Ecological Knowledge of Pollination Services among Different Agro-ecosystems in Chitwan, Nepal

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Abstract

A survey was conducted to assess the knowledge of farmers about bee pollinators and their management practices randomly sampling 50 farmers from each agro-ecosystem: semi-natural (Megauli VDC), organic (Fulbari VDC) and intensive agriculture (Jutpani VDC) agro-ecosystems of Chitwan in 2013. It was found that agro-ecosystems, education, gender and age were determining factor for knowledge of farmers respectively. Knowledge level of farmers was significantly varied with agro-ecosystems ($\chi 2 = 18.375$, significant at $p<0.01$) and agricultural training ($\chi 2 = 12.245$, significant at $p<0.01$) shown by chi-square test where higher percentage of farmers in semi-natural (60%) and organic farming (58%) were aware than in intensive farming. Similarly, trained farmers (55.60%) had knowledge about pollination by bees. Most of farmer in study were aware about ecological conservation. Since training had significant role in knowledge transfer and enhancement, it seems necessity of training program on bee pollinators in all agro-ecosystems, and particularly in intensive agricultural ecosystems to save bee pollinators.

Index Terms— Bee pollinators, farmers' awareness, ecosystem services, agro-ecosystems, pollination, bee forage, food security

• INTRODUCTION

Food security is of first priority in many developing countries. Most of the efforts to address this issue had been directed to almost all inputs of production improving crop yield other than pollination. The transformation from subsistence systems to commercial agriculture posed new challenges for improving and maintaining productivity and quality. This was caused by several factors, the most important of which include the decline in pollinator populations and diversity due to decline in wilderness and loss of habitat, land use changes, monoculture-dominated agriculture and excessive and indiscriminate use of pesticides [1] [2] [3].

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Among the challenges, crop failures were due to inadequate pollination. In developing countries, pollination service is mainly feral except, some farmers keep *A. mellifera* colonies for pollination purposes in plantation crops without determining whether the bee species is the most effective pollinator for those crops [4] [5].
Hence, these days, pollination deficit has been a global problem. [6] stated that the main threats leading to pollinator populations' declines and potentially menacing the provision of pollination services. The decline of pollinators in terms of abundance and species richness has caused great concern about the risk of a

deterioration of crop pollination and the associated crop production [7] [8]. Pollination deficits occur frequently in natural pollinator communities and ecosystems [9] and are thus expected among crops in general. Compared with more diverse landscapes, the lack of resources in intensively managed agricultural landscapes potentially decrease wild bees' contributions to crop pollination [8].

Little information exists on the ways in which local management influences agricultural pollination [1]. Agro-ecosystems with more semi-natural habitats are often more pollinator-species rich [10] [11]. The role of bees as crop pollinators has been largely ignored and a vast potential of using bees to augment national income through increased crop production has been forgotten [12]. Though honeybees as pollinators have great economic and biological importance, it has yet not been made an integral part of agricultural and horticultural management technology in the developing countries of Hindu Kush-Himalaya [13]. Ecological knowledge of ecosystem services of different agro-ecosystems seemed necessary that fruit or seed set of many crops find relying on wild pollinators [14] and management for improved pollination services like rearing honeybees is uncommon to boost agricultural productivity [15]. Therefore, this study was carried out to assess farmer's present level of knowledge about bee pollinators and pollination, and their utilization in crop pollination, and their knowledge on management practices to conserve pollinators' habitat.

2. MATERIALS AND METHODS

The study was conducted in three ecological sites of Chitwan with randomly selected 150 farmers following sampling frame of District Agriculture Development Office, Chitwan. The three ecological sites were semi natural (Megauli), Organic (Fulbari) and intensive agriculture (Jutpani) (Fig, 1).

Fig. 1. Map of Nepal showing locations of the study VDCs in Chitwan district

The primary source of data collection included the interviews of farmers using semi-structured questionnaires, face-to-face interviews with the concerned farmers group and other related personnel. Pre-testing of the designed questionnaire was done with 16 respondents from Sardanagar and Chainpur and questionnaires refined for final survey schedule. The survey data were coded, entered into a spread-sheet and checked prior to analysis. The collected data were analyzed by using socioeconomic statistical tool SPSS. Respondents' knowledge was assessed using farmers' knowledge on different bee species (the crop flower visitors), their nesting requirements, food resources, and their role in pollination and management practices with scaling on the perception of farmers. Their acceptance on most positive choice was considered as 1 and relevant choice was considered as 0.75 and negative statement was considered as 0.5. Thus, summation on different knowledge parameter according to farmers' choice was categorized according to mean as above mean and below mean for other tests. Cross-tabulation with selected variables, percentages and means were undertaken using pivot table in Microsoft Excel 2003. Percentages were based on either the total number of respondents or total responses, details of which are provided in the respective text or tables. Inferential analysis included the Chi- Square Test to determine association of knowledge parameters, knowledge categories with ecosystems and social attributes.

3. RESULTS AND DISCUSSION

The survey was conducted in the three different agro-ecosystems to know several different knowledge parameters. Results obtained from the analysis have been explained here.

3.1 Beekeeping and honey production in study sites

Figure 2 (a) and (b) represents number of bee hives and honey production (quintal) in the research sites. Respondent farmers had 1405 honeybee colonies in Jutpani followed by Megauli (700 colonies) and the lowest number of bee colonies in Fulbari (45 colonies), respectively. Honey production was 421.8 qt/year (30kg/colony/year) in Jutpani, 26 qt/year (57 kg/colony/year in Fulbari and 210 qt/year (30kg/colony/year) in Megauli as shown in Figure 2a and 2b

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Fig. 2(a) Bee colonies in research sites

Fig. 2 (b) honey production in research sites

Apiculture is distributed throughout Chitwan district. The beekeeping in Chitwan was mainly for honey production [16]. Beekeepers of eastern Chitwan (Jutpani is the major pocket) is doing beekeeping as an income generating activity [17]. The number of hives was 3700 from which 98 MT (27kg/colony/year) in 2002/2003 [18]. [19] got an average honey productivity of 34.8 kg/colony/year) while studying sites of Chitwan (36 respondent of hills and 29 of terai). Honey potentiality can be expected more than this however, low productivity resulted in Chitwan is due to effect of deforestation and pesticide poisoning [19]. There was tremendously increased in beekeeping enterprises in Chiwan that 237 farm families involved in beekeeping and produced 480MT (36 kg/colony/year) in an average from keeping 13,200 bee colonies [20].

3.2 Respondents' involvement in training

Training is very important to farmers for improved beekeeping and enjoying its benefits. The respondents living in three survey sites received opportunity of training, i.e. above 70% respondents indicated that they understood improved beekeeping practices and importance of pollination along with pesticide problems. However, 35.7% of the respondents from Jutpani were untrained which is less in other two sites (Figure 3). Survey shown that one fourth in the hills and more than half (58.6%) of the respondents of terai had training on apiculture [19]. According to [21], lack of information about high producing bee (*Apis melifera* L.) seemed to be the general trend across the country in Ethiopia. Even single-session seminars and workshops have shown to be successful in altering people's perception about specific issues [22] [23].

Fig. 3. Involvement in training in three agro-ecological sites.

3.3 Respondents' knowledge in beekeeping and pollination

Figure 4 shows that higher numbers of the respondents of Megauli (28%) and Fulbari (28%) had better knowledge of beekeeping and pollination as compared to Jutpani (24.7%) because of the better exposure of the farmers in training in former two sites. There are many supporting organizations, such as District Agriculture Development Office (DADO), District Development Committee (DDC) and Village Development Committee (VDCs) for supporting and promoting beekeeping there and several other organizations such as WINROCK International (WINROCK), Participatory District Development Program (PDDP), Youth Club of Narayanghat, Dabar Nepal, United State Agency for International Development (USAID) and Sagan Bikas Samaj Jutpani is

involved in impart training and overall development of apiculture in Jutpani and other places [17] [18] [24]. Global pollination Project, Rampur, Chitwan also conducted Farmers Field Schools (FFS) and other training activities on beekeeping and pollination in eastern and western parts of Chitwan. [19] shows that considerable members of respondents (27.8% in hills and 86.00% in terai) realized the role of pollination there.

Fig. 4. Respondents' perception on knowledge of beekeeping and pollination

3.4 Respondents' knowledge on bee habitats

The wild bees build their colonies in forest trees, shrubs and ceilings of the buildings, water tower, and soil). The respondent's knowledge on bee nesting places varied in three study sites (Figure 5).

Fig. 5. Respondents' knowledge in habitat of bee

Only 19.3% of the respondents of semi- natural areas observed bee nests in all places, like wild trees, shrubs, and ceiling of the buildings. The respondents of organic site and intensive agriculture practiced areas pointed out trees and ceilings as the bee nesting places. The respondents of semi-natural site were found more acquainted with bees that nests in all places (trees, shrubs, ceiling/tower and soil). Lesser respondents were found familiar with the bees that nests in soil. This might be their exposure of different community forests. Colonies of Apis dorsata nested on to manmade structures as high as a water tower at Rampur, Chitwan and as low as beam of a house of Sukranagar, Chitwan and Bamboo tree at Bharatpur, Chitwan [19]. Apis florea builds a single-comb nest, usually fairly low down in bushes, or in the open, suspended from a branch or rock surface [25]. Knowledge regarding bee habitat management is important. [26] conducted studies at International Centre for Integrated Mountain Development (ICIMOD) show a decline in the indigenous bee populations in their natural habitat i.e. reducing the availability of forage and nesting places.

3.5 Respondents' knowledge on crop pests and pollinators

Pest and pollinators are sometime confusing to the farmers. The respondents were able to differentiate crop pests and pollinators (Figure 6). Nearly two-third of the farmers in Fulbari (60.00%) differentiated between pests and pollinators, while it was only 28.00% Megauli and 20.00% in Jutpani sites. In Fulbari, farmers were inclined toward organic farming for 15 years and also were well- trained on the subject since several pollination farmers field school (FFS) were been conducted, there .

Fig. 6. Respondent's ability on differentiation of pest and pollinators

3.6 Factors affecting knowledge level of farmer on beekeeping and pollination.

The chi-square test showed significant differences among the study sites and farmers' decision to participate in the training (Table 1). Farmers participating in the training had higher and those non-participating farmers had lower knowledge of beekeeping. The result is similar to study done in Uganda that farmers were able to identify honeybee and other insect pollinator from all other bee species and pests in positive effect of organic management than in conventional farming [27].

TABLE 1
FACTERS AFFECTING KNOWLEDGE LEVEL OF FARMERS ON BEEKEEPING AND POLLINATION

Particulars	Categories of Knowledge Below Mean	Above Mean	Total
Agro-ecosystems		**$\chi 2 = 18.375^{**}$, df= 2**	
Semi- natural farming	20 (40.00)	30 (60.00)	50 (100.00)
Organic farming	21 (42.00)	29 (58.00)	50 (100.00)
Intensive farming	39 (78.00)	11 (22.00)	50 (100.00)
Decision on Participation in Training		**$\chi 2 = 12.245^{**}$, df= 1**	
Yes	48 (44.40)	60 (55.60)	108 (100.00)
No	32 (76.20)	10 (23.80)	42 (100.00)

** indicate significant at P< 0.01
Data in parenthesis denotes percent.

Tabel 1 shows that different parameter of knowledge was associated with agro-ecosystems viz. semi natural farming, organic farming and intensive agriculture farming. Farmers of semi-natural and organic farming have more knowledge on proper bee keeping and crop pollination comparison to intensive agricultural farming. Table 2 also explains that education level of farmer that has also shown some association with knowledge parameter like identification of other honey bee, use of pesticides, types of pesticides, types of fencing etc.

TABLE 2

SUMMATED TABLE FOR ASSOCIATION OF DIFFERENT VARIABLE WITH KNOWLEDGE PARAMETER

Parameter	Ecotype	Sex	Age	Education
Identification	9.852**, df=2			
Bee keeping	21.741**, df=2			
Identification of other bees produce honey	18.695**, df=2		8.746*, df=2	10.955*, df=3
Habitat of bee	68.814**, df=8			
Identification of other bees not produce honey	16.84**, df=2			
Bee annual presence	11.5**, df=2			
Identification of insects	26.611**, df=2			
Differentiation of pest and beneficial	40.58**, df=2			
Benefit of bee on crop	27.493**, df=2		7.797*, df=2	
Parthenocarpy			10.496*, df=2	
Use of pesticide	20.994**, df=2	4.066*, df=1		
Type of pesticide				20.042**, df=6
Type of fencing (Live and Non-live)			17.019**, df=2	11.999**, df=3
Insects living in				19.684**,

holes			df=3
Bee living in holes	9.903**, df=2		16.209**, df=3
Types of bees in hole			13.172*, df=6
Ground cover		5.879*, df=1	
Increase pollinators	15.77**, df=2		
Reason of increase pollinators			48.433**, df=6

** indicate significant at P< 0.01
* indicate significant at P< 0.05

TABLE 3

SUMMATED TABLE FOR ASSOSITATION OF DIFFFERENT VARIBALE WITH CONSERVATION PARAMETERS

Parameter	Ecotype	Sex	Age	Education
Insect control measures in past				19.488*, df=6
Most effective measure of pest control			11.52*, df=4	
Adverse effect of pesticides		4.303*, df=1		
Effect of pesticides on soil microbes				14.328*, df=3
Reason for visit of bee in rapeseed				46.306**, df=6
Pollination increase production			6.962*, df=2	
Habitat destruction (hunting, slash burn)	7.00*, df=2			
Deforestation	7.008*, df=2			
Pesticide use		5.365*, df=1		
Farming Practices (such as mono-cropping)	12.00**, df=2			
Pesticide effect	13.744**, df=2			

** indicate significant at P< 0.01
* indicate significant at P< 0.05

For eco-conservation, agro-ecotype and farmers education has association. Agro-ecotype is significantly (P<0.01) associated with farming practices and pesticides effect, where semi-natural farming and organic farming farmers were more aware with these parameters. Knowledge of habitat destruction and deforestation is important with agro-ecotype. Semi-natural and organic farming farmers have good knowledge about it. Hence, education is the determining factor for reason of visit for bee in rapeseed. Similarly, education also

affect knowledge of soil microbes and knowledge of insect control measures. While, assessing different knowledge parameters, it was found that agro-ecosystems, education, gender and age were determining factors for knowledge of farmers.
Good knowledge of identifying bees and differentiating bees with pests' proximity to natural habitat are often associated with higher crop flower visitation and bee diversity [28]. [29] indicated that age, level of education, gender, general knowledge of importance of protecting natural and semi-natural habitats in the vicinity of coffee fields for coffee yield increase played no important role on pollination knowledge in view of farmers in Uganda. The study result agreed with the findings of [30], who reported that education level affect bee keeping practices.

The higher the level of education of the respondents in organic site (Fulbari) and also female participants involved in training, the better result in identifying bees and knowing bee visits effect in crop production. Similar findings were reported by [31] from surveys conducted in agro-pastoral lands in Kakamega, Kenya. Most of farmer in study were aware about ecological conservation. Since agricultural training has significant role in knowledge enhancement, it seems necessity of training program (such as Farmer Field School) on bee pollinators in all agro-ecosystems and more particularly in intensive agricultural ecosystems. [32] Braun et al. 2006 stated that farmers to perceive and manage an ecosystem service can be improved through development and application of location-dependent knowledge.

4. CONCLUSION

The problem of food security cannot be solved without increased productivity of the crops through pollinators. Promoting use of beekeeping for pollination of agricultural crops will be of benefit to both the beekeeper and the farmer. The perception of farmers about the benefit of pollination in crop yield significantly differed with their education status. Respondents found aware on pesticide effect of pollinators abundance and diversities. Pollinators are more common in semi-natural and organic environments than in the intensive agriculture environment. The male respondents are more involved in training in agriculture and beekeeping than the female respondents. Jutpani area with intensive agriculture consumes higher amount of pesticide than Meghauli- semi natural site (pollinators' natural habitat) and Fulbari- the organic sites (relying on organic principles). The best method of pest control is biological methods in the semi natural and organic sites whereas in intensive agriculture site, the respondents prefer chemical methods. Therefore, significantly higher number of pollinators visited rapeseed in semi natural site, followed by organic site than in the intensive agriculture site. The main determining factor for the unattended pollination are the decrease in pollinators' number and diversity as a result of loss of habitat, excessive and indiscriminate chemical use. Survey research showed that farmers dwelling in semi-natural area have some awareness of cutting, hunting, slash-burn, fire, soil erosion, deforestation that adversely affected abundance and intensity of pollinators. The farmers practicing organic farming were maximizing cropping diversity for attracting diversified abundance of pollinators in their agro-ecosystem. Therefore, minimizing use of hazardous agrochemicals and practicing community forestry, protected buffer zone, and biodiversity garden- herb farming for honeybee, wild bees and indigenous pollinators' help their conservation. However, farmers in Jutpani areas were less aware in conservation and sustainable use of biological diversity. Hence, IPM, organic farming, community forestry, protected area, biodiversity garden etc. were the best management practices to be endorsed in national plans and policies for conservation and sustainable use of biological diversity and conservation of pollinators. Pollinators and pollination awareness, education and training, course curricula in teaching/ training institutes and well trained human resource development seem necessary for mass mobilization in implementation of eco-friendly agricultural practices. Tying up beekeeping and honey policy in farmers' agriculture production is necessary for sustainable management of farmland and forest land. Stock improvement of bees and conserving bee pasture domesticating the local /wild honeybee and organic farming may help reduce mortality of wild honeybee due to pesticide. Web-site development and database management of honeybees, crop pollination and pollinators are imperative side by side for sharing valuable information.

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