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POPULATION DYNAMICS, BIOLOGY OF COTTON APHID, *APHIS GOSSYPII* (GLOVER) AND ITS ASSOCIATED NATURAL ENEMIES IN VADODARA, GUJARAT

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ABSTRACT
The population dynamics study of *Aphis gossypii* Glover (Hemiptera: Aphididae), a serious pest in Vadodara, India were conducted during 2008-2011. The results show that the aphid population is higher in the months of January to March on cotton (*Gossypium hirsutum* L.).Whereas maximum population of aphid were seen in the month of February on Cotton (*Gossypium hirsutum* L.) host plants. The correlation of aphid population was done with abiotic and biotic parameters. The aphid population was showing positive correlation with higher temperature and negative correlation with lower temperature and humidity. The associated insects such as coccinellids and ant showed positive correlation with relative humidity. Further the biology of the *Aphis gossypii* Glover was studied on *Gossypium hirsutum* (L.) under the laboratory conditions. *Aphis gossypii* Glover have a complex life cycle with cyclic parthenogenesis. It is difficult to scan the aphid males because their life cycle continues on the secondary host. The results on different biological parameters showed that the total life duration of female ranged from 28-44 days. The fecundity rate was 1499± 458.2 days. The longevity of female aphid on an average was 8.1 days with a maximum of 22 days. Hence, the information contained in this paper lead to the identification of proper management practices during effective reproductive period for *Aphis gossypii* Glover management.

KEY WORDS: Population dynamics, *Aphis gossypii*, Biological studies, Cotton plant.

INTRODUCTION
Cotton assumes a place of pride in Indian economy as it is one of the most important cash crops in India and plays a dominant role in industrial and agricultural economy of the country (Tomar, 2010). Worldwide, the *Aphis gossypii* Glover is a major threat to agriculture and horticulture in many tropical, sub-tropical and temperate countries (Satar *et al*., 1998) which was found to attack a large number of plant species including crops (Cereals, Pulses and Oilseeds), vegetables, fruits, ornamental plants, weeds and wild Plants (Mifsud *et al*., 2011). They were attacking 220 host plant species belonging to 46 different families throughout the world (Patil, 2013) which makes it a polyphagous pest. However, the evidence of aphid was reported from almost all over India (Singh *et al*., 2014). Due to a large number of host range, aphids seem to be present throughout the year (Razaq *et al*., 2011). The *Aphis gossypii* Glover causes yield loss by directly infesting leaves, stems, fruits, roots and also cause damage indirectly by secreting honey dew which cause development of sooty mold as well as attracting ant as transporting agents of the aphid to the different host plants (Patil, 2013). The Cotton aphids mainly damage the cotton leaves, tender shoots, cotton balls and finally the whole crop. In 2002, the cotton aphid was regarded as the sixth most damaging pest of US cotton. The aphid infested 70.3% of US cotton, causing a 0.119% reduction in yield in 9,307,757 infested acres, resulting in a loss of 31,450 bales (Anwar *et al*., 2007). Heavy infestations may result in stunted leaves with distortions and curling. The aphids deposit sticky honeydew on leaves and cotton balls. Black mold growing on this honeydew can lower the quality of the lint (Steinkraus *et al*., 1991). Propensity to cause damage to various host plants and its association with various natural enemies motivated us to take the population dynamics and biological study of aphids. Application of these studies will be helpful during proper implementation of various control measures against this pest.

MATERIALS & METHODS
Record of aphid population
Observations on population dynamics of aphids and its associated insects were recorded from the selected agricultural sites in Vadodara. The population of aphids was recorded on 10 cm apical shoot length from 2008 to 2011 at weekly interval from randomly selected twenty plants. Similar pattern was followed for associated insects. The relation between an aphid population, its associated insects and weather parameters was also worked out (Hanchinal *et al*., 2010).

Record of biological parameters
The biology of *Aphis gossypii* Glover was studied on the infested cotton leaves at room temperature at 25±1ºC, 60± 10% RH, Photoperiod of 16:8hr (L:D) in the laboratory. The twig of Cotton branch harbouring *Aphis gossypii* Glover colonies were plucked from the field and brought into the laboratory. The aphids present on such twigs were gently removed with the help of camel hair- brush and released on the clean cotton leaves in the plastic boxes (35× 20 cm). Ten such plastic boxes having 10-12 cotton leaves with 30 -60 aphids released in them were

maintained in the laboratory. Rearing method was similar to that used by (Kedar *et al*., 2011). Newly hatched crawlers obtained from the ovipositing females of the laboratory culture were picked up with the help of camel hair-brush and placed onto the cotton leaves at the rate of one crawler/cotton leaf. Such cotton leaves were kept in open petri plates. There are total 25 replicates containing 1 crawler/leaf. Daily observations were made on the ecdysis of nymphs to determine the instar and its duration. The reproductive period, post reproductive period, fecundity and longevity of adult females were also recorded. All the stages are observed under stereomicroscope and then identified using standard manuals.

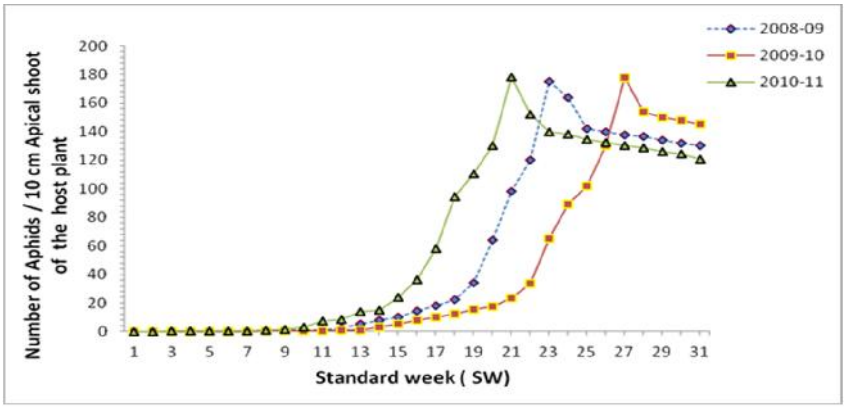
Statistical Analysis

The raw data of all the sampled sites from the field diary of the three consecutive years were transferred in an electronic format in a spreadsheet layout (Microsoft excel, 2007). The data was finally analyzed to calculate important value indices from all the sampling sites. Further correlation was calculated by using Minitab 16 Statistical Software (Pennsylvania state university, USA, 2011) with the biotic (associated insects) and abiotic factors (weather parameters) which are affecting the population of aphids.

RESULTS

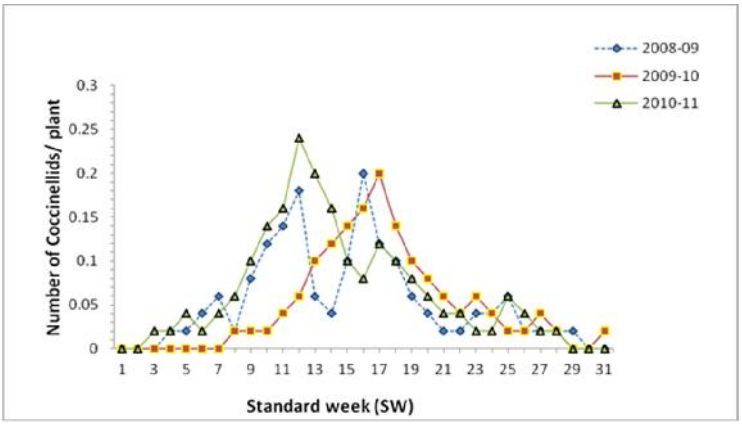
A) Population dynamics and its correlation with weather parameters

In agriculture fields of Vadodara, *Aphis gossypii* Glover infestation started appearing in the month of September which progressively increases on host plants, cotton (*Gossypium hirusutum* L.*)*. Observations were made on increased infestation as crop growth advanced in all the three consecutive years 2008-09, 2009-10 and 2010-2011. The correlation factors were also recorded in respect with weather parameter in all the three years (Table 4). During the year 2008-09 of study period, the Cotton aphid population was 0.45/10 cm apical shoot in the 39th meteorological week and progressively increased throughout the season. The population reached to 120.00 /10 cm apical shoot in the fifth meteorological week of January and thereafter increased suddenly to reach 175.00/10cm apical shoot in the first week of February. Later on, the infestation of aphids declined gradually and reached to 130.00/10cm apical shoot in the 14th meteorological week. In general, population of its associated insects was low during the cropping season. The maximum population of coccinellids and ants were 0.20 and 0.22 per plant, respectively in the third and the first week of December during this season. (Table 1; Figure. 1, Figure. 2, Figure. 3).



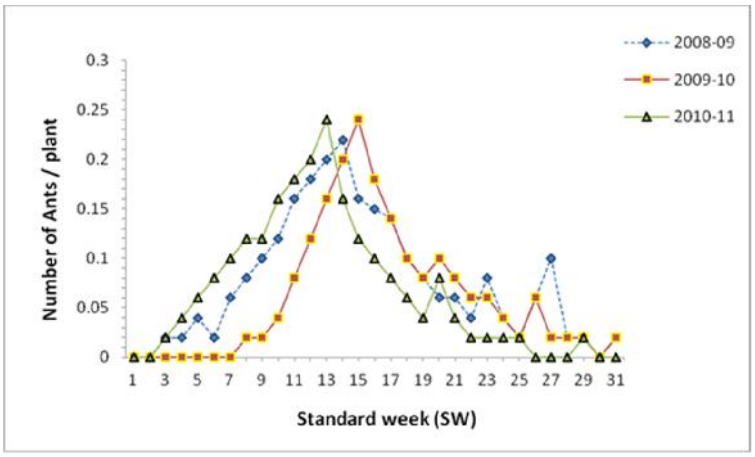
*Standard week (1-31) in X-axis – Refer Table 1to3 (Meteorological weeks 36 to 14; September to March Months)

FIGURE. 1 Population Dynamics of *Aphis gossypii* (Graph showing mean population of aphids collected from 10 cm Apical shoot of the cotton crop at equal interval of time in the three years of study)



*Standard week (1-31) in X-axis – Refer Tables 1to 3 (Meteorological weeks 36 to 14; September to March Months)

FIGURE 2: Population Dynamics of Coccinellid beetles (Graph showing mean population of predators, Coccinellids collected from 10 cm Apical shoot of the cotton crop at equal interval of time in the three years of study)



*Standard week (1-31) in X-axis – Refer Table 1to3 (Meteorological weeks 36 to 14; September to March Months)

FIGURE 3: Population Dynamics of Ants (Graph showing mean population of associated natural enemies, ants collected from 10 cm Apical shoot of the cotton crop at equal interval of time in the three years of study)

Aphid population was significantly and positively correlated with maximum temperature (0.350) and negatively correlated with other parameters (minimum temperature, relative humidity I and II and rainfall). Among predators, there was a significant correlation between coccinellid population and relative humidity I (0.437), relative humidity II (0.481). The other parameters were non-significant. Moreover, it has been observed that there was a positive correlation between the population of ants and relative humidity I (0.523), relative humidity II (0.496) but a negative correlation with other meteorological parameters (Table 4). During 2009-10 of study period, the Cotton aphid population was 0.30/10 cm apical shoot in the 43rd meteorological week and progressively increased throughout the season. The population reached to 102.10 /10 cm apical shoot in the third week of February and thereafter increased suddenly to reach 178.00/10cm apical shoot in the first week of March. Later on, the infestation of aphids declined gradually and reached to 145.00/10cm apical shoot in the 14th meteorological week. In general, the predator population was low during the cropping season. The maximum population of coccinellids, and ants were 0.20 and 0.24 %, respectively in the fourth and the second week of December during this season (Table 2; Figure. 1, Figure. 2, Figure. 3). The aphid population showed positive correlation with maximum temperature (0.0541) and a negative correlation with other parameters (minimum temperature, relative humidity I and II and rainfall). A significant correlation was observed between coccinellid population and relative humidity I (0.034), relative humidity II (0.174). The other parameters were non-significant. Moreover, there was a positive correlation between the population of ants and rainfall (0.062), relative humidity I (0.156) and relative humidity II (0.311) whereas the other meteorological parameters showed negative correlation. (Table 4)

During the year 2010-11 of study period, the Cotton aphid population was 0.15/10 cm apical shoot in the second week of September and progressively increased throughout the season. The population reached to 110.60 /10 cm apical shoot in the first week of January. The peak population of aphids suddenly to reach 178.20/10cm apical shoot in the third week of January. Later on infestation of aphids declined gradually and reached to 120.50/10cm apical shoot in the 14th meteorological week. The maximum population of coccinellids and ants were 0.24 and 0.24 per plant, respectively in the third and fourth week of November during this season. (Table 3; Figure. 1, Figure. 2, Figure. 3)

The aphid population showed positive correlation with maximum temperature (0.020) and a negative correlation with other parameters (minimum temperature, relative humidity I and II and rainfall). A positive correlation was observed between coccinellid population and relative humidity I (0.020), relative humidity II (0.169). The other parameters were non-significant. Moreover, there was a positive correlation between the population of ants and relative humidity I (0.152) and relative humidity II (0.292) whereas the other meteorological parameters showed negative correlation (Table 4). Hence, in all the three consecutive years the maximum temperature shows positive correlation in the case of aphid population and relative humidity shows positive correlation in case of its associated insects such as coccinelids and ant population.

B) *Study of Biological Parameters of Aphis gossypii (Glover)*

The data recorded on different biological parameters are given in (Table 5**)**. The life cycle of aphid was very much unusual. Three different stages are found in aphid cycle, namely eggs, nymphs, and adults. The development from eggs to adult form takes 15 days. Female undergo 4-5 molts. Winged, wingless forms are also present. It was evident that the mean duration were 3.88±1.69, 4.48±2.51, 3.16±1.57, 3.28±1.62 and 8.28±1.90 for the first, second, third, fourth and fifth nymph females of *A. gossypii*, respectively.

For the males, aphid cycle is quite complicated because when winter approaches, some of the females get transformed into males (Pilgrim, 2010). The males are generally found on the secondary host plant so it is quite difficult to scan their life forms. The adult female had pre-reproductive and post-reproductive period of 11.24±3.28 and 17.80±4.0 days, respectively.

TABLE 1: Population dynamics of *Aphis gossypii* (Cotton aphid), Coccinellids (Ladybird beetles) and Ants on apical shoot of host plant, Cotton (*Gossypium hirsutum* L.) in Agricultural fields of Vadodara during 2008-09.

Month	Standard Weeks	Maximum temperature (ºC)	Minimum temperature (ºC)	Relative humidity (%) (8.30 a.m.)	Relative humidity (%) (7.30 p.m.)	Rainfall (mm)	Aphids/ 10 cm Apical shoot	Coccinellids per plant	Ants per plant
September	36	36.3	25.6	70	15	15	0.00	0.00	0.00
	37	34.5	24.7	79	28	28	0.00	0.00	0.00
	38	32.1	23.8	94	69.8	69.8	0.00	0.00	0.02
	39	33.2	24.3	61	0	0	0.45	0.02	0.02
	40	36.2	24	69	2	2	0.50	0.02	0.04
October	41	38	25.1	58	0	0	0.62	0.04	0.02
	42	37.6	21.6	38	0	0	0.68	0.06	0.06
	43	35.8	20.1	52	0	0	0.80	0.02	0.08
	44	34.8	20.1	52	0	0	0.88	0.08	0.10
November	45	34.8	17.6	61	0	0	0.92	0.12	0.12
	46	34.6	17	64	0	0	1.20	0.14	0.16
	47	31.7	17	92	0	0	2.54	0.18	0.18
	48	33.1	15.7	71	0	0	5.24	0.06	0.20
December	49	34.8	18.1	81	0	0	7.82	0.04	0.22
	50	34	16.9	82	0	0	10.28	0.10	0.16
	51	32.7	18.8	89	0	0	14.54	0.20	0.15
	52	32.4	13.3	87	0	0	18.24	0.12	0.14
	1	31.4	12.8	89	0	0	22.54	0.10	0.10
January	2	28.2	13.6	44	0	0	34.24	0.06	0.08
	3	33	16.7	48	0	0	64.20	0.04	0.06
	4	32.3	16.1	44	0	0	98.20	0.02	0.06
	5	33.1	13.7	49	0	0	120.00	0.02	0.04
Febuary	6	33.3	14.6	46	0	0	175.00	0.04	0.08
	7	32.6	14.3	50	0	0	164.00	0.04	0.04
	8	37	17.4	39	0	0	142.00	0.06	0.02
	9	38.9	18.8	42	0	0	140.00	0.02	0.06
March	10	38.1	19.2	55	0	0	138.00	0.02	0.10
	11	38.7	18.7	32	0	0	136.72	0.02	0.02
	12	37.6	21.3	58	0	0	134.20	0.02	0.02
	13	38.7	22.2	33	0	0	132.10	0.00	0.00
	14	42.1	24.6	38	0	0	130.00	0.00	0.02

*Mean of 20 Plants

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TABLE 2: Population dynamics of *Aphis gossypii* (Cotton aphid), Coccinellids (Ladybird beetles) and Ants on apical shoot of host plant, Cotton (*Gossypium hirsutum* L.) in Agricultural fields of Vadodara during 2009-10.

Month	Standard Weeks	Maximum temperature (ºC)	Minimum temperature (ºC)	Relative humidity (%) (8.30 a.m.)	Relative humidity (%) (7.30 p.m.)	Rainfall (mm)	Aphids/ 10 cm Apical shoot	Coccinellids per plant	Ants per plant
September	36	33.8	23.4	93	95	3.6	0.00	0.00	0.00
	37	35.4	25.7	93	99	0	0.00	0.00	0.00
	38	36.6	25	93	90	0	0.00	0.00	0.00
	39	36.8	25.7	90	58	0	0.00	0.00	0.00
	40	39	24.5	80	60	0	0.00	0.00	0.00
October	41	34.7	23.3	85	69	0	0.00	0.00	0.00
	42	35.7	22.9	81	65	0	0.00	0.00	0.00
	43	36.7	17.9	87	59	0	0.30	0.02	0.02
	44	35.8	19.3	82	54	0	0.42	0.02	0.02
November	45	36.6	19	70	61	0	0.52	0.02	0.04
	46	31.2	18.6	88	71	13.2	0.68	0.04	0.08
	47	31.4	14.8	82	71	0	0.98	0.06	0.12
	48	32.3	16.8	89	77	0	1.20	0.10	0.16
December	49	31.5	17	90	81	0	3.40	0.12	0.20
	50	32.9	16	96	87	0	5.28	0.14	0.24
	51	31.3	18	92	88	2.2	7.94	0.16	0.18
	52	30.5	15.4	81	59	0	10.24	0.20	0.14
	1	31.4	14	75	49	0	12.34	0.14	0.10
January	2	29.7	12.9	59	46	0	15.28	0.10	0.08
	3	31.2	11.4	66	49	0	17.48	0.08	0.10
	4	32.3	13.5	67	52	0	23.50	0.06	0.08
	5	32.3	14.4	61	49	0	33.48	0.04	0.06
Febuary	6	34.1	15.2	62	59	0	65.28	0.06	0.06
	7	31.6	15	69	49	0	89.20	0.04	0.04
	8	36	14.3	55	40	0	102.10	0.02	0.02
	9	35.8	16.8	72	46	0	130.00	0.02	0.06
March	10	36.2	18.5	86	55	0	178.00	0.04	0.02
	11	39.2	20.1	74	37	0	154.00	0.02	0.02
	12	42.7	20.7	77	35	0	150.20	0.00	0.02
	13	38.9	21.9	79	32	0	148.00	0.00	0.00
	14	39.5	22.4	80	38	0	145.00	0.02	0.02

*Mean of 20 Plants

TABLE 3: Population dynamics of *Aphis gossypii* (Cotton aphid), Coccinellids (Ladybird beetles) and Ants on apical shoot of host plant, Cotton (Gossypium hirsutum L.) in Agricultural fields of Vadodara during 2010-11.

Month	Standard Week	Maximum temperature (ºC)	Minimum temperature (ºC)	Relative humidity (%) (8.30 a.m.)	Relative humidity (%) (7.30 p.m.)	Rainfall (mm)	Aphids / 10 cm apical shoot	Coccinellids per plant	Ants per plant
September	36	32.3	25.1	92	98	32	0.00	0.00	0.00
	37	31.4	24	92	98	118	0.15	0.00	0.00
	38	34.1	25.1	92	91	21	0.36	0.02	0.02
	39	36.3	24	92	75	1	0.52	0.02	0.04
	40	38.5	24.1	82	62	0	0.60	0.04	0.06
October	41	37.9	24	85	70	1	0.64	0.02	0.08
	42	37.4	24.1	83	65	0	0.76	0.04	0.10
	43	35.3	23.3	86	61	0	0.96	0.06	0.12
	44	36.3	19.4	82	58	0	1.46	0.10	0.12
November	45	33.5	19.3	68	47	0	3.28	0.14	0.16
	46	34.9	23.5	88	76	2	7.28	0.16	0.18
	47	33.8	18.5	86	77	19	8.48	0.24	0.20
	48	31.2	19.4	89	75	1	13.72	0.20	0.24
December	49	30.2	15.7	77	61	0	14.72	0.16	0.16
	50	28.2	11.2	62	66	0	23.74	0.10	0.12
	51	29.1	11.3	64	49	0	36.48	0.08	0.10
	52	29.5	12.4	79	59	0	58.26	0.12	0.08
	1	28.4	10.7	80	52	0	94.28	0.10	0.06
January	2	29	10	64	42	0	110.60	0.08	0.04
	3	29.9	10.5	68	45	0	130.00	0.06	0.08
	4	32.6	11.8	80	48	0	178.20	0.04	0.04
	5	30.2	13.8	69	50	0	152.20	0.04	0.02
Febuary	6	34.8	15.1	82	46	0	140.00	0.02	0.02
	7	34.9	16.2	80	44	0	138.20	0.02	0.02
	8	32.5	13.6	71	42	0	134.60	0.06	0.02
	9	35.8	16.8	50	33	0	132.20	0.04	0.00
March	10	37.3	17.4	82	35	0	130.00	0.02	0.00
	11	39.7	16.8	52	31	0	128.74	0.02	0.00
	12	40.7	20.1	73	39	0	126.20	0.00	0.02
	13	35.8	20.9	77	37	0	124.24	0.00	0.00
	14	37.2	21.1	79	39	0	120.50	0.00	0.00

*****Mean of 20 Plants

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TABLE 4: Correlation coefficient between weather parameters and seasonal fluctuations of Aphids and its associated natural enemies, predator (Coccinellids) and Ant on Cotton crop during three consecutive years.

Parameters	Meteorological Values	Correlation coefficient between weather parameters and Aphids population	Correlation coefficient between weather parameters and Coccinellid populations	Correlation coefficient between weather parameters and Ants populations
2008-09				
Maximum temperature (º C)	42.1	0.350*	-0.418	-0.390
Minimum temperature (º C)	12.8	-0.241	-0.452	-0.527
Rainfall (mm)	69.8	-0.240	-0.285	-0.287
Relative humidity I (8.30a.m.)	98	-0.578**	0.437	0.523
Relative humidity II (7.30p.m)	94	-0.638	0.481	0.496
2009- 10				
Maximum temperature (º C)	42.7	0.0541	-0.701	-0.650
Minimum temperature (º C)	12.9	-0.020	-0.621	-0.586**
Rainfall (mm)	13.2	-0.173	-0.013	0.062
Relative humidity I (8.30a.m.)	96	-0.316	0.034	0.156
Relative humidity II (7.30p.m)	99	-0.662	0.174	0.311
2010-11				
Maximum temperature (º C)	40.7	0.020	-0.379	-0.287
Minimum temperature (º C)	10	-0.590	-0.225	-0.016
Rainfall (mm)	118	-0.295	-0.179	-0.198
Relative humidity I (8.30a.m.)	92	-0.501	0.020	0.152
Relative humidity II (7.30p.m.)	98	-0.780	0.169	0.292

*Differs significantly (P = 0.05) **Differs significantly (P = 0.001)

The duration of the adult reproductive period is about 15 days, and the post-reproductive period five days (Capinera 2009). In the present studies, the total life duration of female ranged from 28-44 days. The fecundity rate was 1499±458.2. Aphids have both Apterous and winged forms. In Apterous form, the nymphal period ranges from 4-24 days, the longevity of aphid on an average was 9.1 days with a maximum of 41 days. A female with an average laid 15 nymphs with maximum of 95. In winged form, the nymphal period ranges from 5 to 22 days at an average of 10.1. The longevity of aphid on an average was 8.1 days with a maximum of 22 days. The fecundity of aphid was 9 nymphs (Table 6). Ullah (1980) also reported the similar observations for apterous and winged forms. The results indicated that the pest reproduced both asexually (parthenogenetically) and sexually. Aphids have many generations in each year.

TABLE 5: Biological parameters of *Aphis gossypii* Glover on *Gossypium hirsutum* (L.) under laboratory conditions

Biological parameters	Number observed	Mean± SD	Range
Incubation period	25	3.21±0.93	2-4
(A) Female Eggs (hatches)	Development from egg to adult is of 15 days		
*Nymphal duration (7days)			
First instar	25	3.88±1.69	3-6
Second instar	25	4.48±2.51	3-6
Third instar	25	3.16±1.57	3-6
Fourth instar	25	3.28±1.62	3-6
Fifth instar (Adult virgin female)	25	8.28±1.90	6-7
Pre- reproductive period (days)	25	11.24±3.28	7-15
Post reproductive period (days)	25	17.80±4.0	15-20
*Fecundity (No. of eggs laid / female)	25	1499±458.2	500-2375
*Adult longevity (days)	25	22.56±1.58	21-28
Total life cycles (days)	25	28.72±1.06	28-44

*****Value of Mean of 25 replicates ± SD

TABLE 6: Developmental stages of Apterous and Winged forms of Aphids

Developmental Stages	Apterous form		Winged form	
	Range	Average	Range	Average
Nymphal period	4-24 days	9.8	5-22	10.1
Adult logevity	1-41 days	9.1	1-24 days	8.1
Fecundity	1-95 nymphs	15	1-35 nymphs	9

DISCUSSION

The importance of the study of population dynamics of insect pests in agricultural fields is helpful for assessing the pesticide productivity and timing of pesticide application. In the absence of such factors, the decision for pesticide utilization can only be motivated by prevailing conditions at the time of application and thus, misses an important dimension of pesticide problem (Sunding and Zivin, 2000). The aphid population was observed from September 2008 to April 2011. The aphid population was seen on the cotton crop in the second week of September till April in all the three consecutive years. The peak incidence of aphid population was in the months of December – February. There are 5-6 associated insects recorded, namely, Coccinellid beetles, Spiders, Syphrid wasp, Hover flies, Ants etc. The ladybird beetles act as a biocontrol agent, though a predator of aphids. The strong Aphid – Ant association was seen on the cotton crop. So, the population dynamics of these two associated insects were calculated. The peak population of associated insects such as ladybird beetles and ants was also observed from September till April. The study on *Aphis gossypii* Glover during study period of 2008-2011 in Cotton fields of Channi, Vadodara. The cotton crop, grown over a half acre area in unprotected field, found that aphid infestation started appearing in the month of September and gradually increased with the advancement of crop growth. The maximum population of aphids was observed in the months of November to February which gradually starts decreasing in the months of March. The aphid population disappears totally in the month of April to reappear again in September (Kataria and Kumar, 2013). Karim *et al*. (2001) also reported that the aphid population started growing from August, reached highest in January and almost vanished in April. The average population reached to 120.00/10 cm apical shoot in the 5th meteorological week of January and thereafter increased suddenly that it reached to an average of 175.00/10 cm apical shoot in the 1st week of February. Later on, infestation of aphids declined gradually and reached to an average of 130.00/10 cm apical shoot in a 14th meteorological week during 2008-09. The correlation factors were recorded in respect with weather parameters, studies concluded that aphid population was significantly and positively correlated with maximum temperature (0.350) and negatively correlated with other parameters. Hasen *et al*. (2009) also reported that among the different environmental factors maximum temperature, dew point and sun shine hours were positively correlated with aphid population and minimum temperature, relative humidity and wind speed were negatively correlated with aphid population. There was positive correlation among the aphids with maximum temperature, whereas negative correlation was observed with relative humidity and rainfall in Madhya Pradesh. All

the meteorological parameters influenced of aphids on okra agro- ecosystem in Chitrakoot region, Madhya Pradesh where aphid showed negative correlation with minimum (r = - 0.2930), and mean temperature (r = -0.2120), rainfall (r = -0.3802), maximum (r = -0.5378) and minimum (r =- 0.5109) relative humidity whereas, positive correlation with maximum (r = -0.0384) and coccinellids (r = 0.7438) (Singh *et al*., 2013). Shivanna *et al*. (2011) reported that the maximum temperature was positively correlated with aphid population and negatively correlated with other parameters. Devi *et al*. (2010) reported that the aphid predators such as Coccinellids show positive correlation with relative humidity. The foraging activity of *Tapinoma indicum* Forel over a period of 72 hours revealed that their activities were negatively correlated with environmental temperature, but positively correlated with relative humidity (Chong and Lee, 2006). In Punjab, the population of predators had a significant positive correlation with maximum, minimum, mean temperature, sunshine and vapour pressure (Soni *et al*., 2013). An experiment was conducted during 1983-91 at Anand (Gujarat) to study the outcome of weather factors on the activity of *Aphis gossypii* Glover infesting okra (Patel *et al*., 1997a). Hence, today it is gaining major concern for the study. The study of its biology is important for understanding the form and extent of its population growth. Since, under field condition due to interference of biotic and abiotic factors, it is difficult to study the life history and pattern of biological activities of *Aphis gossypii* Glover. Hence, study was conducted under laboratory condition. The studies on the biology of aphid, *Aphis gossypii* (Glover) on isabgol were carried out in laboratory condition at Department of Agricultural Entomology, C. P. college of Agriculture, S. D. Agricultural University, Sardar Krushi Nagar during 2008-2009. It was found that the average longevity of the adult was recorded as (16.36±0.54) days and the total life span of *Aphis gossypii* Glover was (23.76±0.65) days (Patil and Patel, 2013). Similarly, studies on the biology and ecology of the cabbage aphid, *Brevicoryne brassicae* Linn. under laboratory conditions at the D.D.U. Gorakhpur University, Gorakhpur, Uttar Pradesh found that one cabbage aphid generation develops in 7-10 days (Pal and Singh, 2013). Research work conducted on biological studies of other species of aphids belonging to the same family, Sugarcane woolly aphid, *Ceratovacuna lanigera* (Zehntner) reported the average longevity of apterous and alatae adults was 36 and 8.3 days, 20.5 and 24.1 days. The average fecundity of apterous adult was 60 aphids, while it was 10 aphids in alatae. The rate of reproduction under laboratory conditions varied from 3 to 5 nymphs per day, with a total fecundity of 41 to 56.6 aphids (Joshi and Viraktamath, 2014). The study of biology of aphid provides information regarding longer life span of adults and higher food requirements leading to the visibility of the pest and symptoms, respectively, on the crop and is thus utilized for proper assessment for use of control measures in the field. Hence, this information will be helpful during the development of successful Integrated Pest Management program (IPM) for *Aphis gossypii* Glover control.

CONCLUSION

The presence of large host range and high reproductive rate of Aphid, *Aphis gossypii* (Glover) causes its persistence throughout the year. This makes them a great economic threat in agricultural fields of Vadodara. The present study on biology of aphid, *Aphis gossypii* (Glover) give the understanding of mode and degree of its population growth. Hence, this information will be helpful during the development of successful Integrated Pest Management program (IPM) for *Aphis gossypii* (Glover) which is considered as the polyphagous pest in the world.

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