DIVERSITY OF WEEDS AND POPULATION DYNAMICS OF PREDATORS AND PREY PRESENT IN WHEAT-MUSTARD ECOSYSTEM AT PAKLIHAWA, RUPANDEHI, NEPAL

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ABSTRACT

A study was conducted at Institute of Agriculture and Animal Science (IAAS), Paklihawa Rupandehi, agronomy field to study the diversity of weeds and population dynamics of predators and prey in wheat-mustard ecosystem. The study was conducted by quadrate sampling method using the wooden frame by selecting 40 sample spots, and locating its coordinates. Predator, prey, some of the beneficial and harmful insects as well as weed species was recorded in 5 days interval in the study. Relationships between the population of the mustard aphid and wheat aphid, lady bird beetle to maximum and minimum temperature were recorded in order to know the effect of temperature in relation to population density. Number of mustard aphid and its nymph has shown the positive significant relationship with the population of the spider in the wheat mustard ecosystem. Shannon Weiner Index value was calculated and the species richness was found to be 2.63 with the effective number of species value 9. The species evenness value was found to be 0.83 in the studied ecosystem which signifies that the given weed ecosystem is somewhat even. The importance value index (IVI) of the given ecosystem with the value of different weed species was calculated and it was found that the weed *Anagalis arvensis* was ranked as first with the IVI value of 57.98 following *Vicia sativa* and *Chenopodium album*. This signifies that the species *Anagalis arvensis* has greater control over the wheat mustard ecosystem of Paklihawa, Rupandehi.

Keywords: diversity, weeds, predators, prey, dynamics

INTRODUCTION

Ecology is the scientific study of relationships in the natural world. Ecology is the scientific study of the interactions that determine the distribution and abundance of organisms (Krebs, 1975). Ecosystem is a biotic community and its associated physical environment in a specific place (Tansley, 1935). These biotic and abiotic components are regarded as linked together through nutrient cycles and energy flow (Odum, 1969). Ecosystem is a dynamic complex of plant, animal and micro- organism communities and their non- living environment as functional unit. In an ecosystem, the energy flows from one trophic level to another trophic level through predation or decomposition. Historically, the study of predator/prey relationships has always been considered of great importance in the shaping of the structure in natural communities – there is nothing subtle about one organism eating another. The various changes in weather and climate affect the status, population dynamics, distribution, abundance and intensity of weeds and insects. Intensity of change in climatic ecosystem noted by meteorological science has showed direct and indirect affect in prey and host relationship and their various physiological functions. However, negligible research has been done in Nepal with respect to predator pest relationship in agroecosystem. In this regard, the study aimed to document the diversity of weeds in wheat mustard ecosystem and also elaborate the interaction between predators and prey as well as temperature in case of Rupandehi district, Province no. 5, Nepal.

MATERIALS AND METHODS

Study Site Selection

Wheat- mustard field of IAAS Paklihawa Campus, Agronomy Farm was purposively selected for the study. The study site is located at Rupandehi district at 27°28' N latitude and 83°26' E (Google Earth, 2017). The study was conducted on the field where mixed cropping of wheat and mustard was followed by making the quadrats of 1mX 1m by using the wooden frame. 40 such quadrates were created in mustard wheat field and its coordinates were located using GPS device.

Data collection and sampling procedure

Data collection was done periodically in the quadrates constructed. The ecological study was done from February 19 to March 19, 2017 until the traces of predators and prey were visible. Sampling by quadrat method (plots of a standard size) can be used for most of the plant communities (Cox, 1990). A quadrat delimits an area in which vegetation cover can be estimated, plants counted, or species listed. Quadrats can be established randomly, regularly, or subjectively with in a study site. Since plants often grow in clumps, long, narrow plots often include more species than square or round plots of equal area, especially if the long axis is established parallel to environmental gradients (Cox, 1990; Barbour *et al*., 1987; Greg-Smith, 1983). The data was taken by recording the number of weeds species, number of predator prey population on the regular weekly interval.

Data analysis

All the information of the collected data was tabulated by using Microsoft excel. The information coded data was statistically analyzed by statistical package for social sciences. Correlation and scattered diagram was constructed during the analysis. R tests were done to correlate the relation between the different parameters related to predators and prey. Shannon diversity index and evenness was calculated to see the richness and evenness of weeds, Importance value index was calculated to see the dominance of weeds in the ecosystem.

RESULT AND DISCUSSION

Indices of weeds

1. Shannon Diversity Index and eveness

The Shannon Diversity Index was found to be 2.19 This mean in a biological sense for this index value we convert into effective number of species (ENS) ENS OF 2.19 = exp (2.19) = 9.This means that the community with Shannon index of 2.19 has an equivalent diversity as a community with 9 equally common species. *Angalis arvensis* was dominant weed species in this field. According to (Marovic, 1983), after wheat as a forecrop, *Galium aparina*, *Angalis arvensis* and *Stachus annuua* are very frequent.

Table 1 : Showing Shannon Weiner Index of weed species in wheat mustard ecosystem at IAAS, Paklihawa, Rupandehi, 2017.

Weeds	N_i	P_i	ln P_i	P_i * ln P_i
Anagalis arvensis	63	0.278761062	-1.2774	-0.356089381
Vicia sativa	21	0.092920354	-2.376	-0.220778761
Chenopodium album	37	0.163716814	-1.8096	-0.296261947
Oxalis cunniculatus	6	0.026548673	-3.6287	-0.096337168
Phalaris minor	14	0.061946903	-2.7814	-0.172299115
Polygonum plebeium	24	0.10619469	-2.2424	-0.238130973
Rumex dentatus	18	0.079646018	-2.5301	-0.201512389
Alternenthera sessilis	1	0.004424779	-5.4205	-0.023984513
Lathyrus aphaca	6	0.026548673	-3.6287	-0.096337168
Fumaria purviflora	16	0.07079646	-2.6479	-0.187461947
Solanum nigrum	2	0.008849558	-4.7273	-0.041834513
Cyanodon dactylon	13	0.057522124	-2.8555	-0.164254425
Ageratum conyzoides	4	0.017699115	-4.0342	-0.07140177
Avena sativa	1	0.004424779	-5.4205	-0.023984513
Total	226			-2.190668584

Shannon Diversity Index= (Pi X ln Pi) = 2.1906
Species Richness= ln(S)=2.63
Species Evenness= H/ln(S)=0.83
Where S=total no. species count. In our case it is 14.
H=Shannon Weiner Index
Ln=Natural logarithm

Species evenness and species richness

It quantifies how equally the community is numerically. The value is found to be 0.83. It shows that the ecosystem of weeds in wheat mustard field is somewhat even. The value of species richness is found to be 2.63. Higher the value higher the species richness. Reduction on the number of species leads to reduction of species richness.

2. Importance Value Index (IVI):

It is the sum of the relative values of abundance, density and frequency of species prevailing in the field studied. The species with higher IVI value has greater control over the ecosystem.
IVI = RD%+RA%+RF%
Where,
RD= Relative Density
RA= Relative Abundance
RF= Relative Frequency

Also

$$RD = \frac{\text{Density value of a species}}{\text{Sum of density value of all species}} X100$$

$$RA = \frac{\text{Abundance value of a species}}{\text{Sum of abundance value of all species}} X100$$

$$RF = \frac{\text{Frequency value of a species}}{\text{Sum of frequency value of all species}} X100$$

Table 2: Showing IVI value of different weed species in wheat mustard ecosystem at IAAS Paklihawa Rupandehi, Nepal, 2017

Weed Species	X	Y	Z	RD%	RA%	RF%	IVI
Anagalis arvensis	63	39	40	27.7533	9.91993	20.3125	57.9857
Vicia sativa	21	20	40	9.25110	6.44795	10.4166	26.1157
Chenopodium album	37	31	40	16.2995	7.32947	16.1458	39.7748
Oxalis corniculata	6	5	40	2.64317	7.36909	0.026042	10.03831
Phalaris minor	14	14	40	6.16740	6.14091	0.072917	12.38123
Polygonum plebeium	24	23	40	10.5726	6.40790	0.119792	17.10039
Rumex dentatus	18	18	40	7.92951	6.14091	0.09375	14.16418
Alternanthera sessilis	1	1	40	0.44052	6.14091	0.005208	6.586648
Lathyrus aphaca	6	6	40	2.64317	6.14091	0.03125	8.815333
Fumaria purviflora	16	16	40	7.04845	6.14091	0.083333	13.2727
Solanum nigrum	2	2	40	0.88105	6.14091	0.010417	7.032385
Cynodon dactylon	13	11	40	5.72687	7.25744	0.057292	13.0416
Ageratum conyzoides	4	4	40	1.76211	6.14091	0.020833	7.923859
Avena sativa	1	1	40	0.44052	6.14091	0.005208	6.586648
Lathyrus sativus	1	1	40	0.44052	6.14091	0.005208	6.586648

Note: X=total number of individuals of a species, Y=number of quadrates in which the species occurred, Z=number of quadrates under study

IVI value specifies the importance value index on an ecosystem that signifies the control of the weed species on the prevailing ecosystem. Higher IVI value of certain weed species signifies its dominance in the given ecosystem. In this case, higher IVI value is seen on *Anagalis arvensis* and it signifies the great dominance of *Anagalis* in wheat mustard ecosystem. Similarly, the dominance of *Anagalis* is followed by *Vicia sativa* and then *Chenopodium album* in the given ecosystem. Similar method was followed by (Ramfrez, Hoyos, & Plaza, 2017) to record the IVI of weed species.

Insect pest population

The insect population varied greatly on different dates in the studied quadrates. Mustard aphid (*Lipaphis erysimi)* population decreased significantly as the date progressed. The population of mustard nymph was seen highest in second date but continued to decrease and reached 0 on 5th reading. Wheat aphid adult (*Diuraphis noxia*) also showed similar pattern to that of mustard nymph. However, the dynamics of wheat aphid nymph showed pattern that of mustard aphid adult. The population of seven spotted lady bird beetle (*Coccinella septempunctata)* kept rising upto 3rd reading and then it began to decrease. However, the dynamics of spider *(Cheiracanthium spp)* and ant *(Solenopsis geminata*) did not followed a regular patten. The population of ant during the study was not significantly different).

Table 3: Average population of different predators and prey recorded in quadrates at mustard wheat ecosystem

DATE	*Lipaphis erysimi (adult)*	*Lipaphis erysimi (nymph)*	*Diuraphis noxia(adult)*	*Diuraphis noxia(nymph)*	*Coccinella septempunctata*	*Cheiracanthium*	*Solenopsis geminata*
2/20/2017	4.48[a]	10.18[a]	2.58[ab]	18.93[a]	1.18[a]	0.3[a]	0.13[a]
2/27/2017	3[b]	18.7[b]	3.2[a]	14.2[ab]	1.85[b]	0.3[a]	0.05[a]
3/1/2017	1.13[c]	26[b]	2.25[b]	12.4[b]	4.38[c]	0.13[ab]	0.08[a]
3/6/2017	1.13[d]	7.05[a]	0.43[c]	1.1[c]	3.83[c]	0.3[a]	0.1[a]
3/11/2017	0.33[e]	0[c]	0[d]	0[d]	2.7[d]	0.05[b]	0[a]
Grand mean	2.01	10.14	1.39	8.37	1.33	0.19	0.05
P	*	*	*	*	*	*	*
CV	37.31	44.67	44.60	44.68	44.36	26.31	40

[*]denotes significantly different at $P<0.05$ respectively. Means within column followed by the different letters are significantly different at 5 % level.

Response of insects with temperature

The effect of maximum temperature was more evident in the population of mustard aphid nymph as compared to ladybird beetle. Each unit's increase of maximum temperature increased the number of mustard aphid nymph by 2.173 units. However, the increase in lady bird beetle was only 0.464 units per unit rise in maximum temperature within the temperature range of 25-35^{0}C.

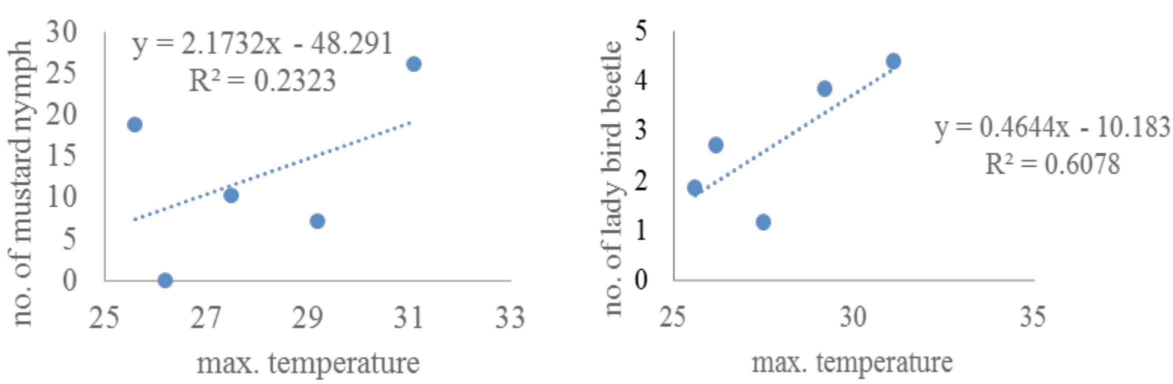

Figure 1: Relationship of maximum temperature on predator (lady bird beetle) and prey (mustard aphid nymph) with maximum temperature

Per unit increase in minimum temperature increased the number of mustard aphid nymph, wheat aphid and wheat aphid nymph by 1.567 units, 0.135 units and 1.755 units respectively. This showed that the increase in minimum temperature has more significant effect on population dynamics of wheat aphid nymph as compared to its adult or mustard aphid nymph.

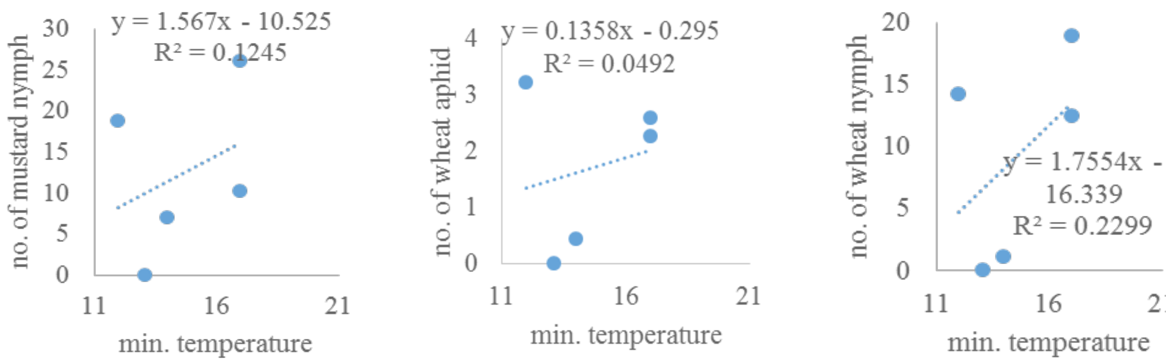

Figure 2: Relationship of maximum temperature on mustard aphid nymph (prey) and wheat aphid (prey) and wheat aphid nymph (prey).

(Bishnoi, Singh, & Singh, 1992) reported that the either mean temperature or saturation deficit contributes significantly to the buildup aphid population. Average maximum and minimum relative humidity had positive relationship with mean aphid infestation index (Samdur, Gulati, Raman, & Manivel, 1997). The feeding capacity of ladybird beetles was significantly greater at 30^{o}C as compared to 25^{0}C which shows that the increase in temperature has positive role in growth and development of ladybird beetle as well (Hoi, Binh, & Hang, 2013).

Dynamics between predators and prey

Spiders seem to relish more on mustard aphids in comparison to what aphids. Per unit increase in the population of mustard aphid increased the population of spiders by 0.049 units. 50.81% variation in population dynamics of spider is explained by population of mustard aphids. However, per unit increase in number of wheat aphids increased the population of spiders by 0.041 units. 24.37% variation in the population of spider is explained by wheat aphids.

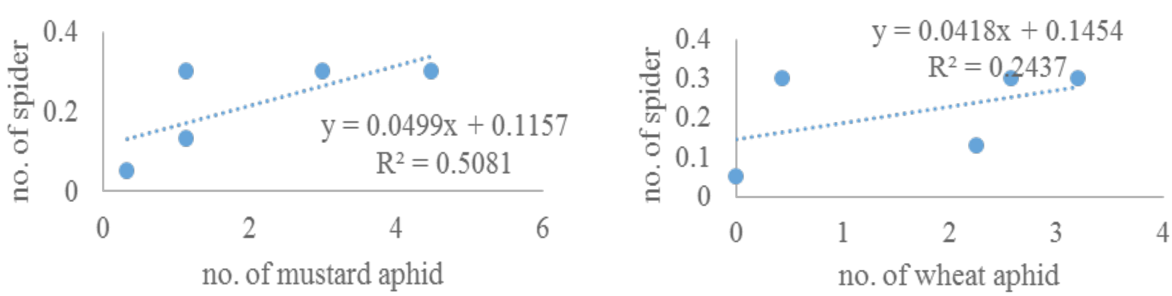

Figure 3: Relationship of spider with mustard aphid and wheat aphids

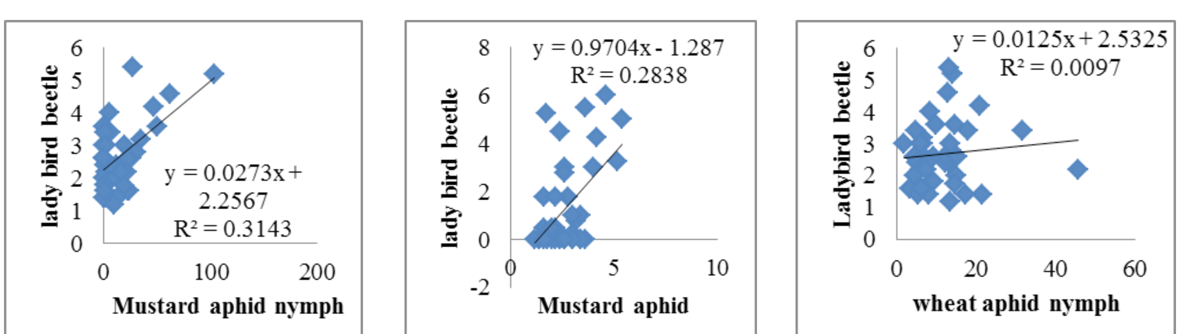

Figure 4: Relationship of lady bird beetle with mustard aphid nymph, mustard aphid adult and wheat aphid nymph

Ladybird beetle seems to enjoy more of mustard aphids' adults in comparison to nymphs of mustard aphids and wheat aphids. Each units increase in mustard aphid nymphs increases the lady bird beetle by 0.027 units. 31% variation in ladybird beetle population is explained by mustard aphid nymphs. Also, per unit increase in mustard aphid adult is increasing the lady bird beetles by 0.97 units. 28% variation in lady bird beetle is explained by mustard aphid adults. But per unit increase in population of wheat aphid nymph is increasing the population of lady bird beetles by only 0.0125 units and only 0.97% variation in lady bird beetles is explained by wheat aphid nymphs population. The result clearly shows the preference of ladybird beetles towards mustard aphids.

Spiders and seven spotted lady bird beetles are effective to control aphids as they seemed to significantly reduce aphid population (Sahito, Solangi, Kousar, Shah, & Mangrio, 2016).

Graphical view of the Lotka-Volterra model

Predator and prey populations cycle through time, as predators decrease numbers of prey. Lack of food resources in turn decrease predator abundance, and the lack of predation pressure allow prey populations to rebound.

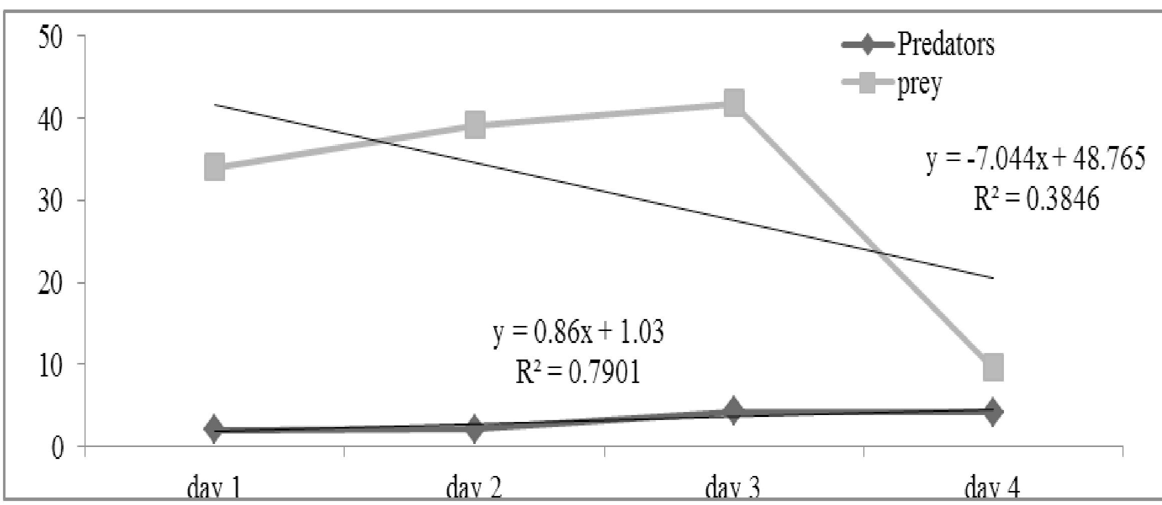

Figure 5: Graphical view of Lokta Volterra model of predator prey population observed during the study.

In the study, when the mean prey population (mustard and wheat aphids) increased from 34.06 to 39.1 per m^2, it increased the population of predators by 10%. Again when the average population of prey increased to 41.77/$m^2$from 39.1, it increased the predators' population by 101.39%. However, when the prey population drastically reduced to 9.69/m^2, it reduced the predator population by only 3.34%.

Correlation between various factors in wheat-mustard ecosystem

Table 4: Correlation between various abiotic and biotic factors available at wheat mustard ecosystem

	Max. temp.	Min. temp	Spider	Ladybird beetle	Mustard Aphid	Mustard aphid nymph	wheat aphid nymph	wheat aphid
Max. temp.	1	0.395	-0.856	0.095	-0.074	0.729	0.666	0.533
Min. temp		1	-0.037	0.444	-0.683	-0.168	-0.052	-0.459
Spider			1	-0.293	0.108	-.975*	-0.418	-0.524
Ladybird beetle				1	-0.945	0.272	-0.679	-0.654
Mustard Aphid					1	-0.031	0.658	0.78
Mustard aphid nymph						1	0.342	0.547
Wheat aphid nymph							1	0.889
Wheat aphid								1

**: Significant at P=0.05*

Strong negative correlation was observed in case of maximum temperature and spider population but weak negative correlation was observed between spider and minimum temperature. This shows that spiders are more susceptible to increase in maximum temperature. Spiders and mustard aphid nymph are strongly negatively correlated and the relation was found to be significant. Weak negative correlation was seen between spider and ladybird beetle as they are competitors of one another. Increase in population of mustard aphid adults weakly increases the population of spiders. Both wheat aphids' adults and nymphs are negatively correlated with population of spiders. Strong but non-significant correlation was observed between mustard aphids and ladybird beetle. Weak positive correlation was observed between ladybird beetle and mustard aphid nymph. Both wheat aphid adults and nymphs shared moderately strong negative correlation with ladybird beetle. Apart with mustard aphid nymph, mustard aphids shared positive and moderately strong correlation with wheat aphids and its nymph. Weak positive correlation was observed for mustard aphid nymph and wheat aphids' adults and nymph. Strong positive correlation was observed between wheat aphid adults and nymphs.

CONCLUSION

Predator and prey are the integral component of agroecosytem. Every organism particularly insects in arthropods respond to every deviation from normal environmental conditions whether it be biotic or abiotic. In case of the wheat mustard ecosystem the prevailing preys are ladybird beetles and spiders. Weeds can directly or indirectly affect the abundance of beneficial insects including predators, parasitoids and pollinators. A positive link can be created by in-depth and thorough examination of ecology in prevailing agroecosystem.

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