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Population Dynamics and Natural Enemies of Aphids on Winter Wheat in Peshawar, Pakistan

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Abstract.- Studies on population dynamics of aphids on wheat varieties Bakhtawar, Saleem 2000, Uqab and Pir Sabaque-85 and their natural enemies were carried out at Malakandher Research Farm, Peshawar. Aphid infestation started during the last week of December, remained low during January with a peak in the 1st week of March. Comparatively higher population of aphids and their natural enemies was observed on variety Pir Sabaque-85. Two species of coccinellids and two of hymenopterous parasitoids appeared in the mid February whereas Syrphid fly and *Chrysoperla* were observed during 1st week of March. The peak population density of coocinellids was observed in the 4th week of March, Syrphid fly in 3rd week of March, *Chrysoperla* in the 2nd week of April and hymenopterous parasitoids in the 3rd week of March. Variety Pir Sabaque-85 appeared to harbour higher number of natural enemies than the other wheat varieties, probably in response to the higher aphid densities.

Key Words: Cereal aphids, natural enemies, winter wheat.

INTRODUCTION

Wheat crop is attacked by several insect pests. Of the prevalent pests cereal aphids are gaining importance since their population has increased over the last few years. This might have been due to cultivation of new susceptible varieties or other factors. In Pakistan damage to wheat by aphids is occasional and sporadic as in other parts of the world. Direct crop yield reductions may range from 10–50% and indirect 20–80% (Tradan and Mileboj, 1999), 19–31% at the boot stage and 14–20% during the anthesis stage of plant growth (Voss *et al*., 1997). In the USA, *Schizaphis graminum* (Rond.) has taken a heavy toll of winter grown wheat (Jackson *et al*., 1971). Lefrory (1909) was first to report *Sitobion avenae* F. on wheat in Indo-Pak sub-continent. Das (1913) reported *S. avenae* from wheat, barley, oats, sorghum and maize. Subramanium (1924) reported 37 coccinelids on aphids in southern India.

Khan (2005) reported cereal aphid infestation in early days of December in D.I.Khan and Bannu, while *Rophalosiphum padi* L. infestation at Kohat during mid January. Distribution of *R. padi* in Peshawar valley (Peshawar, Mardan and Charsadda) was somewhat different from southern zone (D.I. Khan, Bannu and Kohat) and Eastern zone as well. *S. graminum* is one of the major pest of wheat in Pakistan (Hamid, 1976).

Hallqvist (1991) reported yield losses up to 600 kg/ha caused by *R. padi* in Sweden. Studies from other parts of Europe also show that *R. padi causes* up to a 15% decrease in yield (Leather *et al*., 1989). Östman *et al*. (2003) reported reduction in bird cherry oat abundance due to ground-living natural enemies and influenced barley yields in commercial farms in central Sweden. On average, ground-living natural enemies of pests increased barley yields by 303 kg/ha. This corresponded to a potential 52% reduction in yield loss for *R. padi* compared with a scenario where no natural enemies were present. Measured as the percentage increase of actual yield, ground-living natural enemies of aphids increased the yield by 23%.

Due to the deleterious effects of aphids on cereal crops, their population is managed by economically and environmentally compatible biological control method based on Integrated Pest Management. It is necessary for this reason, to know the population trend of natural enemies associated with wheat aphids. The aphid parasitoids of Pakistan have been reported by Irshad (2001) and Irshad and Khan (2005). Aphid predators are generally less discriminating than parasitoids and often feed on a wide range of species other than aphids. Another

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general feature of aphid predators is that they thrive under high aphid densities and are, therefore, not usually suited for use when aphid numbers are low.

Coccinellids are a well-known group of insect predators and 75 species have been recorded from Pakistan (Rafi *et al*., 2005). Most ladybird beetles are predaceous, as both larvae and adults, feed chiefly on aphids. They are frequently quite common, particularly on vegetation where aphids are numerous (Mohyuddin, 1981). The larvae of ladybird beetles are elongate, somewhat flattened, and covered with minute tubercles or spines. They are usually spotted or banded with bright colors. These larvae are often found in aphid colonies (Triplehorn and Johnson, 2005).

Chrysoperla carnea Steph. the green lacewing is a voracious predator of exposed eggs and small larvae of all the lepidopterous pests, aphids, jassids and mealy bugs. It has an advantage over egg parasitoid that it can feed on both egg and larvae stage of pests and also its host range is much broader (Khan *et al*., 2005).

Cereal aphids could become a problem in the future even though their numbers are presently kept low by using insecticides. Integrated pest management will play a major role in the control of cereal aphids in the future (Tradan and Mileboj, 1999). Biological control of pests by natural enemies is, therefore, an important eco-system service (Naylor and Erlich, 1997). There have been rare attempts on evaluation of yield increase due to natural enemies of pests (Daily, 1997; Pimentel, 1997; Winston, 1997). Although a few studies on identification of cereal aphids and their control have been done in different laboratories but a comprehensive study on biological control in North-West Frontier Province (NWFP) is missing. The only study on braconid wasps of the NWFP is by Inayatullah and Karimullah (1997) who have described its five genera.

In view of above the present study was undertaken on population dynamics of aphids on winter wheat and to determine therein associated natural enemies.

MATERIALS AND METHODS

For this study four commonly grown wheat varieties, Bakhtawar, Saleem 2000, Uqab and Pir Sabaque-85 were sown in November, 2005 at Malakandher Research Farm (MRF), NWFP Agricultural University, Peshawar and harvested by the end of April, 2006. Fifteen days before the start of experiment, plots were flood irrigated. Each plot was deep ploughed with cultivator and leveled with wooden plank. A dose of NPK (20: 90: 60 kg/hac) was applied. The nitrogen was applied in split doses – half at the time of sowing and half at first irrigation. Sowing was done with the help of planter.

Six irrigations were done during the cropping season i.e. before sowing, after emergence, at boot stage, pre- and post-anthesis and at physiological maturity. For weed control, Puma Super® was applied @ 500 ml/acre before boot stage.

The experiment was laid in Randomized Complete Block design with three fields/blocks each measuring 0.12 acre and divided into four sub-plots, hence each variety was replicated three times. Due to differences in the topography and soil nutritional level of the farm, the area was divided into four blocks, North, East, West, and South. Within each block, one plot was randomly selected as a replicate. In each replication, five spots of one row (foot space) were randomly selected for sampling in Z – shape. Data were recorded on weekly basis starting from germination of seedlings till harvesting of the crop. The aphids per row foot of tillers were counted. Similarly number of natural enemies associated with cereal aphids in the plots was counted. Syrphid adults, eggs, larvae, pupae were counted. As the adults are good fliers and not easy to be identified, some may have been missed. *C. carnea* eggs, larvae, pupae were considered. Mummified aphids were recorded and counted. This gave incidence of parasitism. The collected data was analyzed using F test for RCB design and means were compared using LSD.

RESULTS AND DISCUSSION

R. padi (L.), *S. avenae* (F.) and *S. graminum* (Rond) were recorded as the dominated aphids of wheat in Pakistan in this study. The population of these three aphid species remained very low during January, started building up in the 4th week of December and reached its peak in the mid February

(Fig. 1). Population was comparatively higher on variety Pir Sabaque-85 (Fig. 1C) in the 2nd week of Feb. (142.8 aphids/row foot) and 1st week of March (83.40 aphids/row foot) and the average population was 23.14 aphids/row foot. The average population of aphids was significantly different on variety Pir Sabaque-85 (23.1) than Saleem 2000 (15.5) (Fig. 1B), Uqab (13.8) (Fig. 1D) and Bakhtawar (10.5) (Fig. 1A). This shows that Pir Sabaque-85 is favoured host of these aphids in this locality.

Population density of R. padi

R. padi infestation started in the last week of December and remained low in January and reached its peak (82.5 aphids/row foot) in the 2nd week of February and declined (9.8) in the 2nd week of March and dropped to 0.1 and 0.2 aphid in the 3rd and 4th week of April, respectively (Table I). The overall *R. padi* density on wheat varieties indicated that significantly higher population of 17.8 *R. padi* was observed on Pir Sabaque-85 variety whereas10.9, 10.3 and 6.1 aphids were recorded on Saleem 2000, Uqab and Bakhtawar, respectively. Variety Pir Sabaque-85 appeared to be susceptible to *R. padi* infestation.

Population density of S. graminum

S. graminum infestation was first observed in the 4th week of January on Saleem 2000 and disappeared in the first two weeks of February (Table II). The population again started building up in the 3rd week of February. Two population peaks were observed in the 4th week of February (13.2 aphids) and 2nd week of March (16.2 aphids). The aphid population sharply declined afterwards, and was not observed in the field from 3rd week of March to the end of April. The overall seasonal mean infestation of *S. graminum* on the selected varieties showed no significant preference for any variety.

Population density of S. avenae

S. avenae population followed the same trend as was observed for *S. graminum* but it stayed longer till the crop become mature (Table III). Infestation was not observed till mid February. The first colony of *S. avenae* (4.55 aphids) was found during the 3rd week of February. Peak population density (9.70 aphids) was recorded in the 1st week of March. The aphid population declined afterward but remained in the field till harvesting of the crop.

Significantly higher population of *S. avenae* was observed on Pir Sabaque-85 (3.01) followed by Salem 2000 (2.2), Bakhtawar (2.1) and Uqab (1.7). This shows the preference of *S. avenae* for Pir Sabaque-85 over other varieties.

Major activities of aphid species were correlated with the rising temperature in the month of February but as the crop mature, less aphids were found on the tested wheat varieties. The population of *R. padi* appeared first and declined early but *S. graminum* started infestation later than the *R.padi* but declined earlier than *S. avenae*. *S. avenae* was observed late as compared to *R. padi* and *S. graminum* and stayed till harvesting of the crop. The decline of aphid at the month of April is of course attributed to the senescence of the crop.

Parasitism on aphids

The recorded parasitoids were *Aphidius colemani* Vier and *Aphidius ervi* Haliday. These are important parasitoids of aphids. The data revealed that there was no activity of parasitoids till mid February. The parasitoids appeared (0.7%) in the 3rd week of February, and the highest percent of parasitism was recorded in the 3rd week of March (48.0%) which is followed by 33.7% in 2nd week of April and after that dropped to 20% at the end of April. The activity of parasitism first started on Saleem 2000 wheat variety with 0.94% (Fig. 1B) and Uqab with 1.66% parasitism (Fig. 1D) on the 3rd week of February, but the highest parasitism was recorded on Bakhtawar variety with 60% (Fig. 1A) in 2nd week of April. On Pir Sabaque-85 (Fig. 1C), the parasitoid activity started in the 4th week of February and continued till the 2nd week of April that kept the aphids population suppressed.

Population density of lady bird beetles

The predators were active very early in the season as compared to the parasitoids. Two species of Coccinellids, *Coccinella septempunctata* L. and *Menochilus sexmaculata* L. were recorded. *C. septempunctata* was first observed during the 3rd

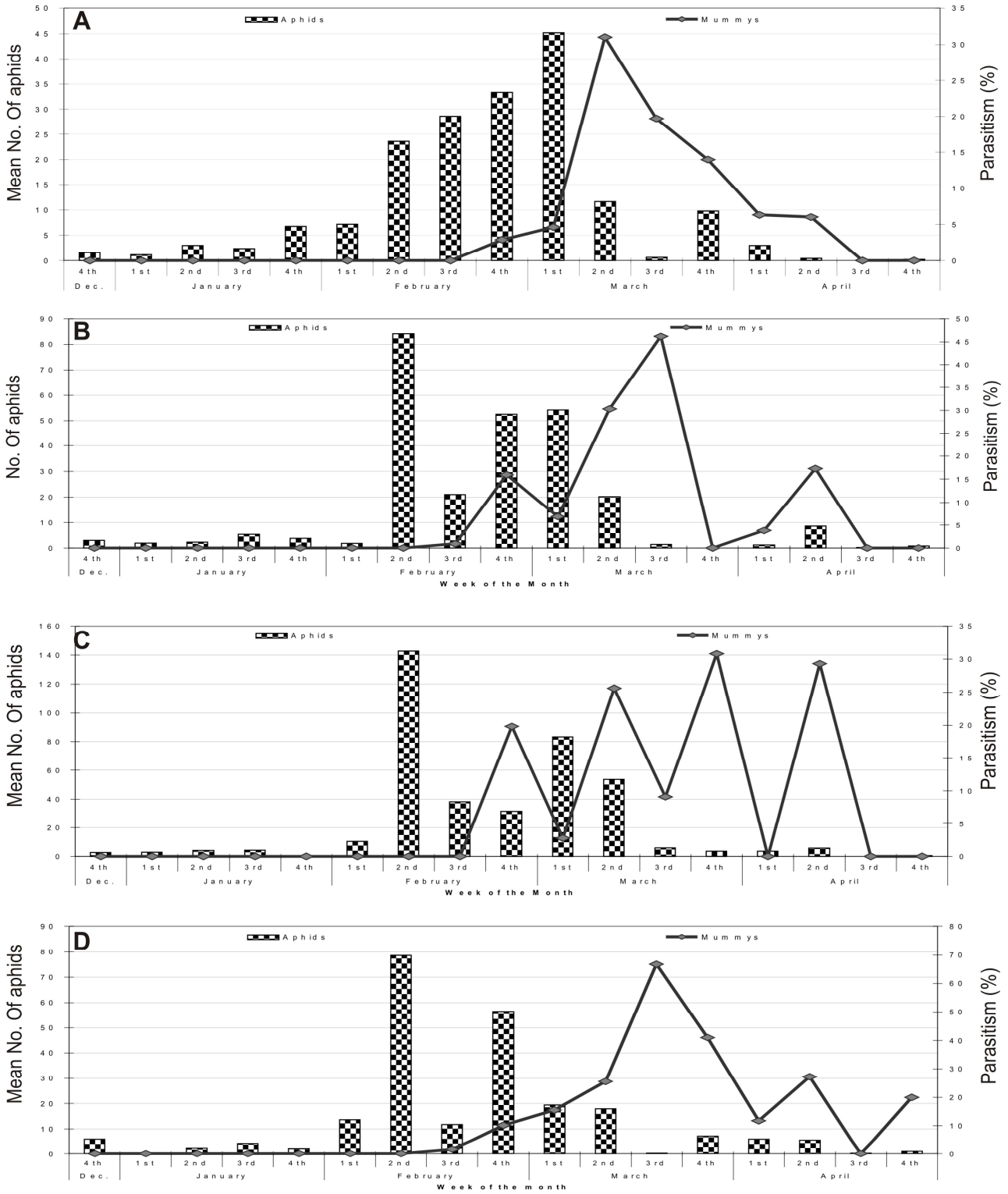

Fig. 1. Mean number of aphids and mummies on winter wheat varieties Bakhtawar (A), Saleem 2000 (B), Pir Sabaque-85 and Uqab (D) in Peshawar during 2006.

Table I. Mean population density (per row foot) of *R. padi* on selected wheat varieties during December 2005 to April 2006.

Months	Week	Wheat varieties				Mean no. of aphids*
		Bakhtawar	Pir Sabaque-85	Saleem 2000	Uqab	
December	4th	1.6	2.6	3.0	6.0	3.3 e
January	1st	1.2	3.0	2.0	0	1.55 e
	2nd	3.0	4.2	2.4	2.4	3.0 e
	3rd	2.4	4.4	5.4	4.2	4.1 e
	4th	6.8	0	3.6	2.2	3.15 e
February	1st	7.2	10.4	1.8	13.6	8.25 de
	2nd	23.6	142.8	84.2	79.2	82.45 a
	3rd	19.8	27.6	16.2	8.0	17.9 cd
	4th	13.6	12.6	32.6	44.6	25.85 bc
March	1st	19.6	72.4	24.6	11.0	31.9 b
	2nd	3.4	22.6	9.8	3.4	9.8 de
	3rd	0	0	0	0	0
	4th	0	0	0	0	0
April	1st	0	0	0	0	0
	2nd	0	0	0	0	0
	3rd	0	0	0	0.20	0.05 e
	4th	0.20	0.20	0.20	0	0.15 e
Mean no. of aphids**		6.02 b	17.81 a	10.93 b	10.28 b	

* Means in a column followed by same letters are not significantly different at P=0.05.
** Means in a row followed by same letters are not significantly different at P=0.05.

Table II.- Mean population density (per row foot) of *S. graminum* on selected wheat varieties during December 2005 to April 2006.

Months	Week	Wheat varieties				Mean no. of aphids*
		Bakhtawar	Pir Sabaque-85	Saleem 2000	Uqab	
December	4th	0	0	0	0	0
January	1st	0	0	0	0	0
	2nd	0	0	0	0	0
	3rd	0	0	0	0	0
	4th	0	0	0.2	0	0.05 c
February	1st	0	0	0	0	0
	2nd	0	0	0	0	0
	3rd	0	4.6	2.6	2.4	2.4 c
	4th	19.8	8.0	13.6	11.4	13.2 a
March	1st	13.4	4.6	14.0	3.8	8.95 b
	2nd	5.2	27.2	17.8	14.6	16.2 a
	3rd	0	0	0	0	0
	4th	0	0	0	0	0
April	1st	0	0	0	0	0
	2nd	0	0	0	0	0
	3rd	0	0	0	0	0
	4th	0	0	0	0	0
Mean no. of Aphids**		2.25 a	2.61 a	2.84 a	1.89 a	

* Means in a column followed by same letters are not significantly different at P=0.05.
** Means in a row followed by same letters are not significantly different at P=0.05.

Table III. Mean population density (per row foot) of *S. avenae* on selected wheat varieties during December 2005 to April 2006.

Months	Week	Wheat varieties				Mean no. of aphids*
		Bakhtawar	Pir Sabaque-85	Saleem 2000	Uqab	
December	4th	0	0	0	0	0
January	1st	0	0	0	0	0
	2nd	0	0	0	0	0
	3rd	0	0	0	0	0
	4th	0	0	0	0	0
February	1st	0	0	0	0	0
	2nd	0	0	0	0	0
	3rd	8.80	5.80	2.20	1.40	4.55 bc
	4th	0	10.80	6.40	2.40	4.90 b
March	1st	12.20	6.40	15.60	4.60	9.70 a
	2nd	3.00	3.80	1.60	0	2.10 cde
	3rd	0.60	11.00	1.40	0.20	3.30 bc
	4th	9.80	3.60	0	6.80	5.05 b
April	1st	1.40	3.60	1.20	6.00	3.05 bcd
	2nd	0.40	5.80	8.60	5.60	5.10 b
	3rd	0	0	0.40	0.20	0.15 e
	4th	0	0.40	0.60	1.00	0.50 de
Mean no. of aphids**		2.12 ab	3.01 a	2.23 ab	1.65 b	

* Means in a column followed by same letters are not significantly different at P=0.05.
** Means in a row followed by same letters are not significantly different at P=0.05.

Table IV.- Mean population density (per row foot) of *C. septempunctata* recorded on the selected wheat varieties during December 2005 to April 2006.

Months	Week	Wheat varieties				Mean no. of Coccinellid*
		Bakhtawar	Pir Sabaque-85	Saleem 2000	Uqab	
December	4th	0	0	0	0	0
January	1st	0	0	0	0	0
	2nd	0	0	0	0	0
	3rd	0	0	0	0	0
	4th	0	0	0	0	0
February	1st	0	0	0	0	0
	2nd	0	0	0	0	0
	3rd	0	0	0.2	0	0.05 d
	4th	0	0.20	0.2	0	0.1 cd
March	1st	0.2	1.40	0	0.2	0.45 abc
	2nd	0	0.20	0.8	0	0.25 bcd
	3rd	0.4	1.6	0	0.2	0.55 ab
	4th	1.8	0.4	0.4	0.4	0.75 a
April	1st	0.2	0	0	0.2	0.1 cd
	2nd	0.2	0.4	0.2	0	0.2 bcd
	3rd	0.4	0	0	0	0.1 cd
	4th	0	0	0	0	0
Mean no. of Coccinellid**		0.18 ab	0.24 a	0.10 ab	0.08 b	

* Means in a column followed by same letters are not significantly different at P=0.05.
** Means in a row followed by same letters are not significantly different at P=0.05.

Table V. Mean population density (per row foot) of Syrphid fly recorded on selected wheat varieties during December 2005 to April 2006

Months	Week	Wheat varieties				Mean no. of Syrphid*
		Bakhtawar	Pir Sabaque-85	Saleem 2000	Uqab	
December	4th	0	0	0	0	0
January	1st	0	0	0	0	0
	2nd	0	0	0	0	0
	3rd	0	0	0	0	0
	4th	0	0	0	0	0
February	1st	0	0	0	0	0
	2nd	0	0	0	0	0
	3rd	0	0	0	0	0
	4th	0	0	0	0	0
March	1st	0.4	0.6	1.2	0.6	0.7 bc
	2nd	0.2	0.8	1.0	1.2	0.8 b
	3rd	2.0	1.0	1.4	1.0	1.35 a
	4th	0.2	0.6	0.4	0.6	0.45 c
April	1st	0.4	0.2	0	0	0.15 d
	2nd	0	0	0	0	0
	3rd	0	0	0	0	0
	4th	0	0	0	0	0
Mean no. of Syrphids**		0.18 a	0.18 a	0.23 a	0.2 a	

* Means in a column followed by same letters are not significantly different at P=0.05.
** Means in a row followed by same letters are not significantly different at P=0.05.

Table VI. Mean population density (per row foot) of *C. carnea* recorded on selected wheat varieties during December 2005 to April 2006.

Months	Week	Wheat varieties				Mean No. of Chrysophids*
		Bakhtawar	Pir Sabaque-85	Saleem 2000	Uqab	
December	4th	0	0	0	0	0
January	1st	0	0	0	0	0
	2nd	0	0	0	0	0
	3rd	0	0	0	0	0
	4th	0	0	0	0	0
February	1st	0	0	0	0	0
	2nd	0	0	0	0	0
	3rd	0	0	0	0	0
	4th	0	0	0	0	0
March	1st	0	0.2	0	0	0.05 c
	2nd	0	0	0	0	0
	3rd	0	0	0.2	0.2	0.1 c
	4th	0	0	0	0	0
April	1st	0.6	0	0	0	0.15 bc
	2nd	0.4	2.8	1.4	0.2	1.20 a
	3rd	0	1.2	0.4	0.2	0.45 b
	4th	0	0.2	0	0	0.05 c
Mean no. of Chrysopids**		0.05 b	0.25 a	0.11 ab	0.03 b	

* Means in a column followed by same letters are not significantly different at P=0.05.
** Means in a row followed by same letters are not significantly different at P=0.05.

week of February with mean number of 0.1 per row foot (Table IV) at the time when the aphid population was abundant (82.25 and 25.85 aphids) (Table I). Ladybird beetle gradually increased and the peak population for *C. septempunctata* was recorded as 0.75 in the 4th week of March and declined to 0.1, 0.2 and 0.1 in 1st, 2nd and 3rd week of April, respectively. Beetles were not recorded during the last week of April. Population density of *C. septempunctata* was significantly higher on Pir Sabaque-85 variety (1.05 beetles/row foot), followed by Saleem 2000, Bakhtawar and Uqab with mean number of 0.45, 0.8 and 0.25 beetles/row foot, respectively. Coccinellids were the first predators observed in the field as compared with Syrphid and Crysoperla. The population of *M. sexmaculata* was very low and no analysis could be done on the recorded data.

Population density of Syrphid flies

The Syrphid fly was first recorded during the 1st week of March (Table V) with mean number of 0.70 Syrphid/row foot. Its population increased and the peak population was recorded in the 3rd week of March with mean number of 1.35 Syrphid/row foot and declined gradually to 0.45 and 0.15 Syrphid/row foot in the 4th week of March and 1st week of April, respectively. No Syrphid was recorded from 2nd week of April onward. The over all seasonal mean population of Syrphid varied non significantly as 0.23, 0.2, 0.18 and 0.18 syrphid/row foot were recorded on Saleem 2000, Uqab, Bakhtawar and Pir Sabaque-85, respectively.

Population density of C. carnea

C. carnea appeared in 1st week of March with 0.05 lacewings per row foot. The lacewing population (Table VI) gradually increased and reached its peak in the 2nd week of April (1.2). Afterwards the population declined and dropped to 0.05 during the 4th week of April. The highest mean population was recorded on Pir Sabaque-85 with 0.3 lace wings, followed by 0.11, 0.05 and 0.03 for Saleem 2000, Bakhtawar and Uqab, respectively.

Of the natural enemies recorded hymenopterous parasitoids are the first to attack, followed by the ladybird beetles, syrphid flies are the third in succession followed by *C. carnea* which stay in the field till harvesting of the crop. It is obvious that these natural enemies do not occupy the same ecological niche at the same time.

The data of parasitism indicated that the parasitoids attack the aphids when they are in abundance or just after they are more in numbers. This may show that these parasitoids are density dependant. However, this has to be confirmed in the laboratory-caged studies. The data also reveal that on Uqab comparatively more parasitism was observed. This may lead to conclusion that this variety may carry some characteristics which favour the invasion of parasitoids. Coccinellids and chrysopa are comparatively higher on Pir Sabaque-85 than others while syrphids showed almost same population level on all these varieties.

Lowering of aphid population after 1st week of March may be attributed particularly to higher activity of natural enemies. This is a critical time regarding management practices. If pesticide application is necessary, treatment beyond this period would not be advisable.

It seems that aphid population is correlated with physical factors like temperature and crop condition. As the crop matures the population of aphids declines and they may shift to other crops or crop plants. Natural enemies complex plays a significant role in the population regulation of aphids. There is not much appreciated difference in the wheat varieties. This is some preliminarily isolated study and more input is required. Overall population of coccinellids remained low probably due to isolated nature of the experimental plots. They might not have been able to establish here at an early stage.

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