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SEASONAL ABUNDANCE AND DAMAGE CAUSED BY HEMIPTERAN PESTS TO WALNUT TREES OF CENTRAL KASHMIR

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ABSTRACT

Abundance and type of damage caused by different hemipteran insect pests were assessed in walnut orchards of Central Kashmir viz., district Srinagar, Budgam and Ganderbal during June 2014- November 2015. In this study five sap sucking hemipteran pests were collected and identified. The pests included Chromaphis juglandicola, Panaphis juglandis, Apodiphus pilipes, Megacoelum stramineum and Paracopium cingalensis. C. juglandicola had largest average value of 225.23 ±141.63 in Srinagar with significant difference between three districts followed by P. cingalensis (93.00 ±20.37) in district Srinagar and lowest was of A. pilipes with average abundance of 8.33±13.70 in district Srinagar. However, aphid population was more than bug population being highest in mid-June and existed up to early October. Sampled pests were quantified from the abaxial and adaxial surfaces of foliage. Seasonal change in abundance was exhibited by each species, maximum during summer and late spring. Nevertheless, it was also found dry season had more number of individuals than wet season. Damage caused by insect pests deteriorates nut quality and productivity. These sap feeders, mostly aphids cause plant dryness, stunted growth of seedlings in nurseries, nut drop, withering of kernels and mostly depositing acidic honey dew on leaves. Bug infested leaves showed the presence of bumps, chlorotic patches and development of galls.

Keywords: Abundance, Aphids, Bugs, Central Kashmir, Walnut

I INTRODUCTION

Kashmir bound with snow covered peaks, glaciers, gushing rivers, streams and captivating wet lands offer propitious breeding grounds for diverse species and is important place for agricultural and horticultural practices. Its rich biodiversity enables people to depend on it conventionally but agricultural fruit crops are highly susceptible to pest damage causing substantial economic losses every year. Walnut industry is one of the potent industries of Kashmir and is the highest yield producing state in India. District Kupwara is leading in walnut production followed by Shopian. It is an important dry fruit with long shelf life and resilience potential. The constituents of walnuts have unique health benefits and are included in FAO list of priority plants [1]. It is mostly used to cure atherosclerosis [2], helminthic infections, microbial infections, stomach aches, Keratolytic effects [3] and mostly to cure gastric, liver and lung cancer [4].Walnut bewitched by diversity of pests which cause depletion of its productivity and irrespective

of its enormous economic value, huge losses occur every year. Walnut trees are attacked by many pests, among which aphids and bugs are most important. Walnut aphids are small, soft bodied insects with piercing and sucking mouth parts resulting in mechanical damage to the host plants. They have direct influence on walnut production as these aphids cause accumulation of honeydew on the leaves and walnut husk which has phyto-toxic effect leading to general blackening of surface with subsequent development of sooty mould fungus. This blackened surface of hull has potential to absorb more heat which causes sunburn to nuts [5]. Aphids consuming excess sugars from leaves excrete it in the form of honey dew. Plant sap has high concentration of glutamic acid and asparagines on which aphids feed and consume large amount of amino acids which eventually are converted into essential amino acids used for their metabolic activities [6]. Photosynthetic capacity of the tree is reduced with the decrease in the amount of fluid present in the leaf resulting in the yellowing, spotting and premature death of trees due to variation in nutrient amount [7, 8]. Bugs act as the source for transmitting number of viral, bacterial and fungal diseases [9]. Walnut bugs are exclusive herbivore category damaging leaves, sprouting buds and fruit, resulting in the formation of galls and bumps on leaves [10]. The deterioration caused by sap suckers is liable on intensity of the hemipteran pest and is often supplemented by significant economic damage [11].

This study aims to survey the hemipteran pests, their seasonal abundance and type of damage caused by them during the active season. Before development of any management practice it is prudent to know about their bionomics and distribution pattern so as to develop most appropriate management practice against them.

II MATERIALS AND METHODS

2.1 Surveys/ Study area

Surveys to determine the seasonal abundance and damage caused by hemipteran pests to walnut orchards of Central Kashmir were conducted during June 2014- November 2015 in three districts - Srinagar (34° 04'54.36' N, 74° 48' 33 .00 E), Budgam (34° 01' 2 .05 N, 74° 43' 6 .71' E) and Ganderbal (34° 13' 39.11' N, 74° 46' 19.78' E). Survey areas of district Srinagar included Botanical garden (KU), Batpora and Khimber. DC office Budgam, Pallar and Budina were surveyed in district Budgam while as survey areas of district Ganderbal included Goripora (Kangan), Nunar and Nagbal. Sites were named as S1, S2 & S3 in district Srinagar, G1, G2 & G3 in district Ganderbal and B1, B2 & B3 in district Budgam.

2.2 Seasonal Abundance and type of damage

The sites for the study of seasonal abundance and nature of damage caused by pests were fortnightly visited and surveys were carried out for one and a half year from June 2014-November 2015. The variation of insect population size in four different seasons has been shown graphically through bar diagram along with standard deviation. Observations have been made in different seasons to check the presence and activity of each pest feeding on walnut canopy. The nature of damage was assessed by tagging the infested leaves. To sample aphids in the walnut trees, we randomly took 5 trees and from each tree 20 sub terminal leaves were selected from each direction mostly from lower and middle canopy. The abundance of aphids was calculated by direct count method from 100 leaflets/

orchard [12, 13]. To sample bugs sweeping with insect collecting net was done by sweeping 10 times each tree with a gap of 10 minutes [14]. Maintenance of records was done to know seasonal abundance. Some specimens were sampled directly by hand picking method.

2.3 Identification of collected samples

Collected species were identified on the basis of external morphology with the help of available literature and by running keys. However, specimens were further send to Zoological Survey of India (ZSI), Kolkata for confirmation.

2.4 Photography

Canon EOS600 D with 300 mm wide angle lenses was used for photography during the entire study.

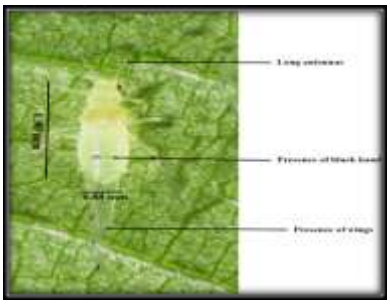
2.5 Statistical analysis

Pest species were analyzed in different districts of Central Kashmir to find significant difference by using one way ANOVA at 0.05% level of significance (Tukey's Honest Square Difference test; $p \leq 0.05$). All statistical analysis was performed using SPSS Statistical software (Version 20) and MS excel 2007.

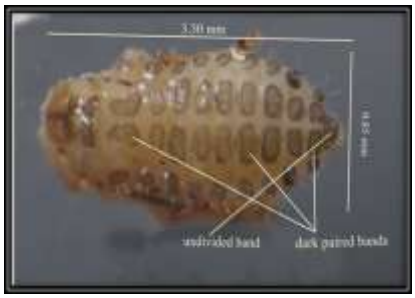
III RESULTS AND DISCUSSIONS

3.1 Type of Damage caused by Sap suckers

Fig. 1 presents various hemipteran pests that were found during the survey at various sites of Central Kashmir while different damaging stages of insect pests and activity period is illustrated in Table 1.



(a)



(b)

(c)

(d)

(e)

Fig. 1: (a) ***Chromaphis juglandicola,*** **(b)** ***Panaphis juglandis*** **(c)** ***Megacoelum stramineum*** **(d)** ***Paracopium cingalensis*** **(e)** ***Apodiphus pilipes***

3.1.1 Chromaphis juglandicola

C. juglandicola, commonly called as walnut aphid is active from April–October being highly vigorous during mid-June. It is scattered on the lower surface of walnut foliage and feeds on it by inserting long stylets in to leaf cells. Its high infestation leads to reduced tree vigour, early leaf drop, reduced nut quality and size which results in the withering of kernels. Aphids show parthenogenesis to increase their number which results in great uptake of the nutrients from the tree. The stylets are placed deep inside epidermal cells of leaves to feed on sugar sap. One of the diminishing factors is the release of brownish- black excrement honey dew on the surface of leaves which in turn attracts black sooty mould fungus resulting in the development of black spots on leaves and nuts.

3.1.2 Panaphis juglandis

P. juglandis is commonly called as dusky-veined aphid. It is active from April to October. It is also phloem feeder and is found to feed near the mid rib of upper surface of leaves. It also develops parthenogenetically, leading to an increase in population densities and nutrient uptake. However, during the study period, it was found that both the pests never fed on the same leaf as acidic honey dew secreted by *C. juglandicola* acts as a limiting factor for the growth of *P. juglandis* and is regarded as a minor pest of walnut.

Both aphids never fed on the same tree during the study period which strongly supports the Gause's competition exclusive principle that no two species having same ecological niche can feed together. Aphids usually attack plant nursery and tendril shoots [15]. The present result is highly in congruity with [13] which accentuated that the number of aphids/ leaflet beyond 15 can diminish the yield. The present results are in line with the findings of [16] who emphasized on the essential contributing factors for reduced market value of nuts. Walnut aphids reduce nut yield and phyto- toxic effect on the surface of cells which is the most important reason for depletion of quality as it is amassed damage caused by honeydew, sooty mould and sunburn [16]. On analyzing the data of three districts of Central Kashmir it was found that sites which were located on road side had high infestation of aphids in comparison to other sites and is in line with the observations found by [17] who scrutinized high occurrence of aphids in urban areas in contrast to park trees and concluded that pollution, human intervention and urbanization are important factors for it.

3.1.3 Apodiphus pilipes

Stink bug is a sap sucking plant feeder with well-developed rostrum which is inserted in plant tissue. It mostly feeds on newly developed buds and leaves. Nymphs and adults were both seen feeding on walnut trees which resulted in appearance of sticky substance on the leaf they fed. It was further observed that its presence was restricted to few trees and few sites, thus is regarded as minor pest of walnut. Attacked trees were seen to have early nut drop and epicarp lesion in spring [18]. Nut drop usually occurs due to peroxidase activity [19].

3.1.4 Paracopium cingalensis

It is commonly called as lace bug and is mostly active from April to October. Its feeding pattern leads to the formation of bumps on leaves. They usually feed in groups, resulting in development of chlorotic patches and galls on the surface of leaves. The nymphs and adults cause mechanical injury to trees and high infestation of tingid bug leads to colour change in leaves that in turn cause premature leaf drop. After feeding on sap they release brownish-black excrement which is deposited on the abaxial surface of leaf. Tingid bugs have wide host range and damage crops of horticultural importance by developing galls and bump on leaves and are mostly liable for viral disease transmission [20].

3.1.5 Megacoelum stramineum

Capsid bugs are gluttonous sap feeders of walnut foliage that mostly feed on tendril shoots and newly developed leaflets. They are active from early spring to late autumn, developing round sunken spots on the leaves. Capsid bugs lay about 150-200 eggs similar to a conspic white collar. The nymphs and adults which develop from these eggs feed voraciously on plant sap [21].

Table 1: Different damaging stages of insect pests and activity period infesting walnuts in Central Kashmir

Name of insects collected	Scientific name	Order	Family	Part of plant collected from	Activity period	Feeding on	Damaging state
Walnut aphid	*Chromaphis juglandicola*	Hemiptera	Aphididae	Leaves	Apr-Oct	Sap	Nymph and Adult
Duskey veined aphid	*Panaphis juglandis*	Hemiptera	Aphididae	Leaves	Apr-Oct	Sap	Nymph and Adult
Capsid bug	*Megacoelum stramineum*	Hemiptera	Miridae	Leaves	Apr-Oct	Sap	Nymph and Adult
Stink bug	*Apodiphus pilipes*	Hemiptera	Pentatomidae	Leaves	May-Sep	Sap	Nymph and Adult
Lace bug	*Paracopium cingalensis*	Hemiptera	Tingidae	leaves	Apr-Oct	Sap	Nymph and Adult

3.2 Seasonal Abundance

3.2.1 Walnut green aphid, *Chromaphis juglandicola*

The monthly variation in population of *C. juglandicola* during the study period is presented in Fig.2. In Srinagar the overall average population abundance of *C. juglandicola* was 225.23±141.63 with maximum number of 486 individuals at site S2 in June 2015 while minimum number of 24 individuals at site S1 in April 2015. Budgam on the other hand recorded an average density of 169.00±129.09 with peak population of 494 individuals at site B1 in June 2014 with a dip of 21 individuals at the same site. Similarly, in district Ganderbal, the average density of *C. juglandicola* was 135.07±91.36 with maximum population of 341 individuals at Site G1 in June 2014 and minimum of 24 individuals at site G2 in April 2015. On the whole, mean abundance values of *C. juglandicola* were found

highest in Srinagar (225.23±141.63) followed by Budgam (169.00±128.09) & Ganderbal (135.07±91.36). Table 2 indicates the overall mean abundance which shows significant difference across three districts (one way ANOVA $F_{2,92}=4.222$; $p=0.018$) . The differences were statistically significant between Srinagar and Ganderbal however, it was insignificant between Ganderbal & Budgam and Srinagar & Budgam. Examination of the data for abundance of *C. juglandicola* showed a definite seasonal trend, being highest in summer and lowest in autumn. Its average value varied from lowest (56.17±30.22) at district Ganderbal with maximum of 102 individuals at site G1 in September 2015 (autumn) & minimum of 31 individuals at G1 in October 2014 in autumn to highest average value (315.67±101.37) at Srinagar with maximum of 486 individuals at Site S2 in June 2015 (summer) & minimum of 145 individuals at Site S2 in August 2015. Overall seasonal pattern showed highest number of individuals in summer followed by spring and decreasing number of pests in autumn and no pest presence in winter is shown in Fig.2.

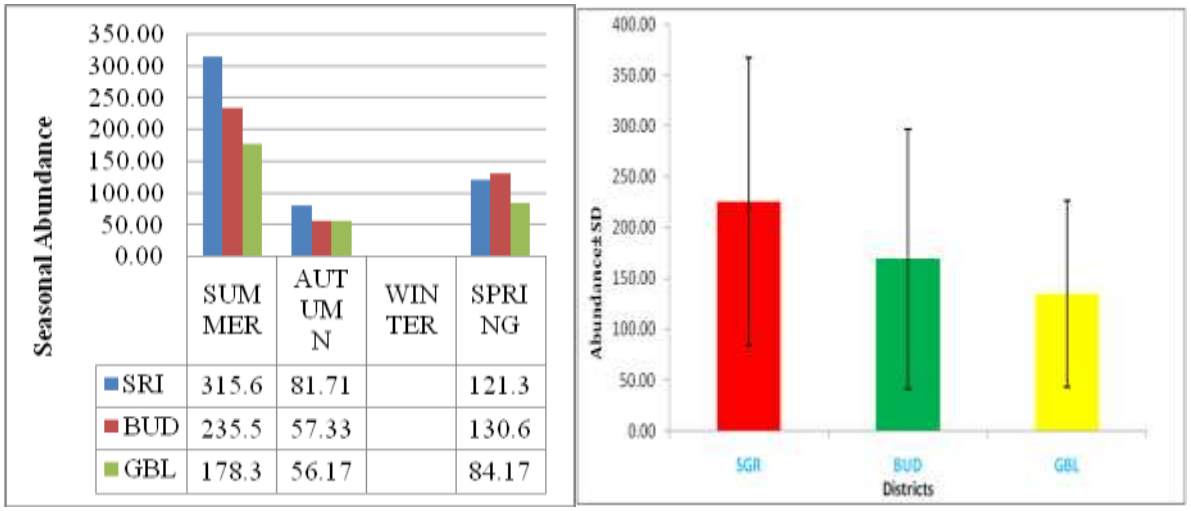


Fig. 2: Seasonal variation & Mean abundance (±S.D) of population of *C. juglandicola* in three districts of Central Kashmir

On comparing the summer season of 2014 and 2015 the density of *C. juglandicola* differed in between two summer seasons but both seasons showed highest number of individuals in month of June in summer and started declining afterwards by the end of year. The aphid density was high in June and declining pattern from the first week of August was observed [22, 23]. *C. juglandicola* occupied walnut trees from spring to autumn. After peak values, the aphid population started declining which can be inferred to population crash due to large number of colonies prevailing on same leaflet [24]. Among different sites, the population of *C. juglandicola* was found on higher side at sites B1, S2 and G2 in comparison to other sites. The high population density can be attributed to pollution, human habitations and urbanization as these sites are located on the roadsides, thus have high infestation of *C. juglandicola* [25].

3.2.2 Dusky–veined aphid, *Panaphis juglandis*

The monthly variation in population of *Panaphis juglandis* during the study period is presented in Fig. 3. The *P. juglandis* average population abundance of species in district Srinagar was 46.32± 38.86 with maximum number of 148 individuals at site S1 in June 2015 while minimum of 4 individuals at same site in April 2015. The average population of *P. juglandis* in district Budgam was 49.06±35.55 with highest number of 142 individuals at site B1 in June 2015 while lowest of 6 individuals at same site in October 2014. In district Ganderbal the average population abundance was 39.91±31.50 with maximum population of 119 individuals at G2 site in June 2015 and minimum of 5 individuals at G1 site in April 2015. The overall mean abundance of three districts depicted that Budgam had maximum population followed by Srinagar & least in Ganderbal. The difference between the districts with regard to this species were found statistically insignificant and is shown in Table 2 (One- way ANOVA, F2,95= 0.57; p=0.568).

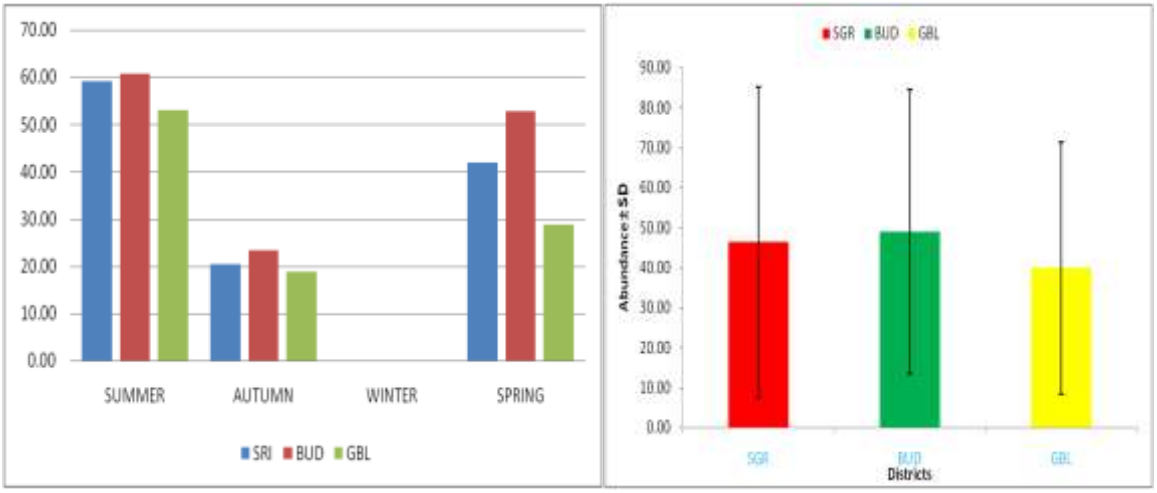


Fig. 3: Seasonal variation & Mean abundance (±S.D) of population of *P. juglandis* in three districts of Central Kashmir

The data revealed that mean abundance values of *P. juglandis* showed a marked seasonal variation between different districts with highest value during summer and lowest value in autumn. It fluctuated between the lowest average values of 18.75±12.46 at district Ganderbal with peak number of 41 individuals at site G2 in September 2015 and lowest of 5 individuals at G3 in October 2014 in autumn. The highest value of 60.72±33.91 was observed at district Budgam with maximum of 142 individuals at site B1 in June 2015 and minimum number of 21 individuals at same site in July 2015 in summer. No individuals were found in winter season albeit, the individuals were observed in spring season with highest number in summer and lowest in autumn (Fig. 3). Our results were strongly reinforced by the findings of [22] who observed highest injury level with maximum number of individuals in the month of June and high infestation level in summer. During the study period, the population of *P. juglandis* was recorded declining at the end of summer season which can be attributed to the high temperature which led to sharp decline in the

population, however, in month of August, population showed slight increase in number due to decrease in temperature that was recorded in the month of July [26]. The aphid population varied in each season with first peak seen in month of June which then declined in the month of July followed by increase in number in the month of August. It can be due to various environmental factors and high aphid densities which lead to population crash and drastic reduction in aphid densities after attaining peak value [27].

3.2.3 Capsid bug, *Megacoelum stramineum*

The monthly variations in population of *M. stramineum* during the study period are presented in Fig. 4. The average population abundance of *M. stramineum* in district Srinagar was 42.29±26.32 with maximum of 101 individuals at site S3 in July 2014 and minimum of 12 individuals at the same site in October 2014. In Budgam, average population density was 59.00±31.42 with peak population of 111 individuals at B1 in July 2014 and least of 9 individuals at site B1 in October 2015, however it was entirely absent in all the three sites of Ganderbal. On comparing overall mean abundance of two districts, it can be concluded that district Budgam had maximum population followed by district Srinagar.

The overall population of *M. stramineum* in different seasons increased in spring while reaching to its peak in summer followed by a continuous decline in rest of the seasons. On comparing the seasonal abundance data, the average value at district Budgam was 82.00±18.16 showing maximum value in summer in contrast to minimum average value of 20.00±7.38 at district Srinagar in autumn. Fig.4 shows no individual was observed during winter from any of the selected sites during one and half year study.

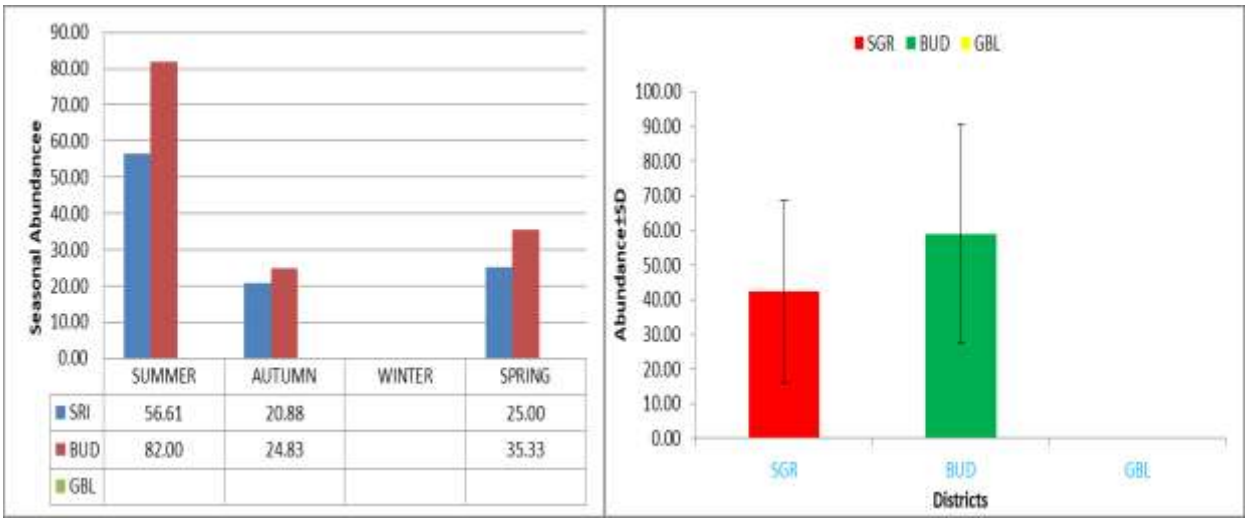


Fig. 4: Seasonal variation & Mean abundance (±S.D) of population of *M. stramineum* in three districts of Central Kashmir.

3.2.4 Lace bug, *Paracopium cingalensis*

The seasonal variation and mean abundance of *P. cingalensis* is depicted in Fig.5 and it is seen that average highest population of 66.36±34.92 is present in district Srinagar whereas lowest average density of 56.62±29.33 is found in district Budgam and 65.78±30.00 in district Ganderbal. Table 2 shows the results after evaluating the data of three districts and unveils the overall difference to be statistically insignificant **(**One- way ANOVA, $F_{1,51}$= 0.588;p=0.559). Fig. 5 demonstrates that the seasonal pattern showed high population during summer and low in autumn with average highest value of 93.00±20.37 and lowest of 23.11±6.33 at district Budgam.

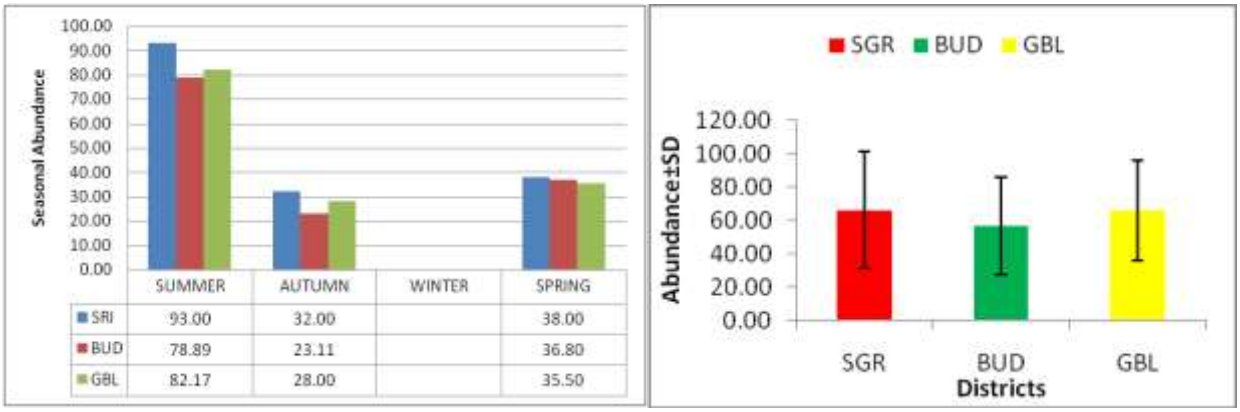


Fig. 5: Seasonal variation &Mean abundance (±S.D) of population of *Paracopium cingalensis* in three districts of Central Kashmir

3.2.5 Stink bug, *Apodiphus pilipes*

The monthly variation in population of *Apodiphus pilipes* during the study period is presented in Fig. 6. The overall average population abundance of *Apodiphus pilipes* in district Srinagar was 7.47±3.81 with maximum number of 16 individuals at site S3 in July 2015 and minimum of 2 individuals at the same site in the month of August in 2014. District Budgam recorded the average population density of 6.25±2.66 with peak value of 10 individuals in July 2014 and dip value of 3 individuals in May 2015, however it was entirely absent at district Ganderbal. On the whole, a mean abundance value was highest in district Srinagar (7.47±3.81) followed by Budgam (6.25±2.66) as presented in Table 2. On comparing the data of *A. pilipes* with other species, it showed striking seasonal variation, being more in summer followed by spring and then by autumn round the year. The average value was higher in summer 8.33±13.70 with maximum number of 16 individuals at site S3 in July 2015 and minimum number of 2 individuals at the same site in August 2014. During autumn, lowest of 2 individuals were found at site S3 in September 2015 in district Srinagar and highest of 4 individuals at site B3 in August 2014 in district Budgam.

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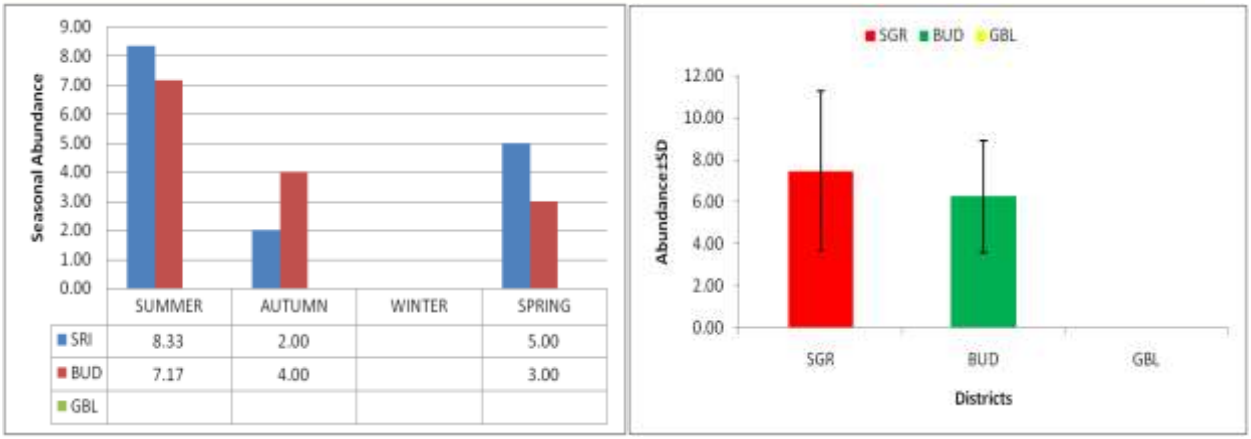

Fig. 6: Seasonal variation & Mean abundance (±S.D) of population of *A. pilipes* in three districts of Central Kashmir

During the survey it was seen that all the three bugs infested walnut trees out of which two bugs *viz., P. cingalensis* and *M. stramineum* had high abundance while *A. pilipes* had low abundance. The reason being *A. pilipes* is a major pest of apple trees and is regarded as a minor pest of walnut [28]. All the species showed high activity in spring attaining peak in summer with no activity in winter. For different developmental stages food plays a vital role and change in food quality or quantity undesirably affects the bug population [28]. Temperature as a key abiotic factor exhibited positive correlation with the development of bugs. High bug infestation was recorded in the months of June and July. The results were further ascertained by the findings of [29] who also observed heavy bug infestation in months of late June and July on cotton. Further, both *M. stramineum* and *P. cingalensis* shared the same ecological niche, feeding on the abaxial surface and acting as the limiting factor for each other in accordance with Gause's law and that is why population of *M. stramineum* was altogether absent in district Ganderbal where *P. cingalensis* had a peak population. Similarly *A. pilipes* was confined to only few sites of district Srinagar and Budgam while it was entirely absent in district Ganderbal. One of reason for absence of *A. pilipes* in district Ganderbal is due to no apple orchards present in close vicinity of walnut orchards whereas reverse was true for district Srinagar and Budgam.

Table 2: Mean of pest abundance in Srinagar, Budgam & Ganderbal districts, Jun 2014- Nov, 2015

Species	Srinagar	Budgam	Ganderbal
C. juglandicola	225.23±141.63^{b}	169.00±128.09^{ab}	135.07±91.36^{a}
P. juglandis	46.32±38.86^{a}	49.06±35.56^{a}	39.91±31.50^{a}
M. stramineum	42.29±26.33	59.00±31.42	-
P. cingalensis	66.36±34.95^{a}	56.63±29.34^{a}	65.78±30.00^{a}
A.pilipes	7.47±3.81	6.25±2.66	-

Significant $p<0.05$, Non-significant $p>0.05$; Mean values with different superscripts are significantly different ($p<0.05$, Tukeys HSD)

IV CONCLUSION

The present study reveals the presence of five hemipteran species in walnut orchards of various district of Central Kashmir. The aphids were seen feeding on walnut trees with the start of spring till late autumn and the population of these pests increased with increase in temperature. C. *juglandicola* and *P. cingalensis* were the major pests of concern while other two pests' *P. juglandis* and *A.pilipes* were found in lesser number and hence regarded to be minor pests. The observations divulge that the sap sucking aphids lead to reduced nut quality and quantity, as they feed on sap of foliage, tendril shoots with their piercing and sucking mouth parts. However after thickening of kernel and combined husk of mature nuts, feeding rate of these pests is reduced which is strengthened by the findings of [30]. The present study is an attempt to know about the seasonal pattern and damage caused by each hemipteran pest that enables to facilitate the proper management and spray decisions on proper time.

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