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IMPACT OF NATURAL AND ANTHROPOGENIC DISTURBANCES ON ORTHOPTERAN COMMUNITY IN KAZIRANGA NATIONAL PARK, ASSAM, INDIA

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ABSTRACT

Impact of natural and anthropogenic disturbance on orthopteran assemblage under grasslands and forestlands in Kaziranga National Park, Assam was studied using BACI (Before-After-control-Impact) method. The study showed that there is a change in the assemblage of orthopterans in the disturbed sites due to natural (flood) and anthropogenic (corridor – road) disturbances in grasslands and forestlands, respectively. Though there is a reduction in the population of orthopteran species after a heavy rainfall, changes in the assemblage of orthopteran community in the disturbed site were in significant. However, in case of forestland frequently disturbed (corridor-road) due to movement of automobiles, the population remain fragmented.

Key words: Orthoptera, Anthropogenic disturbance, Kaziranga National Park, Grassland and forestland.

Introduction

Impact assessment is important for any effort made to conserve biodiversity. Assessing the environmental impact of human activities on natural populations' pose several problems as it is often difficult to separate human perturbations from natural temporal variability displayed by most animal populations. Further, human disturbances are generally unique and non-replicated and, therefore, raise problems of deciding whether observed local effects are due to human interference or to the natural differences in temporal patterns (Hurlbert, 1984). There are several problems in the use of appropriate experimental and sampling designs and replications for detection of unnatural disturbances to biological variables and for identifying a causal relation between an observed effect and the putative anthropogenic cause (Underwood, 1994). As pointed by Hurlbert (1984) the problem of the BACI (Before-After-control-Impact) design could be overcome to some extent by having replicated times of sampling (Stewart-Oaten *et al.,* 1986). Underwood's "Beyond BACI" design requires multiple control sites and evaluates these data with an asymmetrical analysis of variance. However, in analyzing natural disturbances, it is not likely that we would have multiple identical sites that could serve as control. This study looks into how a select orthopteran insect community has been impacted due to natural disturbance (water logging – flood) in a grassland ecosystem and anthropogenic interference in forestland by corridor (road).

Material and Methods

Study site

Two grasslands were selected for the survey of the orthopteran fauna; one representing the impacted site and the other non-impacted control. The impacted site is an area of about 10 acres of grassland at Kohora range wherein the grasses were fully submerged in flood water during July to September. The control site represents grassland about 3 km west of the impacted site, at Baguri range, extended to about 10 acres. Yet another impacted site is an area of about 10 acres of forestland in Kohora range wherein the woodyland is fragmented by the corridor (road) of 2 km long distance with 15m width. The control site represents an another undisturbed isolated forestland, about 4 km west of the impacted site at Baguri range, extending to about 10 acres.

Sampling

The sampling procedure described for Othroptera by Sanjayan *et al.* (2002) was followed. Estimation on the number of individuals of each orthopteran species for three monthly replicates in April, May and June 2008 at both the control and impacted sites was made. To study the impact of disturbances on orthopteran insect assemblages, sampling were made in the study sites again after the impact during January, February and March, 2009. We sampled the insect population at both the control and impacted sites for three months prior to the flood, followed by a similar sampling after the impact. The total insect population in the months of

Although there was reduction in orthopteran population after heavy rainfall, changes in the assemblage was insignificant. However, population remain fragmented in forest land frequently disturbed due to movement of automobiles.

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April, May and June 2008 at the impact and control sites was analyzed for correlation and regression analysis. To avoid temporal influence in insect numbers, the study sites were sampled again after the impact during the same months in the following year. The populations at the control and impacted sites were sampled at the same time during each survey.

Statistical design and analysis

The insect fauna of the control site were first tested for significant difference with the impacted site using student's t test. Non-significant differences between the two sites before the construction activity indicate that the selection of the control site suited to the objective of studying the influence of the impact. To judge whether an impact has occurred, the differences in the insect abundance between the impact and control sites on each survey were calculated. The average of these differences in the before and after periods are then compared following Stewart-Oaten *et al.* (1986) in a sampling design called the Before-After/Control-Impact (BACI) design.

The data were first log transformed to achieve additivity (since some zero values of x occurred, log (x +1) was used) and then the differences (deltas) were calculated between the values at the impacted and control sites on each survey. The deltas were averaged and the difference between the average before and after deltas provides an estimate of the effect of the disturbance. The diversity was calculated using Colwell's (1998) Estimates software.

Results and Discussion

The critical element in detecting the ecological impact of the disturbance is that the population at the control and impacted sites be sampled at the same time during each survey and that they vary in about the same way or track one another, prior to the perturbation being studied (Schroeter *et al.,* 1993). The data indicate a strong correlation value of 0.97 (Fig. 1). The means of the insect abundance at the control and impact sites did not significantly differ (t = 0.246; P = 0.81). These analyses suggests that the insect population at the impact site and the control site vary in about the same way and that the temporal changes at the two sites were identical, tracking one another.

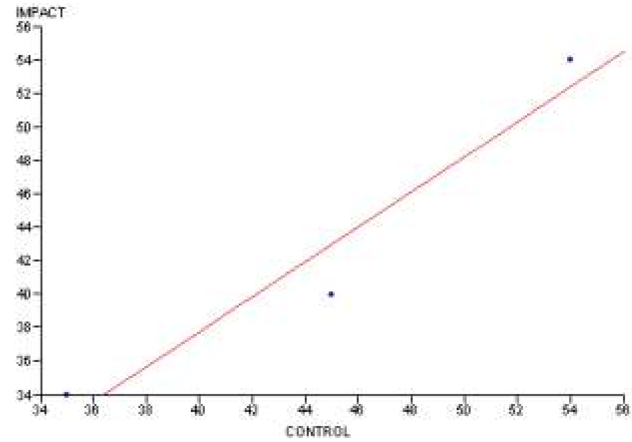

Fig. 1 : Regression graph depicting the relation between the insect abundance at the control and impact sites prior to the disturbance

There was no significant difference in the various diversity indices at the control site before and after the period of impact (Table 1). However, a significant difference was observed at the impacted site. A 42% reduction in alpha diversity, 15% reduction in Shannon diversity and a 58% reduction in the Simpson diversity index was observed as a result of the flood at the site. Since at the control site, the diversity of insects did not change during the sampling period, the observed reduction in the diversity at the impacted site could be as a result of the natural (flood) disturbance.

In the standard analysis of variance, the model specifies that the effect of the different factors viz., location, period and impact, is additive and that the errors are normally and independently distributed with the same variance. In reality, it is unlikely that these ideal conditions are exactly realized. Hence, Tukey's test of additivity was employed to decide if a transformation is necessary and whether it has been successful in producing additivity. Non-additivity can reduce the power to detect an effect or may result in a biased estimate of the effect (Stewart-Oaten *et al*., 1986). If the model underlying the t test is correct, log transformation should produce an additive model. We tested this by regressing the before deltas against the sum of the transformed control and impact values. A slope significantly different from zero indicates non-additivity. Our regression results using the data of the total insect abundance indicate a t value of 0.2387 at P = 0.425 while

Table 1 : Insect diversity indices at the impacted and control sites of grasslands before and after the disturbance

Diversity	Impacted site		Control site	
	Before	After	Before	After
Alpha	2.37	1.95	4.81	5.0
Shannon	1.54	1.39	2.53	2.55
Simpson	4.32	3.74	11.14	11.62

the variance analysis indicate a F value of 0.6824 at P=0.455. This shows that the slope is not significantly different from zero and that the log transformation was successful in producing additivity. Hence, we proceeded with analyzing the effect of the disturbance on the orthopteran community. Table 2 provides data on the insect abundance at the control and impacted sites, before and after the flood. It is evident that at the impacted site, four species were not present after the disturbance while the remaining 17 species showed a decline in their abundance. Among the acridids, *Oxya nitidula* and *Heiroglyphus banian,* among tettigoniids, *Conocephalus maculatus* and *Euconocephalus indicus,* and the gryllid *Gryllodes sigillatus* continued to inhabit the area after the disturbance.

Osenberg *et al.* (1994) showed how natural spatial and temporal variability, coupled with estimated

Table 2 : Insect abundance log transformed in grasslands at the impacted and control sites before and after the disturbance

Species	Impacted		Control	
	Before	After	Before	After
Xenocatantops humilis (Serv.)	1.34	1.00	1.52	1.49
Phlaeoba infumata Brun.	1.23	0.70	1.32	1.32
Phlaeoba tenebrosa (Walk.)	0.78	0.30	0.85	0.70
Atractomorpha crenulata (Fab.)	1.52	1.04	1.61	1.63
Catantops ferruginuous (Walk.)	1.11	0.60	1.28	1.23
Gesonula punctifrons (Stal.)	0.60	0.30	0.78	0.60
Atractomorpha sp.	1.04	0.48	1.23	1.28
Oxya hyla hyla (Serv.)	1.67	1.11	1.72	1.76
Heiroglyphus banian (Fab.)	1.59	0.95	1.67	1.71
Eyprepocnemis alacris (Serv.)	1.41	0.78	1.49	1.52
Orthacris maindroni Bol.	1.28	0.60	1.40	1.38
Acrida exaltata (Walk.)	1.26	0.30	1.28	1.28
Oxya nitidula (Walk.)	1.63	1.00	1.77	1.79
Conocephalus maculatus (Le Guillou)	1.61	0.90	1.73	1.75
Euconocephalus indicus (Redtenb.)	1.11	0.48	1.34	1.32
Elimaea (Orthelimaea) securigera (Brun.)	1.20	0.78	1.51	1.49
Mirrollia sp.	0.60	0.00	0.78	0.60
Teleogryllus sp.	0.00	0.00	0.30	0.30
Gryllodes sigillatus (Walk.)	0.60	0.30	0.95	1.04
Statilia sp.	0.30	0.00	0.30	0.30
Tenodera sp.	0.30	0.00	0.48	0.30

Table 3 : Estimation of the effect of disturbance on insect species abundance in grasslands

Species	Delta		Disturbance effect	t- value	P	% Change
	Before	After				
Xenocatantops humilis (Serv.)	1.34	1.00	0.34	1.5	0.19	25.37
Phlaeoba infumata Brun.	1.23	0.70	0.53	0.92	0.26	43.09
Phlaeoba tenebrosa (Walk.)	0.78	0.30	0.48	0.82	0.28	61.54
Atractomorpha crenulata (Fab.)	1.52	1.04	0.48	0.81	0.28	31.58
Catantops ferruginuous (Walk.)	1.11	0.60	0.51	1.14	0.23	45.95
Gesonula punctifrons (Stal.)	0.60	0.30	0.30	1	0.25	50.00
Atractomorpha sp.	1.04	0.48	0.56	0.63	0.5	53.85
Oxya hyla hyla (Serv.)	1.67	1.11	0.56	1	0.25	33.53
Heiroglyphus banian (Fab.)	1.59	0.95	0.64	0.73	0.29	40.25
Eyprepocnemis alacris (Serv.)	1.41	0.78	0.63	0.23	0.13	44.68
Orthacris maindroni Bol.	1.28	0.60	0.68	2	0.15	53.13
Acrida exaltata (Walk.)	1.26	0.30	0.96	1	0.25	76.19
Oxya nitidula (Walk.)	1.63	1.00	0.63	1	0.25	38.65
Conocephalus maculatus (Le Guillou)	1.61	0.90	0.71	0.52	0.35	44.10
Euconocephalus indicus (Redtenb.)	1.11	0.48	0.63	1	0.25	56.76
Elimaea (Orthelimaea) securigera (Brun.)	1.20	0.78	0.42	4	0.08	35.00
Mirrollia sp.	0.60	0.00	0.60	4	0.08	100.00
Teleogryllus sp.	0.00	0.00	0.00	1	0.25	0.00
Gryllodes sigillatus (Walk.)	0.60	0.30	0.30	0.15	0.045	50.00
Statilia sp.	0.30	0.00	0.30	1	0.25	100.00
Tenodera sp.	0.30	0.00	0.30	1	0.25	100.00

Table 4 : Insect diversity indices at the impacted and control sites of forestlands before and after the disturbance

Diversity	Impacted site		Control site	
	Before	After	Before	After
Alpha	5.17	4.3	3.77	3.83
Shannon	2.65	2.63	2.69	2.70
Simpson	12.71	12.53	13.06	13.25

Table 5 : Insect abundance log transformed in forestlands at the impacted and control sites before and after the disturbance

Species	Impacted		Control	
	Before	After	Before	After
Xenocatantops humilis (Serv.)	0.48	0.30	1.20	0.30
Phlaeoba infumata Brun.	0.95	0.00	1.11	1.15
Spathosternum prasiniferum (Walk.)	0.30	0.00	1.08	1.11
Catantops ferruginuous (Walk.)	1.04	0.48	1.26	1.32
Phlaeoba antennata Brunner von Wattenwyl	0.78	0.00	0.95	0.90
Trilophidia annulata (Thunb.)	0.00	0.00	0.70	0.60
Caryanda sp.	0.00	0.00	0.30	0.48
Tagasta indica Bolívar	0.30	0.00	0.30	0.30
Conocephalus maculatus (Le Guillou)	1.11	0.60	1.20	1.28
Conocephalus (Xiphidion) melaenus (De Haan)	0.30	0.00	0.60	0.48
Letana rubescens (Stål)	0.30	0.00	0.70	0.60
Hexacentrus unicolor Serville.	0.60	0.30	0.90	0.90
Khaoyaiana sp.	0.00	0.00	0.30	0.00
Hexacentrus major Redtenb.	0.70	0.48	0.78	0.85
Elimaea (Orthelimaea) securigera (Brun.)	0.95	0.78	1.04	1.04
Gryllinae sp.	0.30	0.00	0.48	0.30
Gryllodes sigillatus (Walk.)	0.60	0.30	0.78	0.60
Creobroter sp.	0.30	0.00	0.00	0.00
Mantodea sp.	0.00	0.00	0.30	0.30

magnitudes of environmental impacts, constrain the detection of impacts on different environmental parameters. They concluded that effects on individuals might be more easily detected than effects on populations and call for greater integration of individual-based studied into field assessment. Changes in the total insect species diversity observed in the present study might not reflect the response of individual species of insects to the disturbance. Hence, the effect of the disturbance was analyzed separately for each species. Twenty one species of Orthoptera were sampled of which 13 species belonged to the family Acrididae, four species to Tettigoniidae and two species to family Gryllidae. Twenty species were observed at the impact site prior to the disturbance, while at the control site all the twenty one species were observed. The disturbance effect indexed shows that the gryllids, tettigoniids and mantids were the most disturbed among the orthopterans sampled. Most of the acridids except *Phlaeoba tenebrosa, Gesonula punctifrons* and *Acrida exaltata* appeared to be less disturbed. The estimated effect of the disturbances on the insect community is the difference between the mean Before and After deltas, which is an estimate of log (e). e is the proportional change in the average abundance at the impact site during the after period due to the construction activity and (e - 1) x 100 is the percentage change. Except for two species, all the insect species showed more than 50% change in abundance (Table 3).

The results demonstrate that there is a little change in the assemblage of Orthopteran insects in the disturbed grassland. There was a decline in the densities of orthopteran species. However, it is observed that the changes in the diversity and density of the orthopterans may be caused by natural disturbance, in this case the flood affect the grassland inhabitable by the insects. Though there is a reduction in the population of orthopteran species after a heavy rainfall, there is no significant changes in the assemblages of orthopteran community in the disturbed site due to flood. Some insects populations recover remarkably quick from disturbances that subside fairly quickly (Samways, 1994).

In case of forestland there was no significant difference in the various diversity indices at the control site before and after the period of impact (Table 4). However, a significant difference 87% in alpha diversity was observed at the impacted site. A total of 19 species were observed in both impacted and control sites, with 15 and 18 species respectively before impact (Table 5). However, only seven species were observed after the

Table 6 : Estimation of the effect of disturbance on insect species abundance in forestlands

Species	Delta		Disturbance effect	t-value	P	% Change
	Before	After				
Xenocatantops humilis (Serv.)	0.48	0.30	0.18	2.116	0.1	37.50
Phlaeoba infumata Brun.	0.95	0.00	0.95	4.006	0.01	100.00
Spathosternum prasiniferum (Walk.)	0.30	0.00	0.3	1.961	0.12	100.00
Catantops ferruginuous (Walk.)	1.04	0.48	0.56	1.614	0.18	53.85
Phlaeoba antennata Brunner von Wattenwyl	0.78	0.00	0.78	2.466	0.06	100.00
Trilophidia annulata (Thunb.)	0.00	0.00	0	1.53	0.2	0.00
Caryanda sp.	0.00	0.00	0	1.732	0.15	0.00
Tagasta indica Bolívar	0.30	0.00	0.3	1	0.37	100.00
Conocephalus maculatus (Le Guillou)	1.11	0.60	0.51	1.862	0.13	45.95
Conocephalus (Xiphidion) *melaenus* (De Haan)	0.30	0.00	0.3	1	0.37	100.00
Letana rubescens (Stål)	0.30	0.00	0.3	1.976	0.12	100.00
Hexacentrus unicolor Serville.	0.60	0.30	0.3	4.276	0.01	50.00
Khaoyaiana sp.	0.00	0.00	0	$\propto$	1	0.00
Hexacentrus major Redtenb.	0.70	0.48	0.22	3.153	0.03	31.43
Elimaea (Orthelimaea) securigera (Brun.)	0.95	0.78	0.17	1.961	0.12	17.89
Gryllinae sp.	0.30	0.00	0.3	1	0.37	100.00
Gryllodes sigillatus (Walk.)	0.60	0.30	0.3	20.61	0	50.00
Creobroter sp.	0.30	0.00	0.3	1.932	0.12	100.00
Mantodea sp.	0.00	0.00	0	6.297	0	0.00

impact, the most affected groups are tettigoniids and gryllids since they were singleton species. The estimated effect of the disturbances on insect community in the study sites revealed that hundred per cent changes in most of the species (Table 6). It is from this study obvious that there is a fragmentation in the population of Orthoptera due to anthropogenic disturbances. It is due to when conditions are prolonged, and when the disturbances are frequent, that population begin to fragment (Samways, 1994).

Conclusion

The results of this study demonstrate that there is a change in the assemblage of orthopteran insects in the disturbed forestland. The first is a decline in the diversity of grasshoppers relative to populations at the control site. Secondly there was statistically significant relative decline in the densities of orthopteran species. The disturbance, particularly if of high magnitude, is especially disturbing the ecosystem. Sustainability of resources is essential for future human and insect survival. This can be achieved through modification of the planscape and landscape, by the creation of conservation areas, which are areas of natural vegetation types. However, it is impossible to judge whether the observed changes in the diversity and density of the orthopterans were caused by anthropogenic disturbance, in this case the corridor (road) affect the forestland inhabitable by the insects. There is no demonstrable causal chain that could explain the change in the insect community. It is recommended that a more extended period should be employed to study temporal and spatial changes that normally occur in insect populations.

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काजीरंगा राष्ट्रीय पार्क, आसाम, भारत में ऋजुपंखी (ORTHOPTERAN) समुदाय पर प्राकृतिक तथा मानवीय हस्तक्षेपों का समाघात

एन. सेन्थिल कुमार और निजारा, डी. बारठाकुर

सारांश

बी ए सी आई (प्रारंभ और बाद का समाघात प्रभाव) पद्धति से काजीरंगा राष्ट्रीय पार्क, आसाम की घास भूमियों और वन भूमियों में ऋजुपंखियों के जमवाडें पर प्राकृतिक तथा मानवीय हस्तक्षेप के समाघात का अध्ययन किया गया। अध्ययन से पता चला कि घास भूमियों और वन भूमियों में

क्रमशः प्राकृतिक (बाद) और मानवीय (कॉरीडोर-सड़क) हस्तक्षेपों से प्रभावित स्थलों में ऋजुपंखीय जमवाड़ें में परिवर्तन हुआ है। यद्यपि भारी वर्षण के बाद ऋजुपंखीय आबादी में कमी आ जाती है तथापि गड़बड़ी वाले स्थलों में ऋजूपंखीय समुदाय के जमवाड़े में परिवर्तन महत्वपूर्ण थे। किन्तु वन भूमियों में भारी हस्तक्षेप कोरीडोर-सड़क के कारण स्वचालित गाड़ियों की आवाजाही बढ़ने पर भी इनकी आबादी विखंडित रही।

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