**Diversity Analysis of Insect Pests of Apple and Apricot in Trans Trans-Himalayan Region**

**ABSTRACT:** Apple (*Malus domestica*) and apricot (*Prunus armeniaca*) are important temperate fruit crops widely grown in the cold-arid, high-altitude regions of Ladakh, particularly in the Leh district. Although these areas offer ideal conditions for fruit production, the presence of insect pests often limits yield and affects fruit quality. Despite this, little is known about the diversity and population patterns of these pests in such challenging agro-climatic zones. To bridge this gap, the present study was conducted during the 2022 and 2023 growing seasons to document and analyse the diversity of insect pests in apple and apricot orchards across three blocks of Leh -Leh, Saspol, and Khaltsi. Surveys were carried out using standard entomological methods such as visual inspection, handpicking, and various traps. Pest data were analysed using ecological indices, including Shannon-Wiener’s diversity index, Margalef’s species richness, and Pielou’s evenness index. Results revealed notable variation in pest diversity between locations. The Leh block showed the highest pest diversity and species richness for both crops, while Khaltsi recorded the lowest. In apple orchards, the diversity index ranged from 0.50 to 1.29, and in apricot orchards from 0.34 to 0.78. Evenness values suggested a more balanced pest population in Leh and Saspol compared to Khaltsi, where a few species dominated. This study represents a first step towards understanding the pest community structure in the cold-desert environment of Ladakh. The findings highlight the need for location-specific pest management strategies and provide a valuable baseline for future ecological research and the development of sustainable, region-adapted IPM practices.

***Keywords: -*** *apricot pest, apple, Shannon-Wiener’s diversity index, Margalef’s species richness, Pielou’s evenness index*

**INTRODUCTION**

Apple (*Malus domestica*) and apricot (*Prunus armeniaca*) are among the most economically significant temperate fruit crops cultivated in the high-altitude, cold-arid regions of the Trans-Himalayas, especially in the Leh district of Ladakh (Stobdan *et al.,* 2021). These unique agro-ecological zones, characterised by their cool temperatures and low humidity, provide favourable conditions for producing high-quality fruits (Ahmad *et al.,* 2017). Despite these advantages, the cultivation of these crops is frequently hampered by the incidence of insect pests, which contribute substantially to yield losses. These pests inflict direct damage by feeding on foliage, shoots, and fruits and can also serve as vectors for various plant pathogens, ultimately diminishing both yield and fruit quality (Vallad *et al.,* 2018; Sharma *et al.,* 2023).

Due to the remote and climatically challenging nature of the cold-desert ecosystem, the diversity and population dynamics of insect pests in these areas remain insufficiently documented. The region experiences a short growing season, pronounced temperature fluctuations, and minimal rainfall, factors that contribute to the development of a distinct, and in some cases endemic, pest complex (Shaheen *et al.,* 2013*;* Behera *et al.,* 2014). Consequently, there is a pressing need for detailed, location-specific studies that can inform integrated pest management (IPM) programs tailored to these unique environmental conditions.

Although some observational studies have reported insect pests of temperate fruit crops in such regions, systematic and quantitative evaluations of pest diversity are sparse. The application of ecological diversity indices such as the Shannon-Wiener Index (1949) for species diversity, Margalef’s Index (1958) for species richness, and Pielou’s Evenness Index (1966) provides a structured approach to understanding pest community composition, dominance, and spatial distribution. These indices serve as important tools in biodiversity monitoring and help guide targeted pest surveillance and mitigation efforts (Magurran, 2013).

Against this backdrop, the present study was designed to conduct a structured field survey to document and analyse the diversity of insect pests associated with apple and apricot cultivation across three blocks of Leh district, namely Leh, Saspol, and Khaltsi, during the active growing seasons of 2022 and 2023. The primary objective was to assess species richness, relative abundance, and evenness of pest populations using established ecological indices. The outcomes of this research are intended to serve as a foundational reference for future studies and contribute to the development of sustainable pest management strategies suited to the cold-arid agroecosystems of the Trans-Himalayan region

**MATERIAL AND METHODS**

A structured orchard survey was conducted during the 2022 and 2023 growing seasons in selected apple and apricot orchards within the Leh district to assess pest incidence. Three apple orchards, located in Leh, Saspol, and Khalsti, along with their associated pests, were sampled from selected localities using visual searching methods, handpicking, collection of fallen fruits, and various types of traps, including sticky traps, suction traps, light traps, and sweep nets. Fortnightly observations were conducted to assess insect pest incidence in apple and apricot orchards. In each orchard, three trees were randomly selected, and sap-sucking pests were counted per leaf on 30 sub-terminal leaves (10 from each canopy level across four directions). Pest abundance was also estimated using direct count methods. Larvae of butterflies and moths were randomly collected, and fallen or infested fruits were examined for pest damage. Diversity assessments were carried out in pesticide-free orchards. Collected specimens, including adults and nymphs, were preserved using standard entomological methods.

**Estimation of diversity indices:**

Quantitative estimation of individual species will be made using the data derived from field survey. Shannon and Wiener Index (1949), Margalef index (1958) and Pielou’s Evenness Index (1969) will be applied for studying diversity and abundance of apple and apricot insect pests.

1. Index of species diversity (H`) = -∑ pi In pi

Where pi = the proportion within the sample of the number of individuals of the “ith” species and is denoted as Ni/N

 Ni = Number of ‘ith’ species.

 N = Total number of species

1. Evenness index (Pielou, 1966):

Evenness index (J) =H`/In S

Where H` = Shanon Weiner’s index

 S = Number of species.

1. Species richness (Margalef’s index (1958) :

Margalef’s index = S-1/In N

Where S = Total number of species

 N =Total number of individuals in the sample.

**RESULT AND DISCUSSION**

**For apple pests**

To estimate various diversity indices of apple and apricot pests, three blocks were selected of the Leh district of Ladakh, namely Leh, Saspol, and Khaltsi, with three locations in each block. Quantitative estimation of individual species was made using the data derived from the field survey. Shannon and Wiener Index (1949), Margalef Index (1958), and Pielou’s Evenness Index (1969) were applied for studying the diversity and abundance of apple and apricot insect pests. The data sets collected during the study period of two years, 2022 and 2023, were subjected to three different diversity indices, which were mentioned above and are tabulated in Tables 1 & 2. The Shannon-Wiener diversity index shows the species diversity; the greater the index values, the more the diversity. Margalef’s index enables us to know the richness of species with distributional patterns, whereas Pielou’s index gives the evenness of different species, i.e., similarity in abundance of different species.

In the apple orchards of the Leh district, the overall Shannon-Wiener diversity index calculated for the years 2022 and 2023 ranged from 0.50 to 1.29. Shannon-Weiner index explains both the evenness and richness of species. Its higher value indicated an increase in the total number of species. On comparing the three blocks diversity index had a high value of 1.29 at the Leh block and a minimum value of 0.50 at Khalsti for the year (Table 1). However, for 2023, it has been reported that the Leh block diversity index has a high value of 0.58 and a minimum value of 0.22 at Khalsti for the year 2023. This index reflects the extent to which individual species are evenly distributed among various other species. Whereas the Shannon-Weiner index for three blocks in the Leh district showed that the highest richness was in the Leh block, followed by the Saspol block, and the lowest Shannon-Weiner index value was recorded in Khalsti

The Evenness index (Pielou, 1966) for apple pest showed a maximum value of 0.94 at Leh, 0.89 in Saspol, and a minimum value of 0.19 in Khalsti, during the experimental period (Table 1).

Margalef index gives us the number of species, i.e., with the increase in the number of species, the index value also gets increased. for apple pest, the calculated value ranged from 0.23 to 0.53. The highest value was recorded at Leh (0.53), followed by Saspol (0.37), while the lowest was at Khalsti block (0.23) during the experimental period.

Table 1: Diversity indices of different locations for Apple in the years 2022 and 2023

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Location (Block) | Taxa | Individuals | Shanon Weiner H index  | Pielous Evenness | Species Richness (Margalef) |
|  Leh  | 4 | 270 | 1.29  | 0.94 | 0.53 |
| Saspol | 2 | 161 | 0.57 | 0.89 | 0.37 |
| Khaltsi | 2 | 120 | 0.50 | 0.19 | 0.23 |

**For apricot pests**

Its overall value Shannon-Weiner index for apricot pests in the Leh district ranged from 0.347 to 0.788 during the years 2022 and 2023. On comparing the three blocks diversity index had a high value of 0.78 at the Saspol block and a minimum value of 0.34 at Leh for the year 2022 (Table 2). This index reflects the extent to which individual species are evenly distributed among various other species. The Evenness index (Pielou, 1966) for apricot pest showed a maximum value of 0.73 at Saspol and a value of 0.72 at Khalsti, while the lowest value of 0.70 is recorded at Leh during the experimental period (Table 2). Lower evenness values in these locations are likely to indicate dominance by only a few species, affected by factors such as climatic conditions, competition, succession, and predation. Margalef index gives us the number of species, i.e., with the increase in the number of species, the index value also increases. During the survey period, for the apricot pest, the calculated value ranged from 0.18 to 0.37. The highest value was recorded at Saspol (0.37), followed by Leh (0.19), while the lowest was at the Khalsti block (0.18).

Table 2: Diversity indices of different locations for apricots in the years 2022 and 2023

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Location (Block) | Taxa | Individuals | Shanon Weiner H index  | Pielous Evenness | Species Richness (Margalef) |
|  Leh  | 2 | 174 | 0.347 | 0.707 | 0.193 |
| Saspol | 3 | 215 | 0.788 | 0.733 | 0.372 |
| Khaltsi | 2 | 256 | 0.568 | 0.727 | 0.180 |

Species diversity is a crucial parameter for comparing study areas under biotic and abiotic disturbances, as it aids in assessing the significance of collected data from different study sites across various seasons, considering the distributional patterns of pests (Solow, 1993). This study marks the initial attempt to sample insect pests affecting apricots and apples in Leh district, Ladakh. Five pest species from various orders and families were collected, allowing for an assessment of pest abundance and diversity on apple and apricot trees. Similar findings were reported by Mir and Wani (2005), who examined pests associated with walnut trees in the Kashmir Valley. In the Hemiptera order, the Aphididae family was the most abundant across all study sites (UCIPM, 2011; Wani & Ahmad, 2015), suggesting higher host availability and untreated trees, contributing to species diversity and a healthy ecosystem. Altieri (1991) observed that plant community manipulation tends to increase pest incidence, and species richness is significantly affected by food availability for each pest life stage (Pinheiro & Ortiz, 1992). Greater species richness often indicates a higher number of niches associated with the host plant (Hutchinson, 1959). In this study, the Berger-Parker index recorded its highest value in the Baramulla district, reflecting a higher abundance of predominant species in Srinagar. Results demonstrated similar diversity index values across sites within the same district, though species diversity, evenness, and richness varied among districts due to differences in habitat (Denys & Tschantke, 2002). These diversity values differed across districts due to variations in pest occurrence, activity, distribution, and host plant abundance. For example, the Shannon-Wiener index revealed minor variability among sites within the same block. A heterogeneous natural environment directly impacts pest diversity (Perfecto *et al*., 1997), and Margalef’s index values varied across study sites, suggesting species richness depends heavily on land use, whether agricultural, urban, or landscaped, contributing to differences among districts (Kim, 2009). Lower evenness values indicate dominance by only a few species, affected by factors such as competition, succession, and predation (Magurran, 1988; Weiher & Keddy, 1999).

Studies by Memon (2011) on sugarcane insects in three sites showed no similarity in diversity indices, aligning with our findings of non-uniform diversity values over two years. Panzer and Schwartz (1998) proposed that plant species richness explains nearly 49% of insect species variance, a pattern also observed in the present study, where untreated walnut orchards exhibited a diverse pest community. This study’s diversity indices for species richness, diversity, and evenness closely mirrored those found by Reddy and Moos (2015) in mango orchards. Our findings showed a decrease in Shannon diversity with reduced pest abundance, similar to Aslam's (2009) study on moth richness and evenness in Peshawar, Pakistan. Management practices, as noted by Khan and Alam (2007), significantly shape diversity indices of pests and predators. Rahman *et al.* (2004) also concluded that pest and natural enemy abundance are linked to the host's growth stage, with microhabitat shifts driving variations in diversity, abundance, and species richness (Turner & Pharo, 2005).

Abbas *et al.* (2014) observed that seasonal variations affect micro-invertebrate abundance and diversity, consistent with this study's findings of fluctuating Lepidopteran pest populations across seasons. Their presence was confined to a few months, reflecting a seasonal diapause (Kuntee, 2000). Similar findings by Amber *et al*. (2015) indicated high Lepidopteran species richness in March and April, with Shannon diversity index values of 2.47 and 2.40, respectively. Pest life cycles varied slightly among districts, possibly due to temperature, which can alter insect lifespans, as shown by Regniere *et al.* (2012). Additionally, *L. obfuscata* was less abundant or absent at multiple sites compared to *C*. *odata* and *E.* *musculana*, supporting findings by Lindroth *et al.* (1990) that walnut foliage contains juglone, a toxin inhibiting *L. dispar* feeding and contributing to low diversity values. Environmental factors such as seasonal variations in relative humidity and rainfall influence pest diversity, as pests favour hosts with abundant food (Sharma *et a*l., 2006). Furthermore, differences in pest populations across seasons or years are often due to microclimatic changes, which enable pests to exhibit physiological adaptations to temperature and humidity (Sudhikumar *et al*., 2005).

**CONCLUSION**
This study provides a first-hand look into the diversity of insect pests affecting apple and apricot orchards in the unique cold-arid climate of Leh district, Ladakh. By surveying three distinct blocks, Leh, Saspol, and Khaltsi, over two growing seasons, we were able to identify key patterns in pest species richness, diversity, and evenness. The results clearly show that pest populations vary not just in numbers, but also in how evenly they're distributed across locations. Among the three sites, Leh consistently showed higher diversity and richness, while Khaltsi had fewer species and greater dominance by specific pests. These differences are likely influenced by local factors such as altitude, temperature fluctuations, host plant availability, and minimal pesticide use. The relatively high diversity in orchards suggests a stable and potentially resilient ecosystem, but also highlights the need for careful monitoring. Overall, our findings stress the importance of region-specific studies to better understand pest behaviour in such challenging environments. This baseline information can guide the development of more effective, locally adapted pest management strategies. Going forward, regular surveys and more in-depth ecological studies will be essential for promoting sustainable fruit production in this fragile Himalayan ecosystem.

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