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# Diversity and abundance of Chrysomelids associated with rice under natural farming in mid hill conditions of Himachal Pradesh

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## Abstract

**The study on diversity and abundance of chrysomelids associated with rice was conducted in mid-hill regions of Himachal Pradesh during *kharif* 2022 and 2023, identified eight chrysomelid species, their abundance and diversity using various indices under natural farming. Diversity of chrysomelid fauna was found higher at Palampur region with all the eight species recorded during the crop growth period as compared to Jogindernagar, where only five species were found associated with rice ecosystem during both the cropping years. Among these identified species, *Chaetocnema gracilis* and *C. nigrica* were found to be predominant in both the locations surveyed. Findings revealed seasonal variations in chrysomelid abundance, with peak population in the month of July and August, emphasizing critical periods for pest management interventions. Correlation analysis indicates intriguing patterns, such as positive influences of rainfall on certain pest species and varying correlations with maximum temperature. This study contributes essential insights into chrysomelid beetles under natural farming conditions in Himachal Pradesh and their relation to the abiotic factors prevailing in particular area.**

**Key words:** Rice, chrysomelids, abundance, diversity, correlation, temperature, rainfall

Rice (*Oryza sativa* L.) is one of the most important cereal crops and staple food for about half of the world's population. Asia covers 90 per cent of global rice production and consumption in World. Therefore, rice production in Asia is the key for global food security. India is the second largest producer of rice in world after China, with a cultivated area of about 46.38 million hectares and a production of 130.29 million tonnes (Anonymous 2023).

Rice is the source of income and employment for many states of India and other countries. So, there is a need to increase the rice production to meet the requirement of ever-increasing population of the world (Miao *et al*. 2011). In Himachal Pradesh rice is mostly cultivated under lowland conditions, however in hilly areas of the state rice is being produced in upland conditions (Garkoti and Pandey 2022). The quality and production of rice crop is considerably affected by an array of insect- pests infesting at various stages of crop growth. The dynamics of insect pests in rice ecosystem have undergone significant changes in recent times, with several previously considered minor pests now emerging as major threats. One such example is the rice hispa, *Dicladispa armigera* (Olivier) (Coleoptera: Chrysomelidae), which has emerged as a significant concern due to its amplified impact on rice cultivation in India (Sharma *et al*. 2014). This pest's prevalence has notably risen across various rice-growing regions, with Kangra valley of Himachal Pradesh experiencing recurrent outbreaks in recent years (Sharma *et al.* 2012). Other than rice hispa, various flea beetle species of family Chrysomelidae infest rice mainly during the vegetative stage. A significant number of adults tend to congregate on rice plants causing long and narrow scrapings on the leaves, mostly observed in non-flooded rice. While these tiny beetles cause low levels of defoliation, hence are not generally regarded as a major pest in most rice-growing regions (Shepard 1995). However, certain flea beetles such as

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*Chaetocnema* spp. are important vector of viruses like rice yellow mottle virus. This viral infection can lead to severe consequences, causing up to 80-100 per cent yield losses in rice (Iannella *et al*. 2021).

The changing climate is known to have profound effects on the survival, development and distribution of insect-pests, thus influencing population dynamics of the same. Therefore, thorough understanding of correlation between insect pests and climatic factors is crucial for effective weather-based pest forecasting. Farming system tends to affect the diversity of insects and natural enemies in a crop ecosystem (Gallo and Pekar 1999). To encompass the adverse effects of conventional farming, recently a farming system known as "natural farming: a climate resilient type of farming" is being practiced. A plenty of information is available on the insect-pests of rice throughout the country but very little is known about the diversity of chrysomelids under natural farming. Therefore, this study aims to examine the abundance and establish correlations between key weather factors (temperature, humidity, rainfall) and chrysomelids associated with rice under natural farming in the state.

## Materials and Methods

A survey was conducted in farmer's fields growing rice in mid hill regions (Zone II) of Himachal Pradesh to record the seasonal abundance of chrysomelid beetles of family Chrysomelidae under natural farming during *kharif* seasons of 2022 and 2023. Two locations namely, Palampur and Jogindernagar were surveyed and at each location, different localities namely Holta, Batolu, Chatter, Masoli and Majharnu were selected to record the abundance of chrysomelid fauna associated with rice at various crop growth stages. The data were recorded with the help of sweep net sampling method in each locality at fortnightly intervals starting from the vegetative stage and was continued up to maturity. The incidence of pests was recorded on 10 hills of each five quadrats ($1m^2$) selected in each locality. The collected insect fauna was preserved in 70 per cent ethyl alcohol and were got identified from Kerala Agricultural University, Thrissur (Plate 1). The weather data were obtained from the Agro-meteorological observatory of the Department of Agronomy, CSK HPKV, Palampur to work out the correlation between the insect-pests and abiotic factors of Palampur region.

For estimating the diversity of chrysomelid specimens under natural farming, the data of all the localities for each location were combined together. The following formulae was used:

$$\text{Relative proportion of } i^{th} \text{ species} = \frac{\text{Total number of individuals of } i^{th} \text{ species}}{\text{Total number of individuals of all the species}} \times 100$$

The species diversity on rice was evaluated at fortnightly intervals across both seasons. The assessment utilized multiple indices, including Shannon diversity index (H), Evenness index (J) and Simpson index (D) as determined by the respective formulas provided by Shannon (1948) as under:

Shannon diversity index (H) = $-\Sigma p_i \log_e p_i$;

where $p_i$ = fraction of $i^{th}$ species

Species evenness (J) = $\frac{H}{H_{max.}}$

Species dominance (D)=$1/\Sigma pi^2$

## Results and Discussion

### Distribution of chrysomelids associated with rice under natural farming

A total of eight species of insects belonging to family Chrysomelidae of order Coleoptera were recorded and identified from five localities namely, Holta, Batolu, Chatter, Majharnu and Masoli (Table 1)

**Table 1. Distribution of chrysomelids recorded in rice ecosystem under mid hill conditions of Himachal Pradesh**

| Sr. No. | Species | Locations surveyed | | | | |
|---|---|---|---|---|---|---|
| | | Palampur | | Jogindernagar | | |
| | | Holta | Batolu | Chatter | Majharnu | Masoli |
| 1 | *Dicladispa armigera* | + | - | + | - | + |
| 2 | *Rhadinosa* sp. | + | - | - | - | + |
| 3 | *Monolepta signata* | + | + | + | - | + |
| 4 | *Chaetocnema gracilis* | + | + | + | - | + |
| 5 | *Chaetocnema nigrica* | + | + | + | - | + |
| 6 | *Chaetocnema cognate* | + | - | - | - | - |
| 7 | *Monolepta* sp. | + | - | - | - | - |
| 8 | *Medythia suturalis* | + | - | - | - | - |

+ Indicates presence -Indicates absence

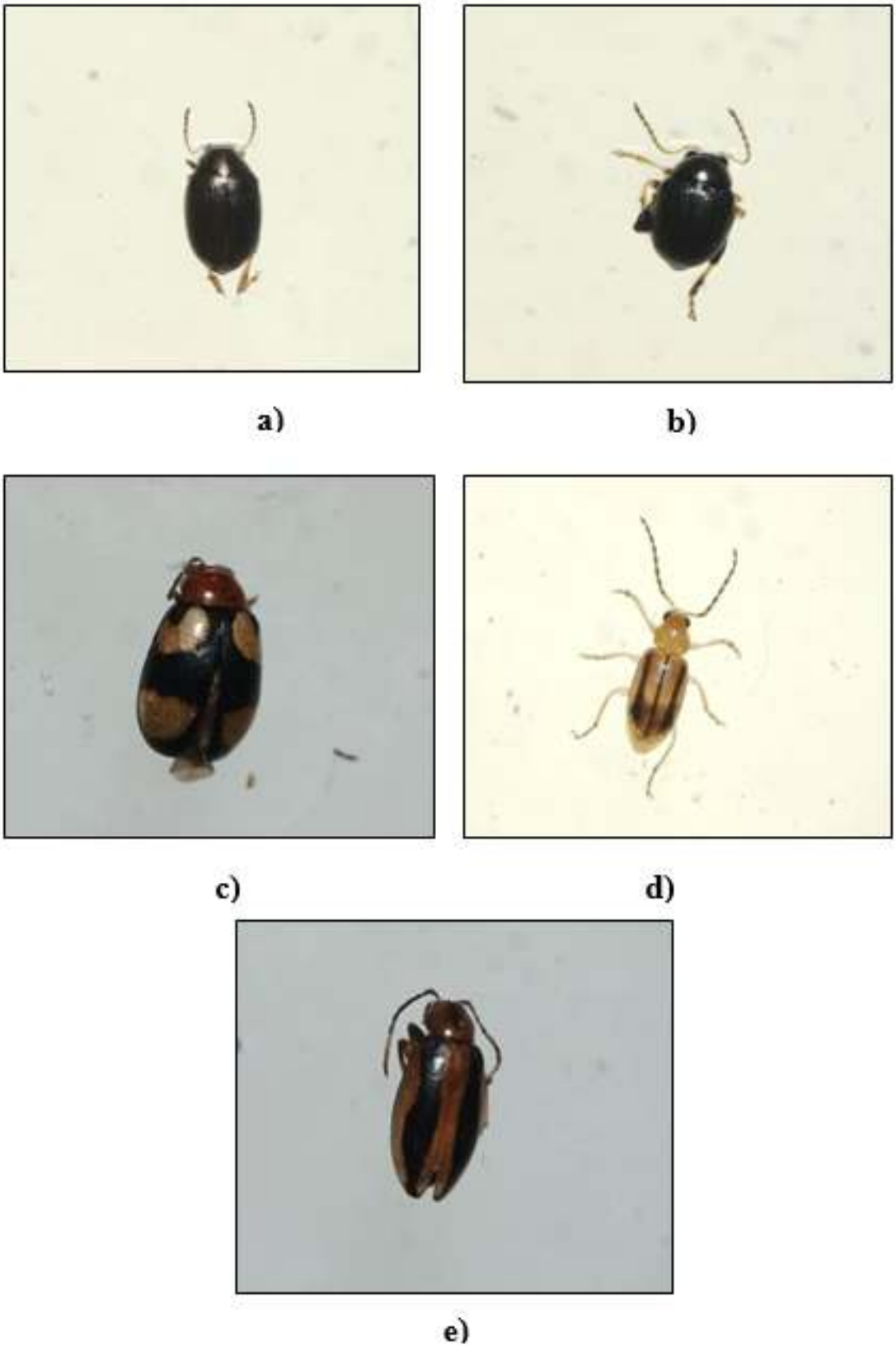


**Plate 1. Chrysomelid fauna a) *Chaetocnema gracilis* b) *Chatocnema nigrica* c) *Monolepta signata* d) *Monolepta* sp. e) *Medythia suturalis***

under natural farming conditions. All the species were recorded throughout the crop growth period at Holta, however no chrysomelid was observed at Majharnu. *Dicladispa armigera* was observed at Holta, Chatter and Masoli, whereas *Rhadinosa* sp. was present only at Holta and Masoli. *Monolepta signata*, *Chaetocnema gracilis* and *C. nigrica* were present at all the localities except Majharnu. However, *C. cognate, Monolepta* sp. and Medythia suturalis were observed only at Holta.

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**Palampur**

*Chaetocnema gracilis* and *C. nigrica* were dominant among the eight chrysomelids recorded from rice ecosystem, with relative proportion of 42.53 and 31.39 during 2022 and 42.12 and 30.16 per cent during 2023, respectively which started appearing from 2nd fortnight of June during both the years (Table 2 and 3). The activity of chrysomelids was observed from 2nd fortnight of June to 1st fortnight of October with peak population density of 90 adults during 2022 and 78 adults / 15 sweeps during 2023 in the 2nd fortnight of July.

Data pertaining to diversity indices during 2022 and 2023 at Palampur revealed that value of Shannon (H) and Simpson index (D) was recorded maximum during 1st fortnight of August (1.77 and 4.85), during 2022 and 1.74 and 4.94, during 2023 which indicates maximum diversity and dominance of insect-pests, respectively. The chrysomelid species were more evenly distributed during 2nd fortnight of July in 2022 and 2nd fortnight of September in 2023.

**Jogindernagar**

The perusal of data presented in Table 4 and Table 5 revealed the presence of five chrysomelid species encountered from three localities of Jogindernagar. The adult population of chrysomelids commenced during 2nd fortnight of August with peak density level of 35 adults/ 15 sweeps during 2022 (Table 4). Similarly, in 2023 the activity of chrysomelids was observed from August to October with maximum population of 40 adults/ 15 sweeps during 2nd fortnight of July, which declined towards maturity (Table 5). Relative proportion of adult catch was recorded higher for *C. gracilis* with the values of 39.29 and 41.04 per cent followed by *C. nigrica* with 27.38 and 30.60 per cent relative proportion during 2022 and 2023,

**Table 2. Diversity and abundance of chrysomelids in rice ecosystem at Palampur during 2022 under natural farming**

| S. No. | Species | Adults caught per 15 sweeps | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | June I | June II | July I | July II | Aug I | Aug II | Sept I | Sept II | Oct I | Oct II | Total | Relative proportion (%) |
| 1 | *Dicladispa armigera* | 0.00 | 0.00 | 2.00 | 0.00 | 3.00 | 5.00 | 6.00 | 3.00 | 3.0 | 0.0 | 22.0 | 5.57 |
| 2 | *Rhadinosa* sp. | 0.00 | 0.00 | 6.00 | 0.00 | 3.00 | 6.00 | 0.00 | 3.00 | 0 | 0 | 18.0 | 4.56 |
| 3 | *Monolepta signata* | 0.00 | 3.00 | 0.00 | 0.00 | 12.0 | 9.00 | 9.00 | 0.00 | 0 | 0 | 33.0 | 8.35 |
| 4 | *Chaetocnema gracilis* | 0.00 | 39.0 | 18.0 | 48.0 | 21.0 | 15.0 | 18.0 | 9.00 | 0 | 0 | 168.0 | 42.53 |
| 5 | *Chaetocnema nigrica* | 0.00 | 22.0 | 12.0 | 42.0 | 18.0 | 15.0 | 12.0 | 3.00 | 0 | 0 | 124.0 | 31.39 |
| 6 | *Chaetocnema cognate* | 0.00 | 0.00 | 0.00 | 0.0 | 6.00 | 0.00 | 3.00 | 3.00 | 0 | 0 | 12.0 | 3.04 |
| 7 | *Monolepta* sp. | 0.00 | 0.00 | 6.00 | 0.0 | 3.00 | 0.00 | 0.00 | 3.00 | 0 | 0 | 12.0 | 3.04 |
| 8 | *Medythia suturalis* | 0.00 | 3.00 | 0.00 | 0.0 | 3.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 6.0 | 1.52 |
| | **Total** | **0.00** | **67.0** | **44.0** | **90.0** | **69.0** | **50.0** | **48.0** | **24.0** | **3.0** | **0.0** | **395** | **100.00** |
| | Shannon index (H) | 0.00 | 0.00 | 1.40 | 0.69 | 1.77 | 1.52 | 1.46 | 1.67 | 0.0 | 0.0 | | |
| | Evenness (J) | 0.00 | 0.00 | 0.87 | 1.00 | 0.85 | 0.94 | 0.91 | 0.93 | 0.0 | 0.0 | | |
| | Dominance (D) | 0.00 | 2.22 | 3.56 | 1.99 | 4.85 | 4.22 | 3.88 | 4.57 | 1.0 | 0.0 | | |

I: First fortnight II: Second fortnight

**Table 3. Diversity and abundance of chrysomelids in rice ecosystem at Palampur during 2023 under natural farming**

| S. No. | Species | Adults caught per 15 sweeps | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jun I | Jun II | Jul I | Jul II | Aug I | Aug II | Sep I | Sep II | Oct I | Oct II | Total | Relative proportion (%) |
| 1 | *Dicladispa armigera* | 0 | 0 | 0 | 0 | 9 | 0 | 3 | 9 | 0 | 0 | 21 | 5.71 |
| 2 | *Rhadinosa* sp. | 0 | 0 | 0 | 0 | 6 | 3 | 0 | 0 | 3 | 0 | 12 | 3.26 |
| 3 | *Monolepta signata* | 0 | 0 | 0 | 6 | 9 | 24 | 6 | 0 | 0 | 0 | 45 | 12.23 |
| 4 | *Chaetocnema gracilis* | 0 | 41 | 18 | 42 | 21 | 15 | 12 | 6 | 0 | 0 | 155 | 42.12 |
| 5 | *Chaetocnema nigrica* | 0 | 36 | 12 | 24 | 15 | 12 | 6 | 3 | 3 | 0 | 111 | 30.16 |
| 6 | *Chaetocnema cognate* | 0 | 0 | 0 | 0 | 3 | 0 | 3 | 3 | 0 | 0 | 9 | 2.45 |
| 7 | *Monolepta* sp. | 0 | 0 | 3 | 0 | 3 | 0 | 0 | 3 | 0 | 0 | 9 | 2.45 |
| 8 | *Medythia suturalis* | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 1.63 |
| **Total** | | **0** | **77** | **33** | **78** | **66** | **54** | **30** | **24** | **6** | **0** | **368** | **100.00** |
| | Shannon index (H) | 0 | 0 | 0.9 | 1.1 | 1.7 | 1.2 | 1.5 | 1.5 | 0 | 0 | | |
| | Evenness (J) | 0 | 0 | 0.8 | 0.8 | 0.9 | 0.9 | 0.9 | 0.9 | 0 | 0 | | |
| | Dominance (D) | 0 | 2 | 2.9 | 2.5 | 4.9 | 3.1 | 3.9 | 4.0 | 2 | 0 | | |

I: First fortnight II: Second fortnight

**Table 4. Diversity and abundance of chrysomelids in rice ecosystem at Jogindernagar during 2022 under natural farming**

| Sr. No. | Species | Adults caught per 15 sweeps* | | | | | |
|---|---|---|---|---|---|---|---|
| | | Aug II | Sept I | Sept II | Oct I | Total | Relative proportion (%) |
| 1 | *Dicladispa armigera* | 3.00 | 3.00 | 2.00 | 2.00 | 10.00 | 11.90 |
| 2 | *Rhadinosa* sp. | 2.00 | 0.00 | 1.00 | 0.00 | 3.00 | 3.57 |
| 3 | *Monolepta signata* | 7.00 | 8.00 | 0.00 | 0.00 | 15.00 | 17.86 |
| 4 | *Chaetocnema gracilis* | 12.00 | 14.00 | 7.00 | 0.00 | 33.00 | 39.29 |
| 5 | *Chaetocnema nigrica* | 11.00 | 9.00 | 3.00 | 0.00 | 23.00 | 27.38 |
| 6 | *Chaetocnema cognate* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7 | *Monolepta* sp. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8 | *Medythia suturalis* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | **Total** | **35.00** | **34.00** | **13.00** | **2.00** | **84** | **100.00** |
| | Shannon index (H) | 0.00 | 1.27 | 1.16 | 0.00 | | |
| | Evenness (J) | 0.00 | 0.92 | 0.83 | 0.00 | | |
| | Dominance (D) | 3.75 | 3.30 | 2.68 | 1.00 | | |

I: First fortnight II: Second fortnight *Observations are mean of four localities

**Table 5. Diversity and abundance of chrysomelids in rice ecosystem at Jogindernagar during 2023 under natural farming**

| Sr. No. | Species | Adults caught per 15 sweeps* | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | July II | Aug I | Aug II | Sept I | Sept II | Oct I | Total | Relative proportion (%) |
| 1 | *Dicladispa armigera* | 1.00 | 2.00 | 0.00 | 1.00 | 3.00 | 0.00 | 7.00 | 5.22 |
| 2 | *Rhadinosa* sp. | 0.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 2.00 | 1.49 |
| 3 | *Monolepta signata* | 3.00 | 6.00 | 17.00 | 3.00 | 0.00 | 0.00 | 29.00 | 21.64 |
| 4 | *Chaetocnema gracilis* | 21.00 | 14.00 | 10.00 | 7.00 | 3.00 | 0.00 | 55.00 | 41.04 |
| 5 | *Chaetocnema nigrica* | 15.00 | 11.00 | 8.00 | 4.00 | 2.00 | 1.00 | 41.00 | 30.60 |
| 6 | *Chaetocnema cognate* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7 | *Monolepta* sp. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8 | *Medythia suturalis* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | **Total** | **40.00** | **34.00** | **36.00** | **15.00** | **8.00** | **1.00** | **134** | **100.00** |
| | Shannon index (H) | 0.00 | 1.31 | 1.14 | 1.21 | 1.08 | 0.00 | | |
| | Evenness (J) | 0.00 | 0.81 | 0.83 | 0.87 | 0.99 | 0.00 | | |
| | Dominance (D) | 2.37 | 3.23 | 2.85 | 3.00 | 2.91 | 1.00 | | |

I: First fortnight II: Second fortnight *Observations are mean of four localities

respectively.

The data on diversity of chrysomelids associated with rice under natural farming at Jogindernagar during 2022 revealed the maximum value of Shannon index (H) at 1st fortnight of September (1.27), whereas during 2023 diversity was highest during 1st fortnight of August (1.31) (Table 4 and 5). Dominance of chrysomelids was highest at 2nd fortnight of August (3.75) in 2022 and at 1st fortnight of August (3.23) in 2023. However, species were more evenly distributed during the month of September.

The present findings on population buildup of rice hispa are strongly supported by the findings of Choudhary *et al*. (2001) from Himachal Pradesh who reported maximum population of hispa in the month of August. The current observations are in proximity with those of Bhattacharjee and Ray (2010) and Chakraborty and Deb (2012), who reported the higher abundance of hispa in Assam and West Bengal in September. Incidence of *M. signata* in the present findings corroborates to the earlier findings of Kumar *et al*. (2018) from Nepal, who reported that population initiated during July and reached to its maximum during the month of August.

**Correlation between incidence of chrysomelid adults and various abiotic factors during 2022-23**

Chysomelid insect-pests associated with rice were correlated with various weather parameters prevailing at Palampur during 2022 and 2023 and have been presented in Table 6. The data revealed that the pest

**Table 6. Correlation between incidence of chrysomelid adults and various abiotic factors during 2022-23**

| Weather parameters | Year | Correlation coefficient (r) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | *Dicladispa armigera* | *Rhadinosa* sp. | *Monolepta signata* | *Chaetocnema gracilis* | *Chaetocnema nigrica* | *Chaetocnema cognate* | *Monolepta* sp. | *Medythia suturalis* |
| Max. Temperature (ºC) | 2022 | -0.30 | -0.06 | -0.10 | -0.08 | -0.06 | -0.16 | -0.01 | -0.01 |
| | 2023 | 0.27 | -0.11 | 0.44 | 0.11 | 0.08 | 0.47 | -0.05 | -0.12 |
| Min. Temperature (ºC) | 2022 | 0.04 | 0.33 | 0.27 | 0.50 | 0.52 | 0.12 | 0.25 | 0.19 |
| | 2023 | 0.32 | 0.09 | 0.55 | 0.47 | 0.40 | 0.44 | 0.21 | 0.11 |
| Rainfall (mm) | 2022 | 0.30 | 0.60 | 0.66* | 0.56 | 0.63 | 0.48 | 0.44 | 0.45 |
| | 2023 | 0.02 | 0.21 | -0.01 | 0.67* | 0.54 | -0.10 | 0.30 | 0.67* |
| Relative Humidity (%) | 2022 | 0.57 | 0.47 | 0.42 | 0.50 | 0.54 | 0.38 | 0.36 | 0.09 |
| | 2023 | -0.04 | 0.37 | 0.09 | 0.72* | 0.68* | -0.15 | 0.27 | 0.47 |

*Significant at P=0.05

population was non-significant and negatively correlated with maximum temperature for all the pests during 2022. However, *D. armigera*, *M. signata, C gracilis, C. nigrica* and *C. cognate* showed positive correlation with the maximum temperature with r value of 0.27, 0.44, 0.11, 0.08 and 0.47, respectively during 2023. Minimum temperature had positive and non-significant effect on population buildup of all pest species during both the cropping years (Table 6). Furthermore, rainfall positively influenced the pest's appearance and structure, registering significant r values of 0.66 for *M. signata* during 2022 and 0.67 for *C. gracilis* during 2023. Average relative humidity mostly appeared favourable for the growth and multiplication of most of the species during both the years, with *C. gracilis* and *C. nigrica* displaying a positive and significant correlation for adult populations during 2023, with r values of 0.72 and 0.68, respectively. However, *D. armigera* (r= -0.04) and *C. cognate* (r= -0.15) were negatively correlated with relative humidity during 2023. Present studies drew support from the findings of Adhikari *et al.* (2021) who have also reported positive and non-significant correlation of *D. armigera* population with minimum temperature and rainfall. A negative and non-significant correlation of *M. signata* with maximum temperature was also reported by Kumar *et al.* (2018).

## Conclusion

The current study provided the valuable insights into the diversity and abundance of chrysomelid beetles associated with rice under natural farming in mid hill conditions of H.P. Diversity and abundance was found highest in Palampur, with eight chrysomelid species present during the crop growth period. Notably, *C. gracilis, C. nigrica* and *C. cognate* were reported for the first time from Himachal Pradesh. However, at Jogindernagar, comparatively lower diversity was recorded with only five species encountered in different localities. Among them, *C. gracilis* and *C. nigrica* were found to be widespread in Holta, Batolu, Chatter and Masoli. The seasonal abundance analysis revealed distinct patterns in the population dynamics, recording the highest diversity and dominance of insect pests in the month of July and August suggesting a critical period for pest management interventions.

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