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Detrimental bio-invasion in the green revolution Belt of India: LSD multiple comparisons post hoc analysis

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Abstract

The present study was undertaken to understand the nitty-gritty of bio-invasion (wildlife, birds and stray cattle) in the green revolution states *viz.*, Punjab and Haryana; as inter-district/zonal comparison has not been done so far. Primary data were collected during the agricultural year of 2016-2017 among 360 randomly selected respondents from 6 districts comprising all the 6 zones. The most affected district was Ropar followed by Rohtak, Rewari, Faridkot, Karnal and Patiala. The overall DB of green revolution belt was 1.975 (\bar{x} value), which connotes that on average green revolution belt respondents had faced the wrath of DI twice in the past 5 years. Post hoc analysis is done only if the F value of one-way ANOVA is significant. In this research both classical F and asymptotically F (Welch and Brown-Forsythe test) was significant at 1 percent level. LSD Multiple Comparisons Post hoc analysis revealed that Ropar had significant ($P < 0.01$) distinction with all the randomly selected districts; while there was no statistically significant difference of Rewari with Rohtak and Faridkot. It can be concluded that if the invasion problem is resolved through fencing of agricultural land to prevent wild animals and stray cattle; discounted electronic bird repellent and community cattle-shed then the prospects of agriculture would further increase in the study locale.

Keywords: Bio-invasion, birds, stray cattle, human–wildlife conflict, wildlife invasion, zoo-invasion

1. Introduction

The terminology ‘bio-invasion’ is used to define a phenomenon where species establish and spread themselves well, in a different ecological zone away from their innate range. Bio-invasion incidences have frequently increased causing many harmful consequences to the society like damage to field crops and tamed livestock at farm, erosion and disruption of biodiversity, posing threat to human health in the invasion area ^[1]. Bio-invasion by some researchers is considered to have become one of the world’s most costly ecological glitches and this includes economic as well as environmental damages caused by alien plants, animals and microbes ^[2]. Bioinvasion occurs mainly because of three changes occurring around the invader’s area, they are migration change i.e. invasion caused because by human activity in invader’s native area; secondly, environmental change i.e. changes because of creation of environment similar to invader’s one; third is the evolutionary change which is caused as a result of genetic changes in the invader ^[1]. In the present paper bio-invasion in terms of wildlife, avian and the stray cattle and its subsequent impact on agriculture in India’s food producing zone is being discussed.

Coming back to the study locale, crop raiding by wildlife, birds and stray cattle are frequent but undesirable phenomenon in green revolution belt. This led to crop loss, uncultivated piece of land and to the extent of farmers quitting agriculture. In Africa, conservationists have pointed out human–wildlife conflict as a significant threat to the success of conservation initiatives as well as economic threat to the rural African populations living beside wildlife ^[3]. Although, the quantum of losses to farmers is not uniform but it is more where the animals usually resides. So, the null hypothesis (H_0) for the present study states that the detrimental bio-invasions are the same across the 6 districts of Punjab and Haryana. In this backdrop, the present research was undertaken with the following two objectives: i) extent of damage caused to agricultural crops due to bio-invasion in green revolution districts of India ii) Inter-district/zonal comparison of bio-invasion.

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2. Materials and Methods

An operational definition, ‘when applied to data collection, is a clear and concise detailed of a measure’ [4]. Detrimental bio-invasion (DB) was operationalized as the number of unwanted/undesirable invasion in the farm field done by stray cattle, wild animals and birds in the past 5 years (Kharif 2012 to Rabi 2017), which had led to damage of $\geq 1/3$ rd or more of the crop area. While, primary data were collected during the agricultural year of 2016-2017.

2.1 Study area, Sampling and data collection

Two green revolution states i.e. Punjab and Haryana were purposively selected and within those 6 districts were selected; 3 each from both the states. In Punjab 3 districts viz., Patiala, Faridkot and Rupnagar and in Haryana 3 districts viz., Rohtak, Karnal and Rewari were selected from each of the 3 zones. 60 farmers from each district were selected through probability sampling method in general and step-wise simple random sampling method in particular.

2.2 Analytical tool

The collected data were scored, compiled, tabulated and analyzed through SPSS software by using various appropriate statistical tools viz., mean, standard errors, standard deviation, frequencies, one-way ANOVA and Post-hoc test. Inter-district/zonal variation of bio-invasion in green revolution belt of India was done through Post-hoc test. There are various types of Post-hoc (Latin, denotation ‘after this’) tests to analyze the results of one’s experimental data viz., Bonferroni Procedure, Duncan’s multiple range test (DMRT), Fisher’s

Least Significant Difference (LSD developed in 1935), Tukey’s Test, Dunnett’s correction [5] but in this research LSD was preferred because it calculates the minutest significance between 2 means as if a test had been run on those 2 or more means [6].

3. Results and Discussions

Detrimental bio-invasion (DB) was caused by Blue bull, Monkey, Swamp deer, Wild boar, Wild pig, Barking deer, Porcupine, Jackal, Peafowl, Wild hen, Parrot, migratory white birds and Stray cattle. These invasions were hampering the prospects of crop diversification in the region. In Ropar, due to its proximity of Shivalik foothill is facing the maximum wrath with \bar{x} value of 3.50, where \bar{x} stands for the ‘sample mean’ [7]. That means respondents faced crop damage of 3.5 times in the past 5 years. The second most affected district was Rohtak (\bar{x} =2.133) which is facing the problem of stray cattle and monkey; monkey chiefly destroys sugarcane crop. The third most affected district was Rewari (\bar{x} =1.817) followed by Faridkot (\bar{x} =1.717), Karnal (\bar{x} =1.367) and Patiala (\bar{x} =1.317). Faridkot and Patiala farmers were facing the problem of stray cattle, which heavily destroyed Maize crops. Farmers from other village bring and set free cattle to another village at night or at lonely place, which destroys farm field. Karnal and Rewari are primarily facing the problem of Blue bull, which is the voracious feeder of Maize. The overall DB of green revolution belt was 1.975 (\bar{x} value), which connotes that on average green revolution belt respondents had faced the wrath of DI twice in the past 5 years (Table 1).

Table 1: Descriptive Statistics of detrimental bio-invasion in various districts (N=360)

Districts (Codes)	N	\bar{x}	SD	SE	95% CI for Mean			
					LB	UB	Min.	Max.
Rohtak (1)	60	2.133	1.1567	.1493	1.835	2.432	.0	4.0
Karnal (2)	60	1.367	.9013	.1164	1.134	1.600	.0	3.0
Rewari (3)	60	1.817	1.3212	.1706	1.475	2.158	.0	5.0
Faridkot (4)	60	1.717	1.1945	.1542	1.408	2.025	.0	5.0
Ropar (5)	60	3.500	1.2419	.1603	3.179	3.821	2.0	5.0
Patiala (6)	60	1.317	.9476	.1223	1.072	1.561	.0	3.0
Total	360	1.975	1.3484	.0711	1.835	2.115	.0	5.0
Model	FE		1.1375	.0599	1.857	2.093		
	RE			.3289	1.129	2.821		

N=Sample Size; \bar{x} = sample mean; SD=Standard Deviations; SE=Standard Errors; LB=Lower Bound; UB=Upper Bound; FE=Fixed Effects; RE=Random Effects.

Between-component variance was 0.628 which suggested that there is a remarkable variance among the mean of the different districts vis-à-vis DI. ANOVA test for DI was significant at 1 percent level with F value of 30.106 and p-value of <0.01 (Table 2).

Table 2: ANOVA test for detrimental bio-invasion

Group	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	194.758	5	38.952	30.106	.000*
Within Groups	458.017	354	1.294		
Total	652.775	359			

Welch and Brown-Forsythe ANOVA are more reliable than the standard F when variances are unequal [8]. For 2 or more independent samples of independent random variables with probability distribution, the asymptotic null distribution of the F-statistic is considered [9] and Welch/Brown-Forsythe test is based on asymptotically F distributed. In the present study, both Welch and Brown-Forsythe were significant at 1 percent

level, which proved the robustness of the tests (Table 3).

Table 3: Robust Tests of equality of means for detrimental bio-invasion

	Statistic ^a	df1	df2	Sig.
Welch	28.842	5	164.629	.000
Brown-Forsythe	30.106	5	331.745	.000

a. Asymptotically F distributed.

Post hoc analysis is done only when F value of one-way ANOVA is significant. In this research both classical F and asymptotically F were significant at 1 percent level. Multiple comparisons were based on LSD post hoc test. Starting with Rohtak (code 1), there was a significant ($P<0.01$) differentiation between it and Karnal, Ropar and Patiala. While between Rohtak and Faridkot distinction was at 5% level. While, there was no significant difference between Rohtak and Rewari vis-à-vis DB. The second factor was Karnal (code 2) and it had significant ($P<0.01$) differentiation

with Rohtak and Ropar. Karnal had significant distinction with Rewari and Faridkot at 5% and 10% level, respectively. While, there was no differentiation between Karnal and Patiala. The third factor was Rewari (3) and it showed the same trend with Karnal, Ropar and Patiala; while, there was no statistically significant difference of Rewari with Rohtak and Faridkot.

The fourth factor was Faridkot (4) and it confirmed significant differentiation with only one district i.e. Ropar at 1% level ($P<0.01$); while, it didn't show any significant demarcation with Rewari, even at 10% level. The fifth factor was Ropar (5) and it is the atypical and most invaded districts and it had significant ($P<0.01$) distinction with all the randomly selected districts. The result is in line with the study done at Ropar district of sub-mountainous region in Punjab, India and was revealed that Monkeys and Porcupines are responsible for the production loss in Kinnow orchard [10]. The last factor was Patiala (6) and it confirmed significant differentiation with only two district i.e. Rohtak and Ropar at 1% level ($P<0.01$); while, it didn't show any significant demarcation with Karnal, even at 10% level.

Table 4: LSD Multiple Comparisons Post hoc analysis of detrimental bio-invasion

(I) Code	(J) Code	MD (I-J)	SE	Sig.	LB CI ^ψ	UB CI ^ψ
Rohtak (1.0)	2.0	.7667*	.2077	.000***	.358	1.175
	3.0	.3167	.2077	.128	-.092	.725
	4.0	.4167*	.2077	.046**	.008	.825
	5.0	-1.3667*	.2077	.000***	-1.775	-.958
	6.0	.8167*	.2077	.000***	.408	1.225
Karnal (2.0)	1.0	-.7667*	.2077	.000***	-1.175	-.358
	3.0	-.4500*	.2077	.031**	-.858	-.042
	4.0	-.3500	.2077	.093*	-.758	.058
	5.0	-2.1333*	.2077	.000***	-2.542	-1.725
	6.0	.0500	.2077	.810	-.358	.458
Rewari (3.0)	1.0	-.3167	.2077	.128	-.725	.092
	2.0	.4500*	.2077	.031**	.042	.858
	4.0	.1000	.2077	.630	-.308	.508
	5.0	-1.6833*	.2077	.000***	-2.092	-1.275
	6.0	.5000*	.2077	.017**	.092	.908
Faridkot (4.0)	1.0	-.4167*	.2077	.046**	-.825	-.008
	2.0	.3500	.2077	.093*	-.058	.758
	3.0	-.1000	.2077	.630	-.508	.308
	5.0	-1.7833*	.2077	.000***	-2.192	-1.375
	6.0	.4000	.2077	.055*	-.008	.808
Ropar (5.0)	1.0	1.3667*	.2077	.000***	.958	1.775
	2.0	2.1333*	.2077	.000***	1.725	2.542
	3.0	1.6833*	.2077	.000***	1.275	2.092
	4.0	1.7833*	.2077	.000***	1.375	2.192
	6.0	2.1833*	.2077	.000***	1.775	2.592
Patiala (6.0)	1.0	-.8167*	.2077	.000***	-1.225	-.408
	2.0	-.0500	.2077	.810	-.458	.358
	3.0	-.5000*	.2077	.017**	-.908	-.092
	4.0	-.4000	.2077	.055*	-.808	.008
	5.0	-2.1833*	.2077	.000***	-2.592	-1.775

Dependent variable/list= Detrimental bio-invasion; Factors=respective codes of districts; MD=Mean Difference; ***, ** and * denotes the mean difference is significant at the 0.01, 0.05 and 0.1 percent level; ^ψ95% Confidence Interval

4. Conclusion

Though, phenomenon like bio-invasion, the human-zoo conflict started long back in the history but its frequency is increasing frequently these days due to deforestation, destruction of forest areas, industrialization and

modernization. The present study was conducted to bring in light the detrimental bio-invasions in green revolution belt of India and the effect of invasion from wild animals, birds and stray cattle to the agricultural stake in the invasion area is described. Wild animal, birds and stray cattle destroys the field by uprooting the standing crops, eating grains and fruits, stumping the crops, engaging themselves in a conflict with the livestock being reared in the farm, poultry etc. As these invasions are generally at the community level its effective and efficient management should be planned and implemented at the community level, keeping in the mind of the international protocol as described in the proceedings of IUCN World Parks Congress [11] and not just at the individual farm level. This will not only spread the cost of management but also lead to effective management of the invading agents. Finally, the following mitigation strategies can be suggested:

- i. Fencing of the agricultural field should be done to stop wild animals and stray cattle.
- ii. Electronic bird repellent could be used to control bird as a pest.
- iii. Community cattle-sheds should be constructed to control the menace of stray-cattle. The lesson gained from study vis-à-vis DB can be replicated in other affected region of India.

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