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Diversity and abundance of hoppers on different vegetable crops in North Kashmir

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Abstract
Hoppers are the insects belonging to order hemiptera. The present study on these insects was conducted during 2017-2018. Six locations (Wadura, Arampora, Dangiwacha, Imberzalwari from District Baramulla and Chogul and Chetkak from Kupwara) were selected to record the diversity of hoppers. Diversity indices such as Species diversity index, Species evenness index, Species richness index and Relative abundance were used to find diversity. A total of nine species of hoppers were recorded on about nine vegetable crops. These include *Empoasca decipiens, Amrasca biguttula, Empoasca fabae, Macrosteles quadrilineatus, Macrosteles sexnotatus, Gurawa minorcephala, Stirellus* spp., *Platymetopius fidelis* and *Ceresa* spp. There was found maximum abundance of *A. biguttula* on most of the vegetable crops except turnip where *M. quadrilineatus* was found abundantly and chilli and potato having the maximum abundance of *E. decepiens*. Species diversity index for crops: brinjal, potato, cucumber, turnip, pumpkin, chilli, knolkhol, was maximum at Dangiwacha. Species diversity index for chinese spinach, mint was maximum at Arampora.

Keywords: abundance, diversity, hoppers and vegetable crops

Introduction
Hoppers are diverse group of insects belonging to order hemiptera. Crops are attacked by different group of insect hoppers *viz.* leafhoppers, planthoppers, treehoppers and froghoppers. All these belong to suborder auchenorrhyncha. The leafhopper family cicadellidae cause considerable damage to crops by direct feeding the plant sap or by indirectly acting as vectors for plant pathogens [11]. These are small wedge shaped insects of various form, color and size and distinguished by having one or more rows of small spines extending the length of hind tibia. Planthoppers are large group of insects exceeding 12,000 species that feed on green plants. Planthoppers feed on plant sap and damage the plant tissue by ovipositing that lead to wilting of plant commonly known as “hopper burn”. Apart from feeding on the plant sap, they also transmit virus during their feeding behaviour which causes disease such as grassy stunt and ragged stunt in rice plant [16] and cause extensive damage to the crop [4]. Tree hoppers are small insects, having greenish to brown colour belonging to family membracidae. In these, insect body show expanded hood covering, which often resembles thorn (Enlarged and ornate pronotum), commonly known as thorn bugs. Membracids cause injury to the plants by making numerous small slits or crescent like punctures in bark where they lay eggs. The excessive sap sucking by these insects results in honey dew production, causing the growth of the sooty mould on leaves and twigs of the host plant. So far 235 species of tree hoppers are reported from India [18]. Froghoppers are the members of the suborder auchenorrhyncha and super family cercopidae. These insects are best known for their nymph stage which produces a cover of frothed up plant sap resembling saliva. Keeping in view the damage caused by these hoppers on different crops, the study was carried to see the diversity of these hoppers on different vegetable crops in the area of North Kashmir.

Material and Methods
The present investigation was carried by surveying different vegetable crops such as brinjal, potato, cucumber, turnip, chilli, pumpkin, chinese spinach, knolkhol and mint at different locations These locations include a) Faculty of Agriculture, Wadura, SKUAST-K which is located at latitude 34˚20' N, longitude 74˚23' E and an altitude of 1590 metres above mean sea level (m AMSL) b) Imberzalwari located at latitude 34˚24' N, longitude 74˚25' E and an

altitude of 2120 m AMSL. c) Dangiwacha located at latitude 34˚31'N, longitude 74˚34' E and an altitude of 1577 m AMSL. d) Arampora Sopore located at latitude 34˚16 'N, longitude 74˚ 37' E, and an altitude of 1605 m AMSL e) Chogal Kupwara located at latitude 34 ˚53'N, 74˚ 37' E and an altitude of 1594 m AMSL. f) Chetkak Kupwara located at latitude 34 ˚53'N, 74˚ 37' E and an altitude of 1592 m AMSL. Hoppers were collected from these areas by using different equipments such as: a) Sweep Net: A canvas sweep net with a fine mesh cloth end over a metal wire was used to sample the hoppers. The net was 38 cms in diameter, 75cms in length and the handle was about 1 m long. b) Light traps: Light traps were installed at all the above mentioned locations in different crops. Hoppers were collected from these areas at fortnightly intervals. c) Sticky traps: Yellow sticky traps were placed in the fields. (Fig 1). Traps were kept overnight and next morning hoppers were removed from traps by placing a drop of oil. Hoppers were removed carefully from the traps so as to prevent injury/damage to them. Samples collected were killed by using ethyl acetate and were removed immediately from killing bottle to prevent discoloration of samples. Samples were dried in oven at 40ºC for 10 minutes then preserved in the vials containing 76 per cent ethanol. Labelling of samples was accordingly done. These samples were sent to IARI New Delhi for identification.

Sweep net | Vials | Poison bottle | Light trap | Sticky trap

Fig 1: Equipments used for survey

Species diversity for each crop and location was worked out by adding up the total number of species found in each community. Different parameters were used to find diversity such as:

a) Relative Abundance: The relative abundance of all the hopper species for each crop and location was worked out by dividing the number of individuals of a species to the total number of individuals of all species for each community and expressed in percentage:

Relative Abundance = NI /N x 100

Where, NI = Number of Individuals of a single species and N = Total number of individuals of all species

b) Species diversity index: To study the proportion of each species within the local community, Species diversity index was computed by using Shannon-Wiener formula, also called the Shannon index or Shannon - Wiener index [17].

Species Diversity Index (H): $-\sum_{i=1}^{S} pi\ lnpi$

Where, H = Shannon-Wiener Biodiversity Index, pi = Relative abundance of each species.
ln pi = Natural log of pi. and S = Total number of species.

c) Species richness index: It was determined to assess how the diversity of the population is distributed or organized among the particular species. Species Richness Index (Ma) was calculated by using the formula [14]: Species Richness Index (Ma) = S-1 / 1n N Where, S = Total number of species collected, N = Total number of individuals in all the species.

d) Species evenness index: In order to understand the measure of how similar the abundance of different species is, Species Evenness Index (J) was calculated to estimate the equitability component of diversity [13].

Species Evenness Index (J) = H / 1n S

Where, H = Shannon-Wiener biodiversity Index and S = Total number of species in the community.

Results and Discussion

The data on Diversity and abundance of hoppers on different vegetable crops in North Kashmir revealed nine species of hoppers belonging to two families on different vegetabe crops (Table-1). These species include: *Empoasca decipiens, Amrasca biguttula, Empoasca fabae, Macrosteles quadrilineatus, Macrosteles sexnotatus, Gurawa minorcephala, Stirellus* spp., *Platymetopius fidelis,* and *Ceresa* spp. (Table 1, Fig 2).

Table 1: List of the hopper species collected

S. No.	Scientific Name	Family
1	*Empoasca decepiens*	Cicadellidae
2	*Amrasca biguttula*	Cicadellidae
3	*Empoasca fabae*	Cicadellidae
4	*Macrosteles quadrilineatus*	Cicadellidae
5	*Macrosteles sexnotatus*	Cicadellidae
6	*Gurawa minorcephala*	Cicadellidae
7	*Stirellus* spp.	Cicadellidae
8	*Platymetopius fidelis*	Cicadellidae
9	*Ceresa* spp.	Membracidae

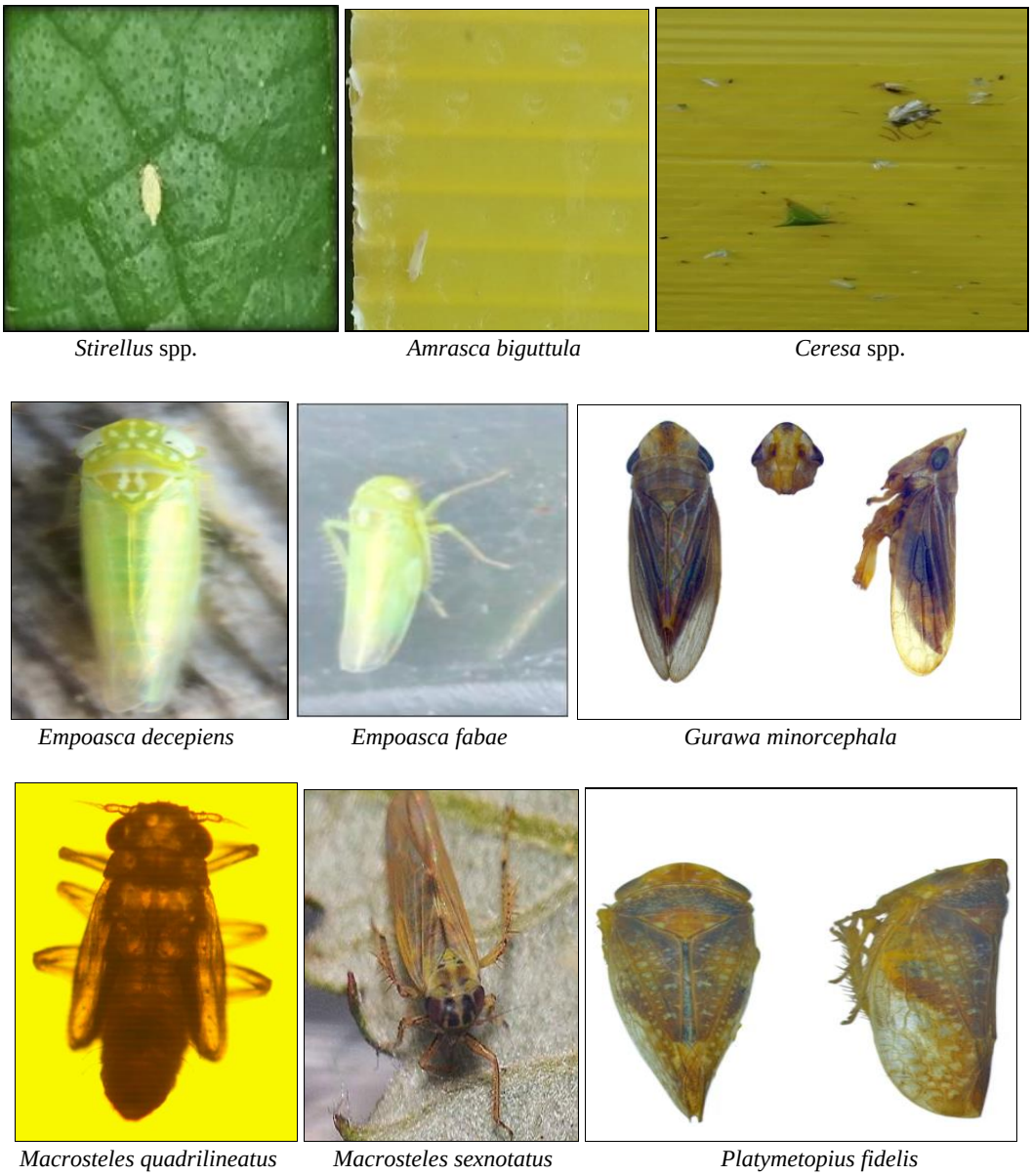


Fig 2: Hopper species observed during the study

The data on relative abundance of hoppers on vegetable crops in North Kashmir is presented in Table 2. Where in *A. biguttula* was found most abundant species at all locations with a mean relative abundance (MRA of 35.01%) followed by *E. decepiens* (MRA =31.40%), *E. fabae* (MRA =26.52%), *P. fidelis* (MRA =4.52%), *G. minorcephala* **(**MRA =1.22 %**),** however *Ceresa* spp. was found to be least abundant on brinjal (with MRA=1.21%). So far as potato is concerned, *E. decepiens* was the most abundant species (MRA =37.63%) followed by *A. biguttula* (MRA =25.77%) and *E. fabae* (MRA =25.63%). *M. quadrilineatus* was least abundant (MRA =10.94%). *A. biguttula* was most abundant species at all locations (MRA= 66.68%) followed by *Stirellus* spp. (MRA= 27.02%), *G. minorcephala* (MRA= 10.78%). *Ceresa* spp (MRA= 6.29%) was found to be least abundant on cucumber. Whereas, on turnip only two species of hoppers were recorded *viz.*, *M. quadrilineatus* (MRA= 79.34%) and *M. sexnotatus* (MRA= 30.98%). On chilli, *E. decepiens* was the most abundant species (MRA =54.70%) followed by *E. fabae* (MRA =35.45%) however, *M. quadrilineatus* was found to be least abundant with 9.84 per cent MRA. On other cucurbit crop, pumpkin *A. biguttula* (MRA =55.38%) was found abundantly and *Stirellus* spp. was least abundant with MRA=44.60 per cent. Chinese spinach was infested with *A. biguttula* and was found most abundant (MRA =52.86%) followed by *M. quadrilineatus* (MRA=24.68). *A. biguttula* was most abundant species at all locations (MRA= 66.73%) followed by *Stirellus* spp. (MRA= 33.26%) on the most popular crop knolkhol. Similarly, *A. biguttula* was most abundant species at all locations (MRA= 58.59%) followed by *Stirellus* spp. (MRA= 41.40%) on mint. (Table 2, Fig 3).

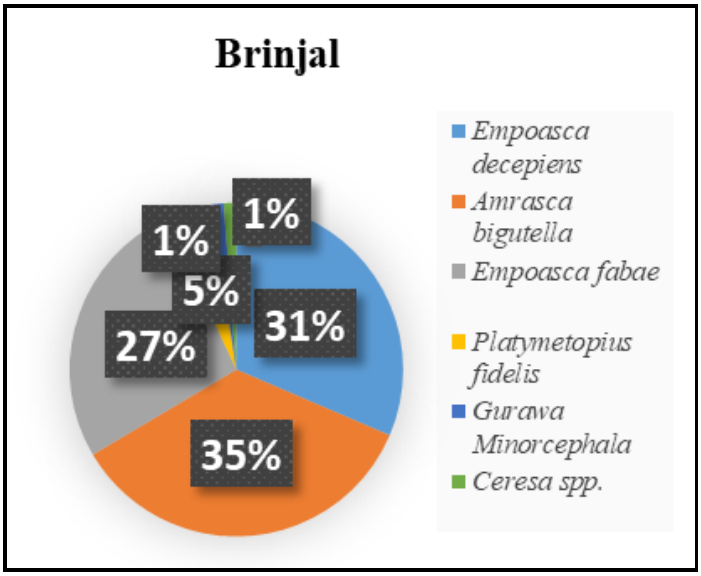
Table 2: Relative abundance (%) of hoppers on vegetable crops in North Kashmir

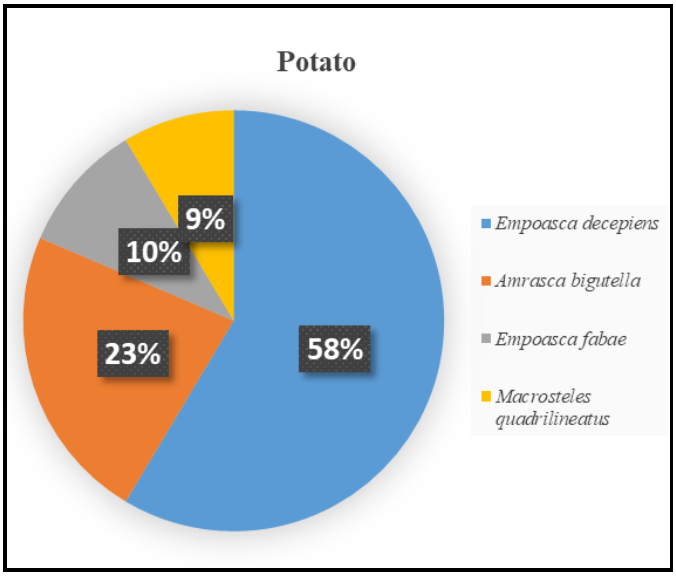
Crops	Location	*Empoasca decepiens*	*Amrasca biguttula*	*Empoasa fabae*	*Macrosteles quadrilineatus*	*Platymetopius fidelis*	*Macrostels sexnotatus*	*Gurawa minorcephala*	*Stirellus* spp.	*Ceresa* spp.	N	S
Brinjal	Wadura	30.6	34.09	26.13	0	5.68	0	2.27	0	1.13	88	6
	Imberzalwari	31.50	35.61	27.39	0	5.47	0	0	0	0	73	4
	Arampora	33.87	37.09	29.03	0	0	0	0	0	0	62	3
	Dangiwacha	31.06	33.98	24.27	0	5.82	0	2.91	0	1.94	103	6
	Chogul	30.10	34.40	25.80	0	5.37	0	2.15	0	2.15	93	5
	Chetkak	31.32	34.93	26.50	0	4.81	0	0	0	2.06	97	6
	Mean	31.40	35.01	26.52	0	4.52	0	1.22	0	1.21	86	5
	95%CI	30.03-32.78	33.77-36.25	24.84-28.19	-	2.17- 6.87	-	0.20-2.65	-	0.15-2.27	69.68-102.31	3.93-6.06
Potato	Wadura	33.73	24.09	30.12	12.04	0	0	0	0	0	83	4
	Imberzalwari	40	26.6	33.33	0	0	0	0	0	0	60	3
	Arampora	51.16	32.55	0	16.27	0	0	0	0	0	43	3
	Dangiwacha	32.96	24.17	29.67	13.18	0	0	0	0	0	91	4
	Chogul	33.33	24.13	29.88	12.64	0	0	0	0	0	87	4
	Chetkak	34.61	23.07	30.76	11.53	0	0	0	0	0	78	4
	Mean	37.63	25.77	25.63	10.94	0	0	0	0	0	73.67	3.66
	95%CI	30.16-45.10	22.07-29.46	12.37-38.87	5.05-16.83	-	-	-	-	-	54.25-93.08	3.12-4.20
Cucumber	Wadura	0	65.21	0	0	0	0	0	26.08	8.69	23	3
	Imberzalwari	0	71.42	0	0	0	0	0	28.57	0	14	2
	Arampora	0	72.72	0	0	0	0	0	27.27	0	11	2
	Dangiwacha	0	60	0	0	0	0	13.63	26.66	13.33	30	4
	Chogul	0	60.71	0	0	0	0	26.92	28.57	10.71	28	4
	Chetkak	0	70	0	0	0	0	24.13	25	5	20	4
	Mean	0	66.68	0	0	0	0	10.78	27.02	6.29	21.00	2.66
	95%CI	0	60.88-72.47	0	0	0	0	-2.45-24.01	25.54-28.50	0.43-12.14	13.09-28.90	2.13-4.19
Turnip	Wadura	0	0	0	71.42	0	28.57	0	0	0	14	2
	Imberzalwari	0	0	0	100	0	0	0	0	0	6	1
	Arampora	0	0	0	100	0	0	0	0	0	4	1
	Dangiwacha	0	0	0	63.15	0	36.84	0	0	0	19	2
	Chogul	0	0	0	68.75	0	31.25	0	0	0	16	2
	Chetkak	0	0	0	72.72	0	27.27	0	0	0	11	2
	Mean	0	0	0	79.34	0	30.98	0	0	0	11.66	1.66
	95%CI	0	0	0	62.19-96.48	0	3.51-37.79	0	0	0	5.55-17.77	1.12-2.20
Chilli	Wadura	50	0	33.33	16.66	0	0	0	0	0	30	3
	Imberzalwari	62.5	0	37.5	0	0	0	0	0	0	16	2
	Arampora	61.53	0	38.46	0	0	0	0	0	0	13	2
	Dangiwacha	50	0	34.37	15.62	0	0	0	0	0	32	3
	Chogul	50	0	35.71	14.28	0	0	0	0	0	28	3
	Chetkak	54.16	0	33.33	12.5	0	0	0	0	0	24	3

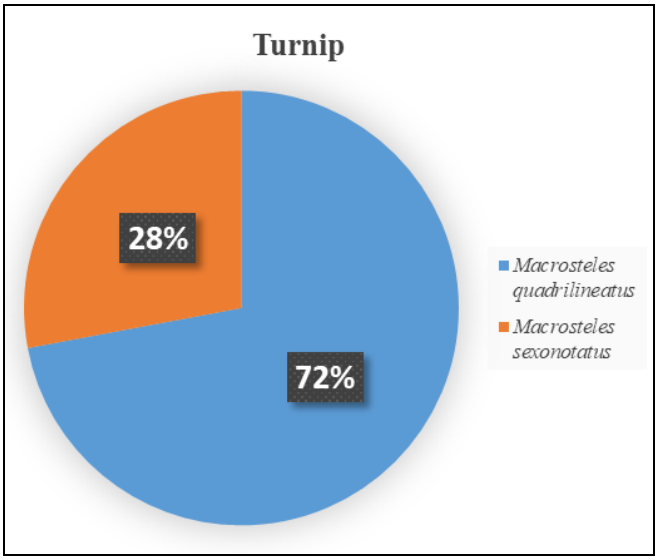
	Mean	54.70	0	35.45	9.84	0	0	0	0	0	23.83	2.66
	95%CI	48.50-60.89	0	33.17-37.72	1.70-17.97	0	0	0	0	0	15.69-31.97	2.12-3.20
Pumpkin	Wadura	0	55.55	0	0	0	0	0	44.44	0	18	2
	Imberzalwari	0	57.14	0	0	0	0	0	42.85	0	14	2
	Arampora	0	53.84	0	0	0	0	0	46.16	0	13	2
	Dangiwacha	0	54.54	0	0	0	0	0	45.45	0	22	2
	Chogul	0	55	0	0	0	0	0	45	0	20	2
	Chetkak	0	56.25	0	0	0	0	0	43.75	0	16	2
	Mean	0	55.38	0	0	0	0	0	44.60	0	17.17	2
	95%CI	-	54.13-56.63	-	-	-	-	-	40.64-46.00	0	13.50-20.82	….
Chinese spinach	Wadura	0	66.66	0	33.33	0	0	0	0	0	15	2
	Imberzalwari	0	66.66	0	33.33	0	0	0	0	0	12	2
	Arampora	0	53.84	0	46.15	0	0	0	0	0	13	2
	Dangiwacha	0	64.70	0	35.29	0	0	0	0	0	17	2
	Chogul	0	0	0	0	0	0	0	0	0	0	0
	Chetkak	0	0	0	0	0	0	0	0	0	0	0
	Mean	0	52.86	0	24.68	0	0	0	0	0	9.50	1.33
	95%CI	-	7.48-76.46	-	4.00-45.36	-	-	-	-	-	1.57-17.43	0.24-2.41
Knolkhol	Wadura	0	66.66	0	0	0	0	0	33.33	0	15	2
	Imberzalwari	0	66.66	0	0	0	0	0	33.33	0	12	2
	Arampora	0	70	0	0	0	0	0	30	0	10	2
	Dangiwacha	0	63.15	0	0	0	0	0	36.84	0	19	2
	Chogul	0	64.70	0	0	0	0	0	35.29	0	17	2
	Chetkak	0	69.23	0	0	0	0	0	30.76	0	13	2
	Mean	0	66.73	0	0	0	0	0	33.26	0	14.33	2
	95%CI	-	64.00-69.46	-	-	-	-	-	30.52-35.98	-	10.84-17.82	-
Mint	Wadura	0	57.14	0	0	0	0	0	42.85	0	35	2
	Imberzalwari	0	59.09	0	0	0	0	0	40.90	0	22	2
	Arampora	0	57.89	0	0	0	0	0	42.10	0	19	2
	Dangiwacha	0	56.41	0	0	0	0	0	43.58	0	39	2
	Chogul	0	56.75	0	0	0	0	0	43.24	0	37	2
	Chetkak	0	64.28	0	0	0	0	0	35.71	0	28	2
	Mean	0	58.59	0	0	0	0	0	41.40	0	30	2
	95%CI	-	55.50-61.68	-	-	-	-	-	38.30-44.48	-	21.29-38.70	-

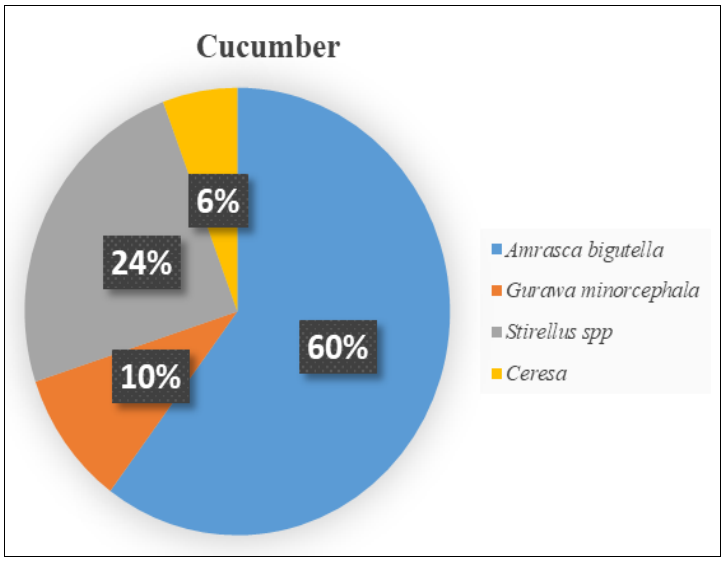
N: Total Number of individuals of identified species collected per five sweep nets

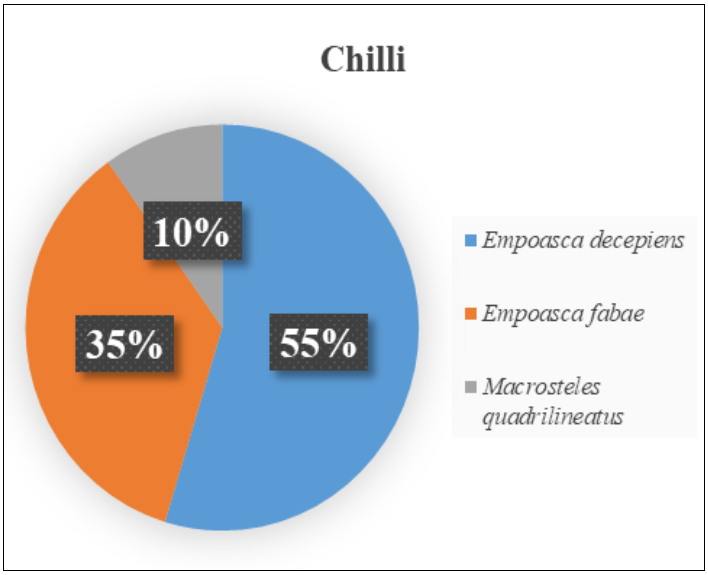
S: Total Number of identified species.

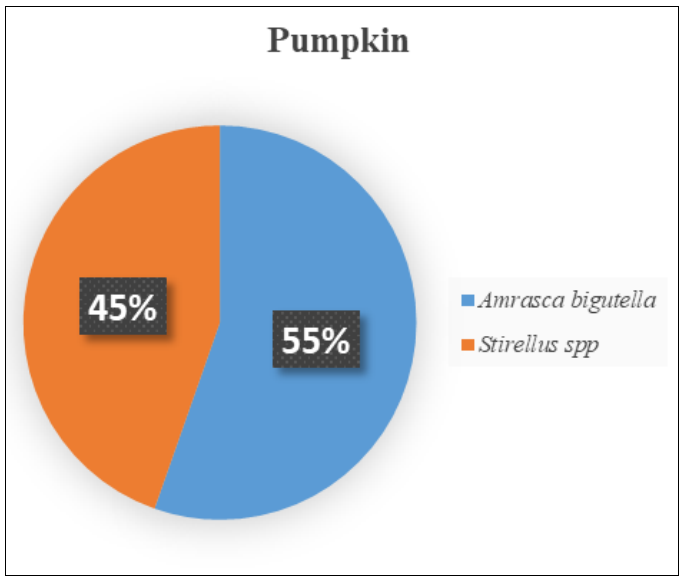

Brinjal
1%
1%
5%
27%
31%
35%
Empoasca decepiens
Amrasca bigutella
Empoasca fabae
Platymetopius fidelis
Gurawa Minorcephala
Ceresa spp.


Potato
9%
10%
23%
58%
Empoasca decepiens
Amrasca bigutella
Empoasca fabae
Macrosteles quadrilineatus


Turnip
28%
72%
Macrosteles quadrilineatus
Macrosteles sexonotatus


Cucumber
6%
24%
60%
10%
Amrasca bigutella
Gurawa minorcephala
Stirellus spp
Ceresa


Chilli
10%
35%
55%
Empoasca decepiens
Empoasca fabae
Macrosteles quadrilineatus


Pumpkin
45%
55%
Amrasca bigutella
Stirellus spp

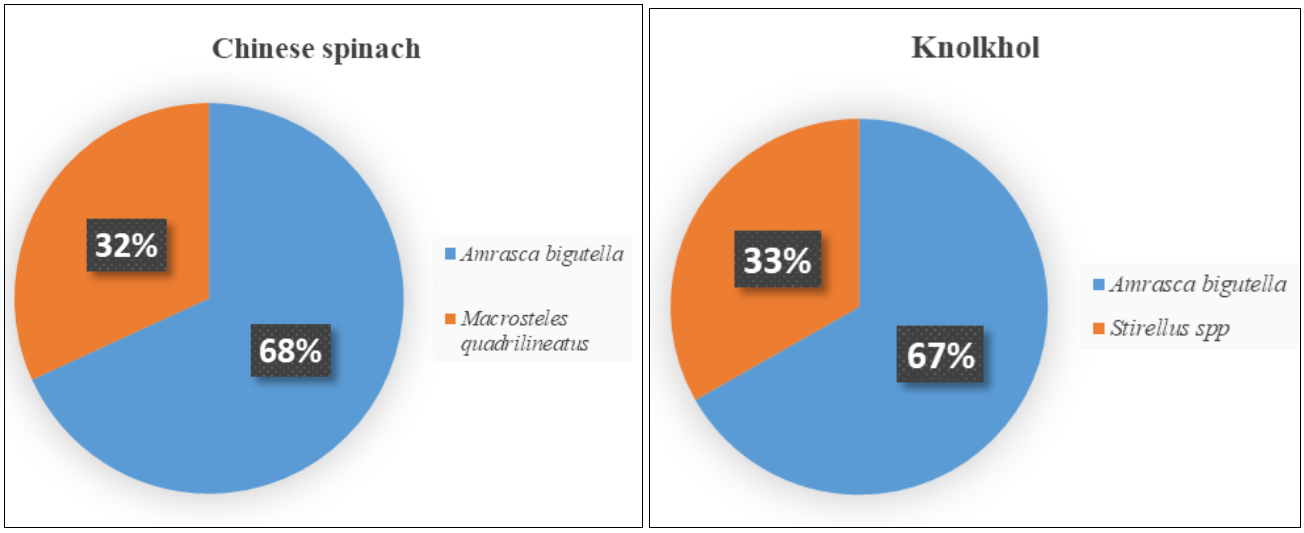


Fig 3: Relative abundance of hoppers on vegetable crops in North Kashmir

Biodiversity indices

Diversity indices such as species diversity index (H), species evenness index (J) and species richness index (Ma) of hoppers on vegetable crops in North Kashmir is presented in table 3. In general, among vegetable crops the species diversity index for surveyed locations was highest on brinjal (1.309) followed by potato (1.233), chilli (0.881), cucumber (0.766), mint (0.677), pumpkin (0.677), knolkhol (0.634), chinese spinach (0.435) and turnip (0.410).

The value of species diversity index on brinjal was recorded highest 1.418 at Dangiwacha followed by 1.400 at Chogul, 1.379 for Wadura, 1.318 for Chetkak, 1.245 for Imberzalwari and lowest 1.093 at Arampora. Similar trend was observed on potato for which the value of species diversity index was recorded highest 1.336 at Dangiwacha followed by 1.331 at Chogul, 1.325 for Wadura, 1.317 for Chetkak, 1.085 for Imberzalwari and lowest 1.003 at Arampora. Similarly in case of cucumber, value of species diversity index was highest 0.927 at Dangiwacha followed by 0.900 at Chogul, 0.841 at Wadura, 0.746 at Chetkak, 0.598 at Imberzalwari and least species diversity index 0.585 was registered at Arampora. On the other hand this value was highest 0.658 at Dangiwacha, followed by 0.621 at Chogul, 0.598 at Wadura, 0.585 at Chetkak in case of turnip. In chilli again the value was highest 1.011 at Dangiwacha followed by 1.003 at Wadura, 0.992 at Chogul, 0.958 at Chetkak, 0.662 at Arampora and lowest 0.661 at Imberzalwari. Moreover, the value was highest 0.689 at Dangiwacha followed by 0.688 at Chogul, 0.686 at Wadura, 0.685 at Chetkak, 0.679 at Arampora and lowest 0.636 at Imberzalwari found on pumpkin. For chinese spinach the value was highest 0.690 at Arampora followed by 0.649 at Dangiwacha and 0.636 the least value was recorded at Wadura and Imberzalwari. In case of knolkhol, the value was highest 0.6581 at Dangiwacha, followed by 0.649 at Chogul, 0.636 at Wadura, 0.636 at Imberzalwari, 0.617 at Chetkak and lowest 0.610 at Arampora. Species evenness index (J), measures the equitability component of diversity in various habitats under different management strategies and the average value of species evenness index was found highest 0.977 on pumpkin, followed by 0.955 on potato, 0.920 on chilli, 0.842 on brinjal, 0.809 on cucumber, 0.677 on mint, 0.634 on knolkhol and lowest 0.435 on chinese spinach. Among different locations its value ranged from 0.770 to 0.955 on brinjal, 0.913 to 0.987 on potato, 0.679 to 0.884 on cucumber, 0 to 0.949 on turnip, 0.872 to 0.961 on chilli, 0.918 to 0.994 on pumpkin, 0 to 0.995 on chinese spinach, 0.610 to 0.658 on knolkhol and 0.940 to 0.988 on mint.

Average value of species richness index (Ma) was highest 4.772 on brinjal followed by 3.431 on potato, 2.341 on chilli, 2.326 on cucumber, 1.700 on mint, 1.643 on pumpkin, 1.618 on knolkhol, 1.094 on chinese spinach and least 1.083 on turnip. Among different locations its value ranged from 3.750 to 5.779 on brinjal, 2.734 to 3.778 on potato, 0.582 to 2.699 on cucumber, 0 to 1.660 on turnip, 1.610 to 2.771 on chilli, 1.597 to 1.676 on pumpkin, 0 to 1.690 on chinese spinach, 1.565 to 1.660 on knolkhol and 1.660 to 1.727 on mint.

Table 3: Diversity indices of hoppers on vegetable crops in North Kashmir

Crop	Location	N	S	H	J	Ma
	Wadura	88	6	1.379	0.770	5.776
Brinjal	Imberzal wari	73	4	1.245	0.898	3.766
	Arampora	62	3	1.093	0.995	3.750
	Dangiwacha	103	6	1.418	0.791	5.784
	Chogul	93	6	1.400	0.781	5.779
	Chetkak	83	5	1.318	0.819	4.773
	Mean	83.66	5	1.309	0.842	4.772
Potato	Wadura	83	4	1.325	0.956	3.773
	Imberzal wari	60	3	1.085	0.987	2.755
	Arampora	43	3	1.003	0.913	2.734
	Dangiwacha	91	4	1.336	0.964	3.778

	Chogul	87	4	1.331	0.960	3.776
	Chetkak	78	4	1.317	0.950	3.770
	Mean	73.66	3.66	1.233	0.955	3.431
Cucumber	Wadura	23	3	0.841	0.766	2.681
	Imberzal wari	14	2	0.598	0.863	1.621
	Arampora	11	2	0.585	0.845	0.582
	Dangiwacha	30	3	0.927	0.884	2.705
	Chogul	28	3	0.900	0.819	2.699
	Chetkak	20	3	0.746	0.679	2.666
	Mean	21	2.66	0.766	0.809	2.326
Turnip	Wadura	14	2	0.598	0.863	1.621
	Imberzal wari	6	1	0	0	0
	Arampora	4	1	0	0	0
	Dangiwacha	19	2	0.658	0.949	1.660
	Chogul	16	2	0.621	0.896	1.63
	Chetkak	11	2	0.585	0.845	1.582
	Mean	11.66	1.66	0.410	0.592	1.083
Chilli	Wadura	30	3	1.003	0.913	2.705
	Imberzal wari	16	2	0.661	0.954	1.639
	Arampora	13	2	0.662	0.961	1.610
	Dangiwacha	32	3	1.011	0.920	2.711
	Chogul	28	3	0.992	0.903	2.699
	Chetkak	24	3	0.958	0.872	2.685
	Mean	23.83	2.66	0.881	0.920	2.341
Pumpkin	Wadura	18	2	0.686	0.991	1.654
	Imberzal wari	15	2	0.636	0.918	1.630
	Arampora	12	2	0.679	0.979	1.597
	Dangiwacha	22	2	0.689	0.994	1.676
	Chogul	20	2	0.688	0.992	1.664
	Chetkak	16	2	0.685	0.988	1.639
	Mean	17.16	2	0.677	0.977	1.643
Chinese spinach	Wadura	15	2	0.636	0.918	1.630
	Imberzal wari	12	2	0.636	0.918	1.597
	Arampora	13	2	0.690	0.995	1.690
	Dangiwacha	17	2	0.649	0.936	1.647
	Chogul	0	0	0	0	0
	Chetkak	0	0	0	0	0
	Mean	9.5	1.33	0.435383	0.628	1.094
Knolkhol	Wadura	15	2	0.636	0.918	1.630
	Imberzal wari	12	2	0.636	0.918	1.597
	Arampora	10	2	0.610	0.881	1.565
	Dangiwacha	19	2	0.658	0.949	1.660
	Chogul	17	2	0.649	0.936	1.647
	Chetkak	13	2	0.617	0.890	1.610
	Mean	14.33	2	0.634	0.915	1.618
Mint	Wadura	35	2	0.682	0.985	1.718
	Imberzal wari	22	2	0.676	0.976	1.676
	Arampora	19	2	0.686	0.981	1.660
	Dangiwacha	39	2	0.684	0.988	1.727
	Chogul	37	2	0.683	0.986	1.723
	Chetkak	28	2	0.651	0.940	1.699
	Mean	30	2	0.677	0.976	1.700

N = Total number of individuals of identified species observed per five sweep nets.

S = Total number of identified species; H = Species diversity index;

J =Species evenness index; Ma= Species richness index.

Brinjal Cucumber Chinese spinach Mint Knolkhol

Fig 4: Hopper damage symptoms on different vegetable crop leaves

The survey of hoppers on vegetable crops in North Kashmir carried out at various locations *viz*. Wadura, Imberzalwari, Arampora, Dangiwacha, Chogul and Chetkak revealed presence of six species of hoppers on brinjal *viz.*, *Empoasca decepiens, Amrasca biguttula, Empoasca fabae, Platymetopius fidelis, Gurawa minorcephala* and *Ceresa* spp, four species *viz., E decepiens, A. biguttula, E. fabae* and *Macrosteles quadrilineatus* on potato, three species *viz., A. biguttula, Stirellus* spp. and *Ceresa* spp. on cucumber, two species *viz., M. quadrilineatus, Macrosteles sexnotatus* on turnip, three species *viz., E. decepiens, E. fabae, and M. quadriline atus* on chilli and two species *viz., A. biguttula* and *Stirellus* spp. on pumpkin, chinese spinach, knolkhol and mint. *A. biguttula* was found to be polyphagous pest attacking brinjal, potato, cucumber, pumpkin, chinese spinach, knolkhol and mint. Our results were in close conformity with Mathew and Ramakrishnan who recorded its infestation in different hosts *viz*., brinjal, bhindi, pumpkin and chinese spinach from Kerala [9]. Simlilar results were found in Andrapradesh where its occurrence was found on brinjal, bhindi, radish, tomato, ridge gourd, mesta, spinach, cluster bean, french bean, garden bean, cauliflower, chillies and beans[15]. Other species of hoppers *E. decepiens* was found on brinjal, potato and chilli and *E. fabae* on potato and chilli. Our results are in agreement with the findings of Gnaneswaran [5] who recorded *Empoasca* sp. on okra, brinjal, bushbeans, longbean, carrot, beetroot and wingbean. Nair [10] reported the occurrence of *Empoasca kerri* on potato from India. However, Nour reported *Platymetopius* on oaks and pistachio [12] while as *Gurawa minorcephala* was found to be rare species feeding on grasses and herbs [19] Difference of host range of these hoppers here in North Kashmir might be attributed due to different climatic zones. *M. quadrilineatus* was found to be infesting potato and turnip. The results were in close conformity with Hagel and Landis who reported *Macrosteles quadrilineatus* Forbes (Hemiptera: Cicadellidae), as a polyphagous pest with over 300 host plant species including important vegetable and cereal crops [6]. Turnip was found to be the host of *Macrosteles quadrilineatus* and *M. sexnotatus*. Similar results were found by Bhat who reported *M. sexnotatus* and *M. quadrlineatus* on turnip in Kashmir valley [2]. *Stirellus* spp. was found to be pest of cucumber, pumpkin, chinese spinach, knolkhol and mint. The results were in close agreement with Blocker who recorded the same species as pest of number of crops and weeds[3]. Species composition of insect communities is affected by combination of geographical and environmental factors including vegetation, topography, altitude, climate, habitat and human influence [8, 17]. Since North Kashmir experiences temperate climate, which is a bit varrieng in all studied locations and therefore the difference in species diversity is related to microclimate *e.g.* solar radiation, temperature and humidity. The findings are further supported by Joshi who observed distinct variation in the diversity of insects occurring between the sites with different degrees of altitude, vegetation and climate [7]. The differences in the diversity of their communities is also explained by the differences in the floristic composition and herbaceous plant densities at the sites [1].

Conclusion

The study revealed maximum number of hoppers on brinjal followed by potato then by cucumber and chilli and minimum on turnip, chinese spinach, knolkhol and mint. *A. biguttula* was found most abundant species on brinjal, cucumber, chinese spinach, knolkhol and mint whereas *E. decepiens* as abundant species on potato and chilli. However on turnip *M. quadrilineatus* was most abundant. The species diversity index for surveyed locations in North Kashmir was highest on brinjal (1.309) followed by potato (1.233), chilli (0.881), cucumber (0.766), mint (0.677), pumpkin (0.677), knolkhol (0.634), chinese spinach (0.435) and turnip (0.410).

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