

Seasonal incidence and bionomics of rose aphid, *Macrosiphum rosae* (Linnaeus, 1758), (Hemiptera: Aphididae) in Kashmir, India

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Abstract: Rose is the principal flower of the world floriculture industry that is being exclusively used as cut flower, potted plant and garden plant. It plays significant part in numerous industries viz. food, perfumery and cosmetic industries. About 96 % of women's perfumes contain true Bulgarian rose oil. Roses are well acclimatized in Jammu & Kashmir because of its suitable agro climatic conditions which can permit its large scale production and rose products produced in the state are at par with the international standards. But the aesthetic and commercial value of roses is greatly lowered by numerous insect pests resulting in low yield. However, its major pest include aphid species most notoriously *Macrosiphum rosae* that pose many challenges and threats to rose plant cultivation. Aphid colonies on roses result in reduction of medical value of the plant and cause economic losses to growers particularly during spring and summer season. In order to reduce the economic losses inflicted by rose aphid, it is necessary to study different biological parameters of this pest species so that an effective management plan can be formulated.

Key words: floriculture; rose; *Macrosiphum rosae*; economic losses; biological parameters

Sezonsko pojavljanje in bionomika vrtnične uši (*Macrosiphum rosae* (Linnaeus, 1758), Hemiptera: Aphididae) v Kašmirju, Indija

Izvleček: Vrtnica je glavna cvetlica v svetovni florikulturni industriji, ki se uporablja za rezano cvetje, kot lončnica in zasaditev vrtov. Ima pomembno vlogo v različnih industrijskih panogah kot so živilstvo, parfumska in kozmetična industrija. Okrog 96 % ženskih parfumov vsebuje olje prave bolgarske vrtnice. Vrtnice so dobro prilagojene razmeram v Jammu in Kašmirju zaradi primernih agroklimatskih razmer, ki omogočajo velikopovršinsko gojenje vrtnic in proizvodi iz njih so v državi pripravljene po mednarodnih standardih. Estetsko in komercialno vrednost vrtnic v veliki meri zmanjšujejo številne škodljive žuželke, kar zmanjšuje pridelek. Največji škodljivci so listen uši in med njimi vrtnična uš (*Macrosiphum rosae* (Linnaeus, 1758)), ki predstavlja resen izziv gojenju vrtnic. Kolonije listnih uši na vrtnicah zmanjšujejo medicinsko vrednost vrtnic in povzročajo ekonomsko izgubo pridelovalcem, še posebej spomladi in poleti. Z namenom zmanjšanja ekonomskih izgub, ki jih povzročajo listne uši na vrtnicah, je potrebno preučiti različne biološke parametre tega škodljivca za pripravo plana učinkovitega upravljanja.

Ključne besede: florikultura; vrtnica; *Macrosiphum rosae*; ekonomske izgube; biološki parametri

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1 INTRODUCTION

Rose is an attractive prickly ornamental shrub belonging to genus *Rosa* of family Rosaceae. It possesses a climbing or trailing habit and is commonly called as “Queen of Flowers”. Roses are exclusively used in beauty and decorations, without these gardens are not considered complete. Apart from adoration, attar extracted from roses is used in making various fragrant mixtures. Roses produce rose oil, rose water, all of which are valuable and important base material for a number of industries such as perfume, pharmaceutical and cosmetic (Ayci et al., 2005). But the main use of roses is in cut flower industry and landscaping.

Roses are also well-known for their medicinal value and are used in manufacture of large number of medicines. The rose hips which are valued for food are also the richest natural source of vitamin C (having thrice more Vitamin C content than citrus fruits) and are pressed commercially to give rose hip syrup that has been long used to prevent scurvy (Anonymous, 1982). Rose hip herbal tea helps to strengthen the immune system and can further prevent colds and flu (Ziegler et al., 1986). Medicinally, it is also an important nervine used to treat depression and anxiety. Roses possess a unique ability to firm boggy or damaged tissue, reduce inflammation and lessen bacterial proliferation while encouraging the growth of healthy tissue which makes it ideal in the treatment of many microbial infections (Jacoby & Wokes, 1944). Mahmood et al., (1996) and Basim & Basim (2003) reported anti HIV properties of rose oil and its ability to stop and kill some strains of *Xanthomonas*.

However, roses are inhabited by numerous pests which include moths from the family Tortricidae, Hymenoptera from the family Tenthredinidae, Argidae and

Cynipidae as well as numerous aphid species. Out of which, the aphid species, *Macrosiphum rosae* (Linnaeus, 1785) is a key pest of roses, with worldwide distribution (Blackman and Eastop, 2000). The significant damage by rose aphid is to the inflorescences, especially at bud burst (Fig. 1). This species cause direct damage by sap sucking from young leaves and developing flower buds which in turn results in discoloration of leaves, stunted growth and gall formation, while as indirect loss is incurred by honeydew secretion on flowers and surface of leaves on which molds grow resulting in reduction in photosynthesis and finally the yield (Jalalizand, 2012). All these factors together cause significant damage to rose plants by decreasing their beauty and the value of cut flowers. Rose aphid is also involved in transmitting viral diseases such as pea mosaic, cauliflower mosaic and cabbage black ring spot (Manddahar, 1987).

Now- a- days, floriculturists round the world do not recommend use of insecticides on flowers and as such aphids are controlled by predators and parasitoids (Bari and Sardar, 1998). As a result, increasing number of studies involving biological control of aphids by natural enemies has become an important feature of pesticide free management strategies (Zehnder et al., 2007). Mehrparvar et al., 2016 reported that natural enemies of *M. rosae* include four species of Coccinellidae [*Hippodamia variegata* (Goeze, 1777), *Coccinella septempunctata* (Linnaeus, 1758), *Adalia bipunctata* (Linnaeus, 1758) and *Exochomus nigromaculatus* (Goeze, 1777)], three species of Syrphidae [*Syrphus vitripennis* Meigen 1822, *Ischiodon aegyptius* (Wiedemann, 1830) and *Scaeva albomaculata* (Macquart, 1842)], two species of Chamaemyiidae [(*Leucopis glyphinivora* Tanasijtshuk, 1958 and *Leucopis* spp. Meigen, 1830)], one species of Chrysopidae [*Chrysoperla carnea* (Stephens, 1836)], a few species of Anthocoridae [*Orius niger* (Wolff, 1811) *Orius minutus*



Figure 1: Infestation of young flower bud by *M. rosae*

(Linnaeus, 1758) and *Anthocoris limbatus* Fieber, 1836] and Miridae [*Deraeocoris punctulatus* (Fallen, 1807) and *Deraeocoris* spp. (Kirschbaum, 1856)], all of these act as predators of rose aphid and four species of parasitoids i.e., Braconidae parasitic wasps [*Aphidius rosae* Haliday 1833, *Aphidius ervi* Haliday, 1834, *Praon volucre* (Haliday, 1833) and *Ephedrus plagiator* (Nees, 1811)] in Iran. In addition to this, numerous researchers *viz.* Chakrabarti and Gosh, 1970; Maezler, 1977; Mohammed and Mallah, 1987; Tomiuk et al., 1990; Jaskiewicz, 1995; Dixon and Agarwala, 1999, Gadakh, 2014 etc have worked on various aspect of different rose aphid species under different climatic conditions and have obtained varied results but in Kashmir little information is available on this particular insect pest. A precise knowledge about seasonal incidence and biology of pest is essential for any effective control plan to succeed. Keeping in view the economic importance of roses, the degree of damage inflicted by *M. rosae* and in order to develop a sound pest management strategy against it, the present investigation was carried out to study its incidence, population build up and biology along with the relative susceptibility of different rose cultivars to *M. rosae*.

2 MATERIAL AND METHODS

2.1 PERCENTAGE INCIDENCE OF *M. rosae*

Random surveys were carried out fortnightly at special rose growing ornamental gardens in Srinagar district of Kashmir for collection of rose aphids from March to December 2015. These include Shalimar, Nishat, Kashmir University Botanical Garden (KUBG) and Naseem bagh campus. At all experimental sites, five plants were randomly selected and from each plant three twigs were examined for calculation of aphid infestation. The aphids were brushed off from apical tender portions i.e. shoots, buds, flowers and occasionally from underside of leaves of rose plants using camel hair brush on to a white paper and counted to determine aphid severity at different locations. For calculation of percentage of brown, green, alate and apterous forms, separate counts were done from onset of aphids on rose plants till their disappearance.

The apical portions of rose plants were considered infested even if only one aphid was observed on it whereas un-infested rose plants were devoid of any rose aphid. Percentage incidence was calculated by the formula

$$\text{Incidence} = n / N \times 100$$

Where, n = number of infested shoots

N = total number of shoots examined.

2.2 IDENTIFICATION OF ROSE APHID

Identification of the pest was done by studying their morphological characters under microscope and comparing them with literature available on their morphology. The diagnosis of the species was confirmed according to key provided by David (1975).

2.3 STOCK CULTURE OF ROSE APHID

In order to study biology, a stock culture of rose aphids was maintained on fresh, tender apical portions of rose plants in the Entomology Research Laboratory of Department of Zoology, University of Kashmir under natural conditions of temperature and humidity. Rose aphids were brushed off from infested rose plant portions using camel hair brush into collection tubes. In the case of heavy infestation, apical 10 cm tender shoots were trimmed carefully, put in sealed polythene bag, and carried to the laboratory (Reshi et al., 2008). Fresh food in the form of fresh tender apical rose plant portions were provided to them on daily basis and these were kept in large beakers which in turn were placed in large glass rearing jars having their open end covered with muslin cloth for ventilation.

2.4 STUDY OF DIFFERENT BIOLOGICAL PARAMETERS OF ROSE APHIDS

Adult apterous viviparous parthenogenetically producing female rose aphids collected from field were placed singly on potted rose plant in the laboratory and left overnight for laying young ones. After 12 hrs, all mothers except a newly laid nymph were removed from each plant and kept in 70 % alcohol. The nymph was reared and examined daily from its birth till death for recording different biological parameters. Observations were recorded on duration and number of nymphal instars, pre-reproductive, reproductive, post reproductive period and adult longevity (Ghetiya, 1992). The data was collected for apterous and alate forms separately in two seasons i.e. late spring (May- June) and autumn (October- November). Each parameter was replicated thrice.

2.5 RESPONSE OF DIFFERENT *Rosa* SPP. TO *M. rosae*

The response of different cultivars of *Rosa* spp to *M. rosae* was studied under natural field conditions at Kashmir University Botanical Garden *viz.* Grand Gala,

Golden Gate, Konfettii, Naranga and Nobless. Aphid intensity was recorded separately for each cultivar of *Rosa* spp. at fortnightly interval by examining apical 10 cm portion of rose plant. The observations were recorded from the appearance of aphid in the field and experiment for each species was repeated five times. Mean aphid intensity was calculated by transforming the observations to corresponding square root values. Further, the relative susceptibility of different cultivars was determined on the basis of relative mean population load during the study period and categorized following Malik & Deen (1998):

1. Highly resistant (HR): value between 0.0 to mean – Critical difference (CD) at 5 % level

2. Resistant (R): value between HR to mean – CD at 5 % level

3. Moderately resistant (MR): value between R to mean

4. Low resistant (LR): value between MR to mean + CD at 5 % level

5. Susceptible (S): value between LR to mean + CD at 5 % level

6. Highly susceptible (HS): value above S

3 RESULTS

3.1 SEASONAL INCIDENCE OF *M. rosae* INFESTING ROSES

The data from different localities of Srinagar, Kashmir on aphid no/ twig i.e. aphid infestation and percentage incidence (Table 1 & 2) revealed that insect pest

Table 1: Infestation of rose aphid, *M. rosae* at four different sites of Srinagar district from March to December 2015

S. No.	Month	KUBG	Nishat	Shalimar	Naseem bagh	Mean aphid infestation*
1	March	0.00	0.17	0.23	0.00	0.40
2	April	9.00	7.13	12.60	8.47	9.30
3	May	29.03	32.06	34.86	25.15	30.27
4	June	1.70	9.93	12.26	0.38	6.07
5	July	0.13	1.5	2.03	0.00	0.91
6	August	6.26	11.93	15.33	4.66	9.50
7	September	21.40	24.02	27.00	17.80	22.55
8	October	4.87	7.20	10.93	9.53	8.13
9	November	1.07	2.87	3.00	2.01	2.23
10	December	0.00	0.27	0.33	0.00	0.60

*Mean based on aphid population counted on 3 twigs/ plant/ site.

Table 2: Incidence of *M. rosae* at four experimental sites of district Srinagar, Kashmir

S. No.	Month	Percentage incidence				Mean*
		KUBG	Nishat	Shalimar	Naseem bagh	
1	March	0.00	13.66	19.42	0.00	8.27
2	April	30.00	37.66	42.00	27.33	34.25
3	May	72.02	87.00	102.00	63.13	81.04
4	June	20.12	54.22	60.00	13.66	37.00
5	July	20.00	14.00	26.66	0.00	15.16
6	August	24.13	33.33	50.00	20.66	32.03
7	September	66.00	70.33	82.66	40.00	64.75
8	October	46.33	33.66	40.00	20.00	35.00
9	November	12.00	19.00	25.33	8.00	16.08
10	December	0.00	10.66	14.00	0.00	6.16

*Mean based on aphid population counted on 3 twigs/ plant/ site.

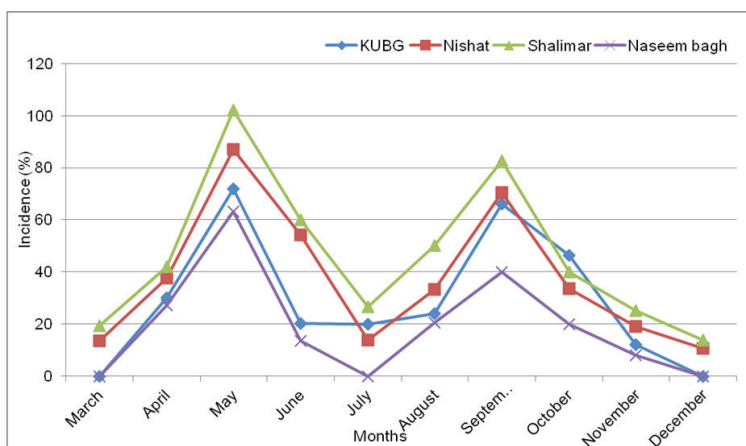


Figure 2: Monthly incidence of *M. rosae* at four sites of district Srinagar, Kashmir

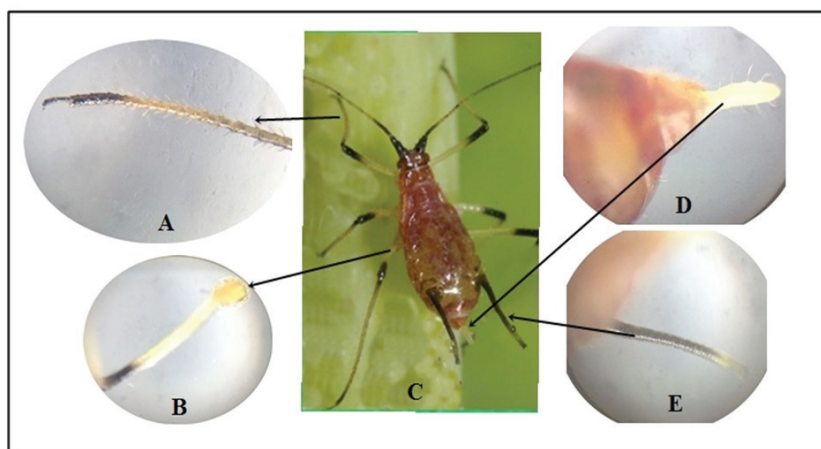


Figure 3: Identification of *M. rosae*. A. Tibia, B. Femur, C. Adult, D. Cauda and E. Siphunculi

occurred during March at Nishat and Shalimar having mean aphid no/ twig and percentage incidence of 0.17 and 0.23 and 13.66 and 19.42 at two sites respectively. The pest population reached its first peak at all sites during May with mean aphid no/ twig recorded as 29.03, 32.06, 34.86 and 25.15 while percentage incidence was 72.02, 87.00, 102.00 and 63.13 for KUBG, Nishat, Shalimar and Naseem bagh respectively. Afterwards, a rapid reduction in aphid no / twig and percentage incidence of pest population was observed at all sites till July. However, the aphid population starts building up from August and reached to its 2nd peak in September with mean aphid no. / twig 21.40, 24.02, 27.00 and 17.80 with percentage incidence of 66.00, 70.33, 82.66 and 40.00 at KUBG, Nishat, Shalimar and Naseem bagh respectively (Fig. 2). The pest population as per mean aphid no/ twig and percentage incidence showed reduction in October and November. During December the pest population

was observed at Nishat and Shalimar but it completely disappeared at KUBG and Naseem bagh.

3.2 PEST IDENTIFICATION

The study on various morphological features of adult apterous viviparous specimens collected from district Srinagar revealed that this insect pest is medium sized, broadly spindle shaped with dark head, siphunculi (a pair of horn shaped tubes on abdomen) dark throughout that bent outside and reticular at distal end (Fig. 3). The average antennal length was 3.6 mm, with a cluster of rhinaria arranged all over the surface at the base of 3rd antennal segment, caudal end possessing 10- 14 hairs and leg femora and tibiae were pale at the base and dark black in distal parts. These morphological characters were compared with taxonomic review of genus *Macrosiphum* occurring in India, provided by David (1975)

and Blackmann & Eastop (2000) and it was concluded that the insect pest is *M. rosae*.

3.3 PERCENTAGE OF BROWN AND GREEN MORPHS OF *M. rosae*

The data obtained from the fields on percentage of brown and green morphs of *M. rosae* are depicted in Table 3. From the data on overall population of both brown and green aphids, it is clear that brown morphs varied from 54.79 % to 60.00 % which is slightly higher than green morph ranging from 40.00% to 45.20%. Further, both brown and green morphs were observed on the plants at the same time throughout the infestation season i.e. colour morphs were normally distributed but slightly biased towards the brown morphs (Fig. 4).

3.4 PERCENTAGE OF ALATE AND APTEROUS FORMS OF *M. rosae*

The data on percentage of alate and apterous forms is represented in Table 4 which indicates that a significant percentage of alate form ranging from 16.00 % to

20.51% while as apterous form range from 79.48 % to 84.00 % were observed in the beginning of season. Afterwards, the percentage of alate forms declined as low as 3.19 % in the 1st week of August. Later, their percentage increased considerably and outnumbered the apterous forms towards the end of the season ranging from 39.64 % to 81.82 % of adult population in the first week of November.

3.5 BIOLOGY OF ROSE APHID, *M. rosae*

The present studies on the biological aspects conducted on stock culture of rose aphids maintained on tender apical portions of rose plant under laboratory conditions revealed that these aphids undergo both parthenogenetic and viviparous modes of reproduction producing both wingless and winged forms. In vivo observations on the biological aspects of the rose aphid were indicative of the fact that the newly born nymphs passed through four nymphal instars before molting into adult. The data on duration of nymphal instars and total developmental period for apterous as well as for alate form of the rose aphids in two seasons i.e. late spring and autumn are given in Table 5.

Table 3: Percentage of brown and green morphs of *M. rosae* at four selected sites of Srinagar, Kashmir

S. No.	Sites	Total aphid population*	Brown aphid population	Green aphid population	Percentage of brown morphs	Percentage of green morphs
1	KUBG	826	470	356	56.90	43.09
2	Nishat	1268	726	542	57.26	42.74
3	Shalimar	1635	981	654	60.00	40.00
4	Naseem bagh	584	320	264	54.79	45.20

*Data based on aphid population on 3 twigs/ host plant/ site.



Figure 4: Severe infestation of apical portions of rose plant by brown and green morphs of rose aphid, *M. rosae*

Table 4: Percentage of alate and apterous forms of *M. rosae* at KUBG, Srinagar during 2015

S. No.	Month	Total aphid population	Apterous aphid population	Alate aphid population	Percentage of apterous aphid form	Percentage of alate aphid form
1	March	50	42	8		16.00
2	April	320	230	90	71.87	28.12
3	May	848	674	174	79.48	20.51
4	June	178	167	11	93.82	6.18
5	July	94	91	3	96.80	3.19
6	August	128	121	7	94.53	5.46
7	September	386	353	8	91.45	8.55
8	October	565	341	224	60.35	39.64
9	November	98	30	68	30.61	69.39
10	December	22	4	18	18.18	81.82

*Data based on aphid population on 3 twigs/ host plant/ site.

Table 5: Duration of various developmental stages of *M. rosae* in two different seasons of Kashmir valley

Season	Phase of rose aphid	Nymphal instar	Observations			Duration of nymphal instars (Mean \pm SD)*	Pre-reproductive period (days)	Total developmental period (days)	
			1	2	3				
Late Spring	Apterous	I	2.5	3.0	2.0	2.7 (\pm 0.35)	1.50	11.80	
		II	2.5	2.0	1.5	2.2 (\pm 0.29)			
		III	2.0	3.0	2.0	2.3 (\pm 0.58)			
		IV	3.3	2.5	3.5	3.1 (\pm 0.53)			
	Alate	I	3.0	3.5	2.9	3.1 (\pm 0.32)	2.93	16.03	
		II	2.7	2.4	2.1	2.4 (\pm 0.30)			
		III	3.0	2.5	2.8	2.8 (\pm 0.25)			
		IV	5.2	4.5	4.8	4.8 (\pm 0.35)			
	Autumn	Apterous	I	2.5	3.0	2.6	2.7 (\pm 0.26)	2.25	13.25
			II	1.5	2.0	2.8	2.1 (\pm 0.65)		
			III	2.8	3.2	2.0	2.7 (\pm 0.61)		
			IV	4.0	3.5	3.0	3.5 (\pm 0.50)		
Alate		I	3.7	3.3	4.0	3.7 (\pm 0.35)	6.00	21.00	
		II	2.6	2.4	3.4	2.8 (\pm 0.53)			
		III	3.0	2.5	3.5	3.0 (\pm 0.50)			
		IV	5.5	5.7	5.3	5.5 (\pm 0.20)			

*Mean of 3 replications/ season/ for each phase of aphid life.

In apterous form 2nd instar usually took least time in comparison to other instars while for alate forms 4th instar is the longest instar, since aphids develop wings in this very stage and as a result this instar takes more time. *M. rosae* showed polymorphism in its generations with predominant brown morphs in contrast to green morphs. Throughout the infestation season, colonies of

rose aphids comprising of alate and apterous forms, were seen crowding on rose plants at the same time (Fig. 5).

The data on mean reproductive period, total fecundity (nymphs laid/ female) and rate of reproduction (nymphs laid/ day/ female) for apterous and alate forms in the late spring and autumn season are shown in Table 6. The data on mean duration of post reproductive period, adult longevity and total longevity of apterous form

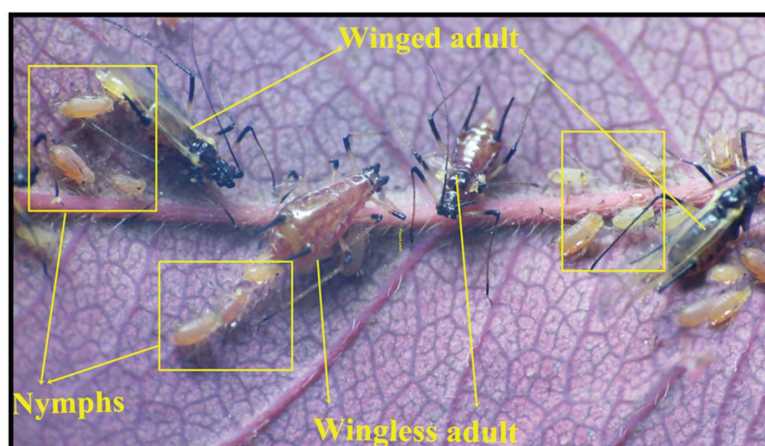


Figure 5: Colony of rose aphid depicting different phases in the life cycle of *M. rosae*

Table 6: In vitro studies on reproductive and longevity of *M. rosae* in two seasons of Kashmir

Season	Phase of aphid	Reproductive period	Total fecundity	Rate of reproduction	Post reproductive period	Adult longevity	Total longevity
Late spring	Apterous	14.63	94.62	6.46	4.25	18.44	30.24
	Alate	9.80	50.87	5.19	8.87	14.36	30.39
Autumn	Apterous	20.10	65.12	3.24	9.50	28.50	41.75
	Alate	12.35	30.74	2.49	12.75	23.00	44.00

was recorded as 4.25, 18.44, 30.24 days in late spring and 9.50, 28.50, 41.75 days in autumn respectively whereas for alate form the post reproductive period, adult longevity and total longevity were found to be 8.87, 14.36, 30.39 days in late spring and 12.75, 23.00 and 44.00 days in autumn respectively.

The pest first appeared in the 3rd week of March and remained active on the rose plants for about ten months of the year. Under laboratory conditions, the rose aphid was observed to complete its life cycle from 3rd week of March to 4th week of December, reproducing parthenogenetically, viviparously all the year round.

3.6 RESPONSE OF DIFFERENT *Rosa* SPP.. TO *M. rosae*

The results on screening of different cultivars of *Rosa* spp. viz. Grand Gala, Golden Gate, Konfettii, Naranga and Nobless against rose aphid, *M. rosae* are shown in Fig. 6 which clearly depicts that 'Konifitti' had least mean aphid intensity than rest of cultivars. Further, 'Grand Gala' was found to have highest mean aphid intensity during the whole growing season was designated as highly susceptible while as 'Naranga' and 'Nobless' were classified as moderately susceptible and suscep-

tible respectively (Table 7). However, Golden Gate and Konfetti were grouped as resistant and highly resistant cultivars with mean aphid intensity of 1.91 and 1.58 respectively.

4 DISCUSSION

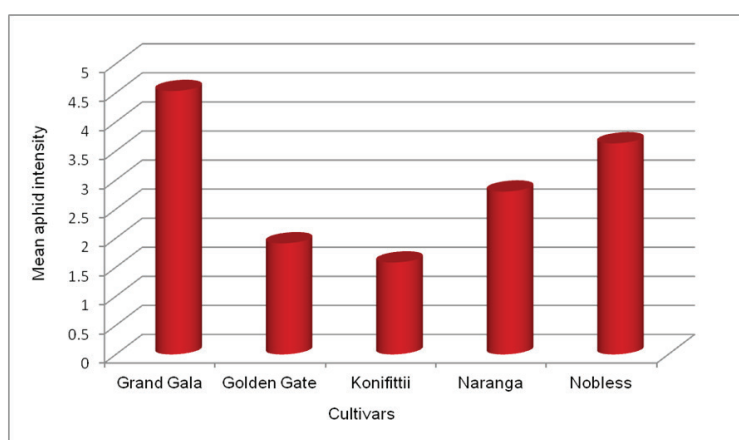
4.1 SEASONAL INCIDENCE OF *M. rosae*

During the survey of ornamental shrubs carried out for the purpose of collection of rose aphids, it was evident that this insect pest first appeared on the apical tender portions of rose plant in the 3rd week of March in the Srinagar district (Table 1 & 2). The findings were in close association with the prior findings of Mohammed & Mallah (1987) and Jaskiewicz (1995) who concluded that this aphid species first appeared in the spring season on the rose shoots in mid May and mid February in Poland and Iraq respectively. A large number of aphids forming huge colonies were also observed by Bhagat & Ahmad (1995) on *Rosa* spp. at Jammu during spring season. Rani & Mohan (1997) observed the *M. rosae* clusters were found around the growing shoots of rose plant during Oct.- Feb. when the weather is cool and cloudy in Bangalore. However, Atwal & Dhingra (1971) and

Table 7: Mean aphid intensity of five cultivars of *Rosa* spp. at KUBG, Srinagar

S. No.	Cultivars	Replications			Mean aphid intensity per shoot*	Response category
		1	2	3		
1	Grand Gala	8.00	5.00	7.00	20.00 (4.53)	Highly Susceptible
2	Golden Gate	0.93	0.99	1.23	3.15 (1.91)	Resistant
3	Konfettii	0.56	0.84	0.60	2.00 (1.58)	Highly Resistant
4	Naranga	2.19	2.13	3.00	7.35 (2.80)	Moderately Susceptible
5	Nobless	3.05	4.60	5.00	12.65 (3.63)	Susceptible

* Mean of observations recorded from March to December 2015; five replications for each cultivar; figures in parenthesis are $\sqrt{x+0.5}$ transformed values.


Figure 6: Relative susceptibility of different rose cultivars to *M. rosae*

Hole et al. (1998) reported that the pest first appears in November and 3rd week of January in Punjab and Pune states of India respectively. This difference in appearance of pest may be ascribed to the different agroclimatic conditions/ seasons, latitudinal clines and different growth stages of host plant in the different regions of the country.

The population of aphids increased steadily, achieving its 1st peak in the month of May when rose plants were in flowering and bud stages. Interestingly, a 2nd peak which was lower than the 1st one was observed in 1st week of October. This observation was credited to the drop in high temperature and to the 2nd flush of vegetative growth on rose bushes which augment its vulnerability to the pest. The population of pest starts declining sharply in the month of October and completely disappears thereafter in December. These observations coincide with the prior observations of Maezler (1977) who recorded three peaks of *M. rosae* in spring- summer with respect to the three growth flushes of rose in South Australia.

Thereafter, with the further fall in temperature and production of alate form of pest, population started declining further and completely vanishes from rose plants

in the 3rd and 4th week of December. The complete disappearance of the pest from roses has been observed in different months from different regions of the world e.g. Atwal & Dhingra (1971) reported from Punjab that the pest disappears in the month of May, at the end of October from Lublin, Poland (Jaskiewicz, 1995), by the mid-June in Mosul, Iraq (Mohammed & Mallah, 1987) and by the end of April in Pune, Maharashtra (Hole et al., 1998) which may be attributed to the agroclimatic factors, latitudinal clines and the growth stages of the rose bushes.

4.2 PERCENTAGE OF BROWN AND GREEN MORPHS OF *M. rosae*

In our study, two phenotypic morphs i.e. brown and green representing clones of *M. rosae* colonizing rose plants either separately or together were observed. These findings are in uniformity with many previous researchers viz. David et al. (1958), Atwal & Dhingra (1971), Tomiuk & Wohrmann (1990) and Chen De Qiao et al. (1997).

As far as percentage of brown and green morphs of *M. rosae* is considered, the observed bias towards brown form is attributed to high reproductive rates and better adaptability of this morph in comparison to its green morph as suggested by Tomiuk & Wohrmann (1990).

4.3 PERCENTAGE OF ALATE AND APTEROUS FORMS OF *M. rosae*

Throughout the study period, both apterous and alate forms were found to variable extent. In the beginning of season, percentage of alate forms increased gradually up to mid May. Atwal & Dhingra (1971) have also observed that alate population progressively increased from the beginning of season. But as the population peaked to its maximum in the 4th week of May, thereafter their population declined possibly in response to crowding and high temperature as suggested by Maezler (1977) and Atwal & Dhingra (1971). Das (1918) pointed out that possibly the alate forms may be carried to high altitude cooler regions along with wind debris. The alate percentage remained very low in the hotter months but October onwards; their percentage increased progressively and towards the end of season more than 70 % population was alate form. Atwal & Dhingra (1971) observed more than 80 % population as alate form towards the end of season. This urge was possibly in response to short photoperiod and maturity of host plants as suggested by Grewal & Bains (1975) for *Macrosiphum (Sitobion) avenae* Fabricius, 1775. Howard and Dixon (1992, 1995) also suggested that maturity of plants induces alate production.

The production of alatae in most of aphid species is in response to increased aphid density and in some species even small increase in population triggers wing formation (Johnson, 1965; Lees, 1967; Shaw, 1970). The immediate reason for such changes appears to be increased tactile stimulation between aphids that is mainly mediated by antennae in some species (Johnson, 1965). In addition to this, the mere occurrence of particular natural enemy was known to elicit an increase in winged morph production in pea aphid, *Acyrtosiphon pisum* Harris, 1776 (Dixon and Agarwala, 1999; Kunert & Weisser, 2003). The induction of winged morphs is triggered by either predator avoidance behaviour or from the release of aphid alarm pheromone (Kunert et al., 2005). Aphid or plant pathogens (i.e., fungi or viruses) and facultative aphid endosymbionts may also affect wing development (Muller et al., 2001; Leonardo and Mondor, 2006). Furthermore, several abiotic factors like temperature may influence wing induction either directly or indirectly through host plant (Johnson and Birks, 1960; Schaefer

and Judge, 1971; Liu, 1994). In clones (that do not undergo sexual reproduction), appearance of wings may be ascribed to change in photoperiod (Lees, 1966). Wing development in aphids is thus an evolutionary phenomenon by which they undergo either sexual reproduction or migrate to favourable environments.

4.4 BIOLOGY OF *M. rosae*

The study of biology revealed that pest passed through four nymphal instars. This was in consonance with the findings of Atwal & Dhingra (1971) and Mohammad & Mallah (1987). The apterous form passed through four instars with the total longevity of 30.24 and 41.75 days in spring and autumn seasons respectively. For the alate form it was 30.39 and 44.00 days in two seasons (late spring and autumn) respectively. These observations are slightly higher than those recorded by Atwal & Dhingra (1971) for *Macrosiphum rosaeformis* (Das, 1918). The variation may be due to the host/ species differences and agroclimatic conditions but in close conformity with the observations of Reshi et al., 2008 in Kashmir for *M. rosae*. Further, it was noted that the 2nd instar of apterous form takes the least time in comparison to other instars while for the alate forms the 4th instar took the longest time, since aphids develop wings in this very stage and as a result this instar takes more time. Similar observations were made by Mohammad & Mallah (1987) for *M. rosae* in Somul, Iraq.

The pre-reproductive period of apterous and alate forms in late spring and autumn was 1.50, 2.25 and 2.93, 6.00 days. This is higher than *M. rosaeformis* as reported by Atwal & Dhingra (1971) and the observed difference may be attributed to agroclimatic disparity followed by difference in pest and host plant used for the study.

As far as total developmental period of rose aphid was concerned, the present observations are in close agreement with that of Atwal & Dhingra (1971) and Kakkar & Sood (1989) for *M. rosaeformis* and with Reshi et al., 2008 for *M. rosae*. In present study, mean reproductive period of apterous form in two seasons is 14.63 and 20.10 days whereas for alate form it is 9.80 and 12.35 days respectively. These are in association with the results of previous workers viz. Atwal & Dhingra (1971) for *M. rosaeformis*.

This pest was observed to reproduce parthenogenetically and viviparously all the year round. Reshi et al., 2008 reported that the pest undergo 7 complete generation from 3rd week of March to 4th week of December. The pest did not possess any sexual stage and thus appeared anholocyclic. Observations of David (1957, 1975) and Maezler (1977) in India and South Australia respec-

tively supported the anholocyclic mode of reproduction in *M. rosae* on roses. Wohrmann et al., 1991 reported that the ability of German clones to undergo sexual reproduction is stronger than the Australian clones on manipulation of environmental conditions in the laboratory. He further suggested that this disparity in the mode of reproduction in *M. rosae* may be due to the genetic and environmental factors. Sexual phase is triggered by environmental changes in the temperate regions (Hille Ris Lambers 1966 and Lees, 1966) and many clones and certain aphid species have lost the ability to undergo sexual reproduction either partially or completely (Lee, 1966 and Simon et al., 1991).

4.5 RELATIVE SUSCEPTIBILITY OF ROSE CULTIVARS TO *M. rosae*

The present study revealed that none of rose cultivar was found to be free from aphid infestation. Throughout the study period, variable aphid intensity was recorded on different cultivars. This is in conformity with the observations of David et al. (1958) who reported that both garden and wild roses are attacked by this insect pest. From the analysis of mean aphid intensity, it is clear that Grand Gala harboured maximum aphids whereas Konfittii had minimum mean aphid intensity. Furthermore, Naranga and Golden Gate demonstrated moderate mean aphid intensity. These are in uniformity with findings of Akhtar & Khaliq (2003) who ascertained that none of *Rosa* spp. was aphid free. Further, certain rose varieties were more susceptible to the attack of thrips than others. Rani & Sridhar (2003) observed that more no. of thrips attacked red and orange flowers than yellow flowers which may be explained by the fact that colour of rose may act as source of attractant for insect pests like thrips and aphids. A number of morphological characters (like colour, thorns etc) and presence of chemical compounds (like presence of catechin i.e. 1, 2 benzenediol) in sap of rose plant act as feeding deterrent for numerous pests as reported by Rani & Sridhar (2003).

5 CONCLUSIONS

In the present study, an extensive survey of rose plants was carried out to monitor aphid populations on them. The results obtained revealed that the pest remained active for ten months of the year with its first incidence in the month of March. Maximum aphid population was observed in May after which the population declined till the month of July. The aphid population reached a 2nd peak in the month of October. Thereafter,

population plummeted till their complete disappearance in the month of December. Both alate and apterous forms of *M. rosae* were observed to pass through 4 nymphal instars in two different seasons (late spring and autumn). The developmental period, pre reproductive period, reproductive period, post reproductive period and adult longevity of apterous morphs in spring were recorded as 11.80, 1.50, 14.63, 4.25 and 18.44 days whereas in autumn, these phases were of 13.25, 2.25, 20.10, 9.50 and 28.50 days duration respectively. Alate morph of rose aphid had developmental period, pre reproductive period, reproductive period, post reproductive period and adult longevity of 16.03, 2.93, 9.80, 8.87 and 14.36 days in spring season. The durations of these phases in autumn season for alate morph were recorded as 21.00, 6.00, 12.35, 12.75 and 23.00 days respectively. Further, none of the rose cultivars studied during the entire growing season escaped the aphid attack. 'Konfittii' was categorized as highly resistant with lowest mean aphid intensity of just 2.00 aphids/ shoot while 'Grand Gala' was classified as highly susceptible cultivar with highest mean aphid intensity of 20.00 aphids/ shoot. In conclusion, the geographical position of Kashmir valley makes it better suited to meet huge demand of cut flowers in Middle East than Netherlands which is situated much far away from this region. As such the future research should focus on inter specific hybridization programs for development of aphid resistant cultivars of roses. This can provide much needed impetus to nascent floriculture industry of our state.

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