	1.24	1.28

N: Number; S: Species richness; H’: Shannon-Wiener diversity index; D_{Mg}: Margalef index

Table 5. Statistical analysis showing the interaction between species and habitat of two consecutive years in Chipkuthi forest

1st year					2nd year			
F Value (F_1-F_3)	Mean Sq	Sum of Sq	Df	Source	Df	Sum of Sq	Mean Sq	F Value (F_1-F_3)
52.01	16.4	327.89	20	Species	19	375.04	19.74	44.22
98.72	31.12	124.48	4	Habitat	4	105.43	26.35	59.05
15.2	4.79	383.37	80	Interaction	76	444.71	5.85	13.11
	0.31	132.39	420	Residuals	400	178.54	0.45	