International Journal of Research Studies in Zoology (IJRSZ)
Volume 1, Issue 1, June 2015, PP 1-9
www.arcjournals.org

Life History Parameters of *Aphis gossypii* Glover (Homoptera: Aphididae) Reared on Three Vegetable Crops

Rajendra Singh, Kusum Singh

Department of Zoology
D.D.U. Gorakhpur University
Gorakhpur, U.P., India
rsinghgpu@gmail.com

Abstract: *The Aphis gossypii Glover is a cosmopolitan, polyphagous species and locally is a serious pest of okra, cucurbits, brinjal and chilli. It pass through four nymphal stages before adulthood. The objective of the present study was to determine the variations in biological performance of a okra population of A. gossypii on three food plants: brinjal (Solanum melongena L., Solanaceae), chilli (Capsicum frutescens L., Solanaceae) and bottle gourd (Lagenaria siceraria (Molino) Standl., Cucurbitaceae). The total nymphal period was longer (8.24±O.82 days) on brinjal, followed by chilli (7.64±0.96 days) and gourd (7.07±0.62 days) and the differences were significant. The reproductive period was maximum (11.37±0.06 days) on gourd, followed by chilli (10.67±1.63 days) and brinjal (9.97±1.33 days). The analyses of survival curves (1x) of A. gossypii revealed no significant difference among the three host plant tested. The highest age-specific number of nymphs/aphid/day (m_x) occurred on gourd and brinjal at an age of six days with 4.1 nymphs/aphid, and the lowest on chilli with 3.8 nymphs/aphid on the sixth day. The tested host plants significantly affected the fecundity of A. gossypii ($P < 0.05$). Age-specific net fecundity rate (R_o) for A. gossypii was 36.57±2.23 nymphs/aphid on gourd and was significantly more than on brinjal (33.83±2.26 nymphs/aphid) and chilli (30.63±1.85 nymphs/aphid). The generation time (GT) of A. gossypii on the three food plants ranged between 11.87 days (on gourd) to 12.57 days (on chilli). The highest intrinsic rate of increase (r_m) occurred on gourd (0.3031 aphids/aphid/day) and the lowest on chilli (0.2747 aphids/aphid/day). Doubling time (DT) is the period during which the population of an organism double its original size. Since its value is calculated by using the value of rm, it follows the pattern of the latter. The DT of A. gossypii significantly differ on different food plants ($P < 0.01$) and was shortest on gourd (2.29 days) followed by on brinjal (2.36 days) and on chilli (2.52 days).*

Keywords: *Life-table statistics, Lagenaria siceraria, Capsicum frutescens, aphid, Solanum melongena Aphis gossypii, food preference.*

1. Introduction

The *Aphis gossypii* Glover (Homoptera : Aphididae), a cosmopolitan, polyphagous sap sucking insect infesting over 900 plant species in the world [1], is a major pest of numerous crops throughout the world [2]. Locally, it is a major pest of okra, cucurbits, brinjal, chilli etc. It causes direct damage to the plant by sucking their nutrition. It also injure the crop by excretion of honeydew that favour growth of sooty mould inhibiting photosynthesis and also by transmission of plant viruses [3]. Besides the appearance of insecticide resistance [4-6] and the reduction of natural enemies, changes in nutritional and bioclimatic factors result in conditions more favourable to *A. gossypii*, which in turn may account for the enormous damage of crops. It is well known that the performance of *A. gossypii* originating from different plant hosts and/or geographical regions varies largely among different host plant species and regions [7-9]. Furthermore, more recent studies provided strong evidences that genetically distinct host races exist in *A. gossypii*. Cotton aphid clones from cucumber performed badly on chrysanthemum and similarly those from chrysanthemum developed poorly on cucumber [10-12]. From the present knowledge, it may be concluded that the existence of host incompatibility and host races is a common phenomena in *A. gossypii*. The objective of the present study was to determine the variations in biological performance of a okra population of *A. gossypii* on brinjal (*Solanum melongena* L., Solanaceae), chilli (*Capsicum frutescens* L., Solanaceae) and bottle gourd (*Lagenaria siceraria* (Molino) Standl., Cucurbitaceae) as no work has been done on the biology of the aphid species on vegetable crops in the northeastern Uttar Pradesh.

2. MATERIALS AND METHODS

A. gossypii were obtained from okra [*Abelmoschus esculentus* (L.) Moench (Malvaceae)] fields and colonised on the same food plant at 25±1 °C, 65±10 % R.H. and 14 h photoperiod in the laboratory. Three host plants were grown in the field laboratory : *S. melongena* (variety : *Shahna*), *C. frutescens* (variety : *Wonder Hot*) and *L. siceraria* (variety : *Pusa Neveen*). Leaves of the plants used in the experiments were between 4-6 week of age and fully extended. Randomly selected apterous virginoparous females from the stock culture were transferred onto cut leaf disks of each of the three host plants placed upside down on wet cotton wool in the Petri dishes (5 cm diameter). Offspring born within 24 h were individually confined on leaf disks in the Petri dishes. The replications in which the newly born nymphs died within 24 h after transfer or in which individuals were lost during the experiment were excluded from the data. The cotton wool in the Petri dishes was saturated daily with water and every 3-5 days aphids were transferred to new leaf disks. For each set (total 3 sets) of the experiments 10 apterous female were utilized. The exuviae were used to determine the moulting time; new born nymphs were removed after counting.

Differences in developmental time and fecundity were tested by analysis of variance (ANOVA). If significant differences were detected, multiple comparisons were made using the Duncan's Multiple Range Test (DMRT) at $P < 0.01$. For each host plant survival curves were calculated employing a product limit technique. Individuals that were still alive at the end of the 15-day experiment period were censored. Survival curves were analysed by using the χ^2-test to separate differences among curves.

Population growth rates were computed from the equation of Lotka [13]:

$$\Sigma\, l_x m_x e(-r_m x) = 1$$

where x = pivotal age in days, r_m = intrinsic rate of natural increase, 1_x = age-specific survival rate, m_x = age-specific number of female births.

The net reproductive rate (R_o) defined as the mean number of female progeny produced by one female during its mean life-span, was calculated by the equation:

$$R_o = \sum l_x m_x$$

The generation time (GT) which was equivalent to the mean period of elapsing between the birth of parents and the birth of the progeny and doubling time (DT), defined as the time required to double the population size were calculated by the formulae:

$$GT = \text{In } R_o / r_m$$

$$DT = \text{In } 2 / r_m$$

The finite rate of increase λ_m and the weekly multiplication rate, r_w, i.e. the factor of the population by which the population increase per week were calculated as :

$$\lambda_m = \exp(r_m)$$

$$r_w = \lambda_m^{\ 7}$$

3. RESULTS

3.1 Developmental Period

A. gossypii pass through four nymphal stages before attaining adulthood. There was no significant difference in the duration of the first and third instars on the three crops, viz., chilli, gourd and brinjal, however, significant differences in the duration of second and fourth nymphal instars were observed (Table 1). The duration of the first instar lasted 2.07±0.64, 2.03±0.18 and 2.17±0.38 days on chilli, gourd and brinjal, respectively. The second instar was completed in 2.10±0.31, 1.80±0.41 and 2.07±0.25 days on chilli, gourd and brinjal, respectively; the third instar completed in 2.00±0.26, 1.97±0.32 and 2.03±0.32 days on chilli, gourd and brinjal, respectively; while the duration of the fourth instar was 1.47±0.68, 1.27±0.45 and 1.97±0.41 days on chilli, gourd and brinjal, respectively.

Table 1. *Developmental period (in days) of instars and nymphal mortality of Aphis gossypii on chilli, bottle gourd and brinjal. Values are expressed as mean ±SD.*

Host plants	Duration of instar (days)				Developmental period	Nymphal mortality (%)
	I	II	III	IV		
Capsicum frutescens	2.07 ±0.64	2.10 ±0.31	2.00 ±0.26	1.47 ±0.68	7.64±0.96ab	3.4
Lagenaria siceraria	2.03 ±0.18	1.80 ±0.41	1.97 ±0.32	1.27 ±0.45	7.07±0.62a	2.1
Solanum melongena	2.17 ±0.38	2.07 ±0.25	2.03 ±0.32	1.97 ±0.41	8.24±0.82b	4.8
F-values	0.74	7.53	0.37	13.96	15.26	-
Level of significance	NS	0.01	NS	0.01	0.01	-
Mean differences followed by common letter are not significantly different (P <0.05), DMRT.						

The total nymphal period was more (8.24±0.82 days) on brinjal, followed by chilli (7.64±0.96 days) and gourd (7.07±0.62 days). A significant difference in the duration of total nymphal period on three test crops was observed (Table 1).

3.2 Nymphal Mortality

Mortality of *A. gossypii* nymphs was considerably low for all three host plants tested, with a maximum rate of 4.8% on brinjal (Table 1).

3.3 Pre-reproductive, Reproductive and Post-reproductive Periods

There was significant difference in the duration of pre-reproductive and reproductive periods but was not significant for post-reproductive periods on all the three crops (Table 2). Pre-reproductive period was 1.73±0.94, 1.30±0.10 and 1.67±0.88 days on chilli, gourd and brinjal, respectively. The reproductive period was maximum on gourd (11.37±0.06 days), followed by chilli (10.67±1.63 days) and brinjal (9.97±1.33 days) when the mean temperature and relative humidity was 20°C and 60-70 per cent, respectively. Post-reproductive period was 0.83±0.91, 0.50±0.20 and 0.90±0.88 days on chilli, gourd and brinjal, respectively.

There was no significant difference in the longevity of the adults on all the three crops (Table 2). However, the adult survived longer on chilli (13.23±2.91 days) followed by on gourd (13.17±3.45 days) and brinjal (12.53±2.56 days).

Table 2. *Pre-reproductive, reproductive and post-reproductive periods (in days) of Aphis gossypii on chilli, bottle gourd and brinjal. Values are expressed as mean ±SD.*

Host plants	Pre-reproductive period	Reproductive period	Post-reproductive period	Adult longevity
Capsicum frutescens	1.73±0.94	10.67±1.63	0.83±0.91	13.23±2.91
Lagenaria siceraria	1.30±0.15	11.37±0.06	0.50±0.20	13.17±0.25
Solanum melongena	1.67±0.88	9.97±1.33	0.90±0.88	12.53±2.56
F-values	8.57	5.06	1.23	0.65
Level of significance	0.01	0.01	NS	NS

3.4 Life-table Parameters

3.4.1 Age-specific survival rate (l_x)

The course of the age-specific survival rate (1_x) of *A. gossypii* for each host plant are presented in Fig. 1A. Adult mortality began after 7 days on chilli and gourd and after 10 days on brinjal. Interestingly, the mortality of *A. gossypii* on all food plants increased considerably shortly after the peak in nymph production (Fig. 1B). Survival curve analyses revealed that no significant differences exist among the three host plant tested (F = 0.06; NS).

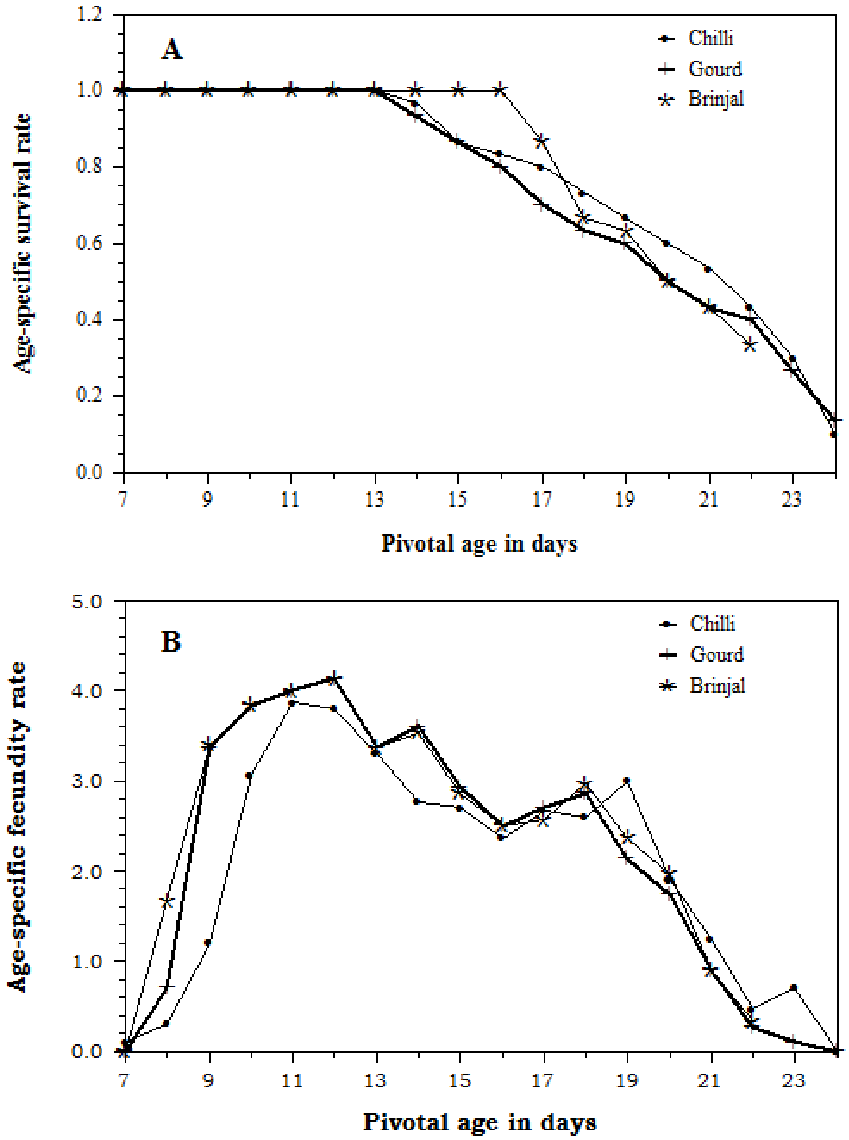

Fig. 1. *Age-specific survival rate (A) and age-specific fecundity rate (B) of Aphis gossypii on three food plants.*

3.4.2 Age-specific fecundity rate (m_x) and net fecundity rate (R_o)

The age-specific number of progeny per day (m_x) of *A. gossypii* for each host plant is presented in Fig. 1B. The value of m_x was highest on gourd and brinjal at an age of six days with 4.1 nymphs/aphid, and the lowest on chilli with 3.8 nymphs/aphid on the sixth day. The tested host plants significantly affected the fecundity of *A. gossypii* ($F = 5.59$, $P < 0.05$). The cumulative age-specific number of progeny per day is illustrated in Fig. 2A which demonstrated that most of the nymphs are produced before 20 days of pivotal age. Because *A. gossypii* has overlapping generations, the definition of R_o, generally referred to as net reproductive rate, is more limited here and only depicts the mean number of aphids laid during an individual's lifetime. R_o-values for *A. gossypii* were calculated to be 36.57±2.23 nymphs/aphid on gourd. The reproduction was significantly lower on chilli (30.63±1.85 nymphs/aphid). On average, 33.83±2.26 nymphs/aphid were deposited on brinjal (Table 3).

Table 3. *Generation time (GT), net reproductive rate (R_o), and rate of population growth (r_m) of a okra population of Aphis gossypii on three different host plants at 25 °C in the laboratory. Values are expressed as mean ±SD.*

Host plants	GT	R_o	r_m
Capsicum frutescens	12.57±0.055	30.63±1.845	0.2747±0.0048
Lagenaria siceraria	11.87±0.336	36.57±2.230	0.3031±0.0068
Solanum melongena	12.00±0.207	33.83±2.259	0.2934±0.0057
F-values	7.83	5.89	18.36
Level of significance	0.05	0.05	0.01

3.4.3 Generation time (GT)

The generation time (GT) of *A. gossypii* on the three food plants ranged between 11.87 days (on gourd) and 12.57 days (on chilli) (Table 3) and the differences are significant ($F = 7.83$, $P < 0.05$).

3.4.4 Intrinsic rate of increase (r_m)

The highest intrinsic rate of increase (r_m) of *A. gossypii* was observed on gourd (0.3031 aphids/aphid/day) and the lowest on chilli (0.2747 aphids/aphid/day). The mean differences are statistically significant ($F = 18.36$, $P < 0.01$) (Table 3).

3.4.5 Doubling time (DT)

Doubling time (DT) is the period during which the population of an organism doubles its original size. Since its value is calculated by using the value of r_m, it follows the pattern of the latter. Fnukad DT of *A. gossypii* significantly differ on different food plants ($F = 19.48$, $P < 0.01$). It was shortest on gourd (2.29 days) followed by on brinjal (2.36 days) and on chilli (2.52 days) (Table 4).

Table 4. *Doubling time (DT), weekly multiplication rate (r_w), and finite rate of population growth (λ_m) of a okra population of Aphis gossypii on three different host plants at 25 °C in the laboratory. Values are expressed as mean ±SD.*

Host plants	DT	r_w	λ_m
Capsicum frutescens	2.52±0.044	6.84±0.226	1.32±0.006
Lagenaria siceraria	2.29±0.051	8.35±0.403	1.35±0.009
Solanum melongena	2.36±0.047	7.80±0.312	1.34±0.008
F-values	19.48	16.92	18.16
Level of significance	0.01	0.01	0.01

3.4.6 Finite rate of increase (λ_m) and weekly multiplication rate (r_w)

The finite rate of increase (λ_m) is calculated by taking exponent value of r_m. Any factor over it depicts that the population increase by that period in days. For example, λ_m^7 ($= r_w$) indicates the factor by which the population increase per week. Since its value is also calculated by using the value of r_m, it follows the pattern of the latter. The r_w of *A. gossypii* significantly differ on different food plants ($F = 16.92$, $P < 0.01$). It was maximum on gourd (8.35) followed by on brinjal (7.80) and on chilli (6.84) (Table 4).

4. DISCUSSION

Although, *A. gossypii* is known as a highly polyphagous species [3], it is widely accepted in the literature that its performance varies widely among different host plants [10, 14-25]. There are three possible reasons, which may account, alone or in combination, for the observed differences: a. host plants vary widely in their nutritional value for *A. gossypii*; b. the utilization of a new host plant depends on the experience of the aphid in that *A. gossypii* needs time to adapt to a new host; and c. genetically distinct forms or host races exist in *A. gossypii*, which differ in their ability to colonize various host plants.

In the present experiments only one line of *A. gossypii* was tested, originally obtained from okra (*A. esculentus*) and maintained on the same host plant in the laboratory for one generation. Thus, it may be presumed that this population was adapted to okra. Transfer to a new host plant should, therefore, affect the performance of the aphid; while some may succeed, others may be totally unable to adapt to the new host [26]. In aphids, in which the offspring are born live and generations are “telescoped” in that embryos of grand-daughters are already developing within the embryonic daughters of a given female, maternal effects on offspring quality seems particularly likely [27]. Embryos are bathed in any ingested compound that passes into the haemolymph. This very early experience could potentially bias subsequent feeding preferences for alternative host plants, and even a brief delay on an unusual host plant in an early-instar aphid could prejudice its subsequent performance. The negative correlation of aphids to utilize new host plants has been already reported for several species, including *A. gossypii* [27-29].

The present experiments demonstrated significant differences in the performance of the *A. gossypii* among the three food plants tested. *A. gossypii*, at least for the okra aphid population used in the experiments, performed significantly better on gourd than on chilli and brinjal where upon a significant low population growth was recorded. There are reports that host plants significantly influence the survival curve of *A. gossypii* [27]. They observed that the form of the survival curve of the *A. gossypii* population enclosed with okra was significantly different from that on common mallow and cotton, however, they reported no significant differences between the survival curves of *A. gossypii* on common mallow and cotton.

In general, *A. gossypii* took less time to develop on gourd. The developmental period of *A. gossypii* on the same or the other host plants recorded in literature [14, 27, 30-33] cannot be compared as the experimental design and environmental conditions such as temperature, humidity, quality of food plant, nutrients in soil etc. vary significantly through these studies [34].

The nymphal period recorded in the present study was higher than recorded at Bhubaneswar (5.0-5.5 days) on brinjal where the studies were made under controlled conditions while almost similar duration was reported in Punjab [14]. Nymphal mortality recorded in the present study was almost similar to earlier studies [14, 27].

Data shown in Table 5 display a high range of variation in estimates of fecundity rate, intrinsic rate of increase and other life-table parameters of *A. gossypii* on different or on the same food plants. For example, the fecundity of *A. gossypii* was reported as high as as 82.1 nymphs/aphid on cucumber [28] and as low as 12.1 nymphs/aphid on chrysanthemum [35] at 25 ºC.

The *A. gossypii* displayed a significant higher fecundity on gourd than on brinjal and chilli and only small differences were observed between developmental times on these plants. Thus, for *A. gossypii*, gourd appears to be of most suitable food plant than others. However, besides a lower nutrition value, the existence of defense mechanisms in brinjal such as hairs, trichomes or allelochemical defenses might be responsible for the low reproduction of *A. gossypii* on chilli and brinjal than gourd.

Table 5. *Estimates of net fecundity rate (R_o), intrinsic rate of natural increase (rm), doubling time (DT) anf generation time (GT) of Aphis gossypii at 25 ºC on various food plants reared in the laboratory.*

Food plants	R_o	r_m	DT	GT	Reference
Abelmoschus esculentus (L.) Moench)	25.6	-	-	11.1	[36]
Chrysanthemum cv. Dark Splendid Reagan	12.1	0.215	3.2	11.5	[35]
Chrysanthemum cv. White Reagan	14.6	0.239	2.9	11.1	[35]
Chrysanthemum cv. Yellow Snowdon	46.1	0.315	2.2	12.3	[35]
Citrus unshiu Marcow.	23.4	0.301	2.05	10.5	[37]
Cucumber	82.1	0.526	-	-	[28]
Cucumber	76.8	0.472	-	-	[23]
Cucumber cv. Sporu	65.9	0.556	-	-	[32]
Cucumis melo	40.6	0.420	-	-	[38, 39]
Gossypium hirsutum	24.4	0.386	1.8	-	[40]
Grape fruit	14.5	0.302	-	-	[28]
Psidium guajava	45.9	0.338	5.44-7.44	14.2	[41]
Pumpkin	32.7	0.393	1.40	-	[23]
Solanum nigrum	-	0.527	-	-	[42]
Spermacoce latifolia	-	0.194	-	-	[16]
Squash	43.9	0.492	1.75	-	[23]

This study is in agreement of the opinion that *A. gossypii* from different host plants showed biologically different forms [12]. Earlier, distinguishable variations in morphology, ecological performance and esterase pattern of *A. gossypii* populations from these hosts was reportef [11]. Therefore, *A. gossypii* should be regarded as a heterogenous species infesting various host plants at different rates, that is, it showed host plant specialization. Studies on *A. gossypii* suggest that its evolutionary potential to adapt to newer host plants might be quite large and it holds the potential of becoming pest on an increasing number of crops 9, 43, 44] which is reflected by its host range (569 plant species under 103 families [3].

5. Conclusion

The objective of the present study was to determine the variations in biological performance of a okra population of *A. gossypii* on brinjal (*S. melongena*), chilli (*C. frutescens*) and bottle gourd (*L. siceraria*) in the eastern Uttar Pradesh. The results presented herein demonstrated significant differences in the performance of the *A. gossypii* among the three food plants tested. *A. gossypii*, at least for the okra aphid population used in the experiments, performed significantly better on gourd than on chilli and brinjal where upon a significant low population growth was recorded.

Acknowledgements

The authors are thankful to the Head of the Department of Zoology, DDU Gorakhpur University, Gorakhpur for providing research facilities.

References

[1]. Blackman R.L. and Eastop V.F. (2000). *Aphids on the World's Crops: An Identification Guide*, 2nd ed. Wiley, New York.

[2]. Fuchsberg J.R., Yong T.H., Losey J.E., Carter M.E. and Hoffmann M.P., Evaluation of corn leaf aphid (*Rhopalosiphum maidis*; Homoptera: Aphididae) honeydew as a food source for the egg parasitoid *Trichogramma ostriniae* (Hymenoptera: Trichogrammatidae). Biol. Contr. 40, 230-236 (2007).

[3]. Singh G., Singh N.P. and Singh R., Food plants of a major agricultural pest *Aphis gossypii* Glover (Homoptera : Aphididae) from India : an updated checklist. Int. J. Life Sc. Biotech. and Pharma Res. 3(2), 1-26 (2014).

[4]. Jhansi K. and Subbaratnam G.V., Effect of insecticide resistance on the biology morphometrics of *Aphis gossypii* Glover. Pesticide Res. J. 17(2), 67-69 (2005).

[5]. McKenzie C.L. and Cartwright B., Susceptibility of *Aphis gossypii* (Glover) to insecticides as affected by host plant using a rapid bioassay. J. Ent. Sc. 29, 289-301 (1994).

[6]. Wang K.Y., Guo Q.L., Xia X.M., Wang H.Y. and Liu T.X., Resistance of *Aphis gossypii* (Homoptera: Aphididae) to selected insecticides on cotton from five cotton production regions in Shandong, China. J. Pesticide Sc. 32(4), 372-378 (2007).

[7]. Ekukolé G., Effects of selected plants on the fecundity of *Aphis gossypii* Glover under laboratory conditions. Cotton and Fibres Tropic. 45, 253-266 (1990).

[8]. Wool D., Hales D. and Sunnucks P., Host plant relationships of *Aphis gossypii* Glover (Hemiptera: Aphididae) in Australia. J. Aust. Ent. Soc. 34(3), 265-271 (1995).

[9]. Wool D. and Hales D., Components of variation of morphological characters in Australian *Aphis gossypii*: host-plant effects predominate. Ent. Exp. Appl. 80, 166-168 (1996).

[10]. Guildemond J.A., Tigges W.T. and Vrijer P.W.F.de, Host races of *Aphis gossypii* (Homoptera: Aphididae) on cucumber and chrysanthemum. Env. Ent. 23(5), 1235-1240 (1994)..

[11]. Agarwala B.K. and Das K., Host plant based morphological, ecological and esterase variations in *Aphis gossypii* Glover populations (Homoptera: Aphididae). Entomon 32(2), 89-95 (2007).

[12]. Agarwala B.K. and Raychaudhuri P., Host plant based biological variations in *Aphis gossypii* Glover populations (Homoptera: Aphididae). Entomon 34, 57-60 (2009).

[13]. Birch L.C., The intrinsic rate of natural increase of an insect population. J. Anim. Ecol. 17, 15-26 (1948).

[14]. Kandoria J.L. and Jamwal R., Comparatve biology of *Aphis gossypii* Glover on okra, brinjal and chilli in the Punjab, India. J. Aphidol. 2, 35-39 (1988).

[15]. Mogeni T.D. and Rezwani A., Study on the biology and population dynamics of *Aphis gossypii* Glover (Homoptera: Aphididae) of cotton field in Gorgan, region. J. Ent. Soc. Iran 16/17, 1-10 (1998).

[16]. Perng J.J., Life history traits of *Aphis gossypii* Glover (Hom., Aphididae) reared on four widely distributed weeds. J. Appl. Ent. 126(2/3), 97-100 (2002).

[17]. Michelotto M.D., Silva R.A. da and Busoli A.C., Age specific life tables of *Aphis gossypii* Glover, 1877 (Hemiptera: Aphididae) on different cotton cultivars. Arqui. Inst. Biol. Sao Paulo 69, 275-277 (2002).

[18]. Michelotto M. D., Silva R. A. da and Busoli A.C., Life table for *Aphis gossypii* Glover, 1877 (Hemiptera: Aphididae) on different cotton cultivars. Bol. Sanidad Veg., Plagas 29(3), 331-337 (2003).

[19]. Kumar A., Ramkishore and Parihar S.B.S., Development of *Aphis gossypii* Glover on different host plants. Insect Env. 9(4), 179-181 (2003).

[20]. Du L., Ge F., Zhu S.R. and Parajulee M.N., Effect of cotton cultivar on development and reproduction of *Aphis gossypii* (Homoptera: Aphididae) and its predator *Propylaea japonica* (Coleoptera: Coccinellidae). J. Econ. Ent. 97(4), 1278-1283 (2004).

[21]. Kumar A., Ramkishore and Parihar S.B.S., Population build up of *Aphis gossypii* Glover on different crops. Insect Env. 10(1), 6-7 (2004).

[22]. Pessoa L.G.A., Souza B., Carvalho C.F. and Silva M.G., Biological aspects of *Aphis gossypii* Glover, 1877 (Hemiptera: Aphididae) on four cotton cultivars in the laboratory. Ciencia Agrotec. 28(6), 1235-1239 (2004).

[23]. Shirvani A. and Naveh V.H., Fertility life table parameters estimation of *Aphis gossypii* Glover. Iranian J. Agric. Sc. 35(1), 23-29 (2004).

[24]. Wang Y.M., Zhang P.F. and Chen J.Q., Host-preference biotypes of the cotton aphid, *Aphis gossypii* Glover and the behavioral mechanism in their formation. Acta Ent. Sinica 47(6), 760-767 (2004).

[25]. Razmjou J., Moharramipour S., Fathipour Y. and Mirhoseini S.Z., Demographic parameters of cotton aphid, *Aphis gossypii* Glover (Homoptera: Aphididae) on five cotton cultivars. Insect Sc. 13(3), 205-210 (2006).

[26]. Klingauf F. A., Host plant finding and acceptance. Aphids, Their Biology, Natural Enemies and Control, Vol. 2B. A.K. Minks and P. Harrewijn (Eds.) Elsevier Scientific Publisher, Amsterdam, 209-223 (1987).

[27]. Satar S., Kersting U. and Uygun N., Development and fecundity of *Aphis gossypii* Glover (Homoptera: Aphididae) on three Malvaceae hosts. Turk. J. Agric. 23, 637-643 (1999).

[28]. Satar S., Kersting U. and Uygun N., Effect of different citrus host plants and temperatures on development rate and fecundity of apterous *Aphis gossypii* Glover (Homoptera: Aphididae). Turk. Ent. Dergisi 22(3), 187-197 (1998).

[29]. Michelotto M.D. and Busoli A.C., Biological aspects of *Aphis gossypii* Glover, 1877 (Hemiptera: Aphididae) on three cotton cultivars and on three weeds species. Ciencia Rural 33(6), 999-1004 (2003).

[30]. Kandoria J.L., Jamwal R. and Singh G., Developmental behaviour of alate and apterous forms of *Aphis gossypii* Glover on chilli in the Punjab, India. J. Aphidol. 4(1-2), 75-78 (1990).

[31]. Aldryhim Y. and Khalil A.F., Biological studies of melon aphid, *Aphis gossypii* Glover, on squash under field conditions. J. King Saud. Univ., Agric. Sci. 7(1), 75-83 (1995).

[32]. Steenis M.J. van and El-Khawass K.A.M.H., Life history of *Aphis gossypii* on cucumber: influence of temperature, host plant and parasitism. Ent. Exp. Appl. 76(2), 121-131 (1995).

[33]. Rathod R.R. and Bapodra J.G., Bionomics of aphid, *Aphis gossypii* on cotton. Indian J. Ent. 68(2), 113-116 (2006).

[34]. Singh K., Srivastava P.N. and Singh R., Screening of cultivars of bottle gourd, *Lagenaria siceraria* (Molino) Standl. for susceptibility against *Aphis gossypii* Glover (Homoptera : Aphididae). J. Aphidol. 24, 61-66 (2010).

[35]. Soglia M.C.M., Bueno V.H.P. and Sampaio M.V., Fertility life table of *Aphis gossypii* on three commercial chrysanthemum cultivars. Bull. OILB/SROP 28(1), 241-244 (2005).

[36]. Shah M.A.S., Singh T.K. and Chhetry G.K.N., Life table, stable age, distribution and life expectancy of *Aphis gossypii* Glover on Okra. Ann. Pl. Prot. Sc. 15(1), 57-60 (2007).

[37]. Komazaki S., Effects of constant temperatures on population growth of three aphid species, *Toxoptera citricidus* (Kirklady), *Aphis citricola* van der Goot and *Aphis gossypii* Glover (Homoptera: Aphididae) on citrus. Appl. Entomol. Zool. 17(1), 75-81 (1982).

[38]. Narai Y. and Murai T., Development and reproduction of *Aphis gossypii* Glover and *Aphis craccivora* Koch (Homoptera : Aphididae). Bull. Shimane Agric. Exp. St. 25, 71-77 (1991).

[39]. Murai T. and Tsumuki H., Population increases of the green peach aphid, *Myzus persicae* (Sulzer) and cotton aphid, *Aphis gossypii* Glover. Bull. Res. Instt. Bioresources, Okayama Univ. 4(1), 59-65 (1996).

[40]. Xia J.Y., Werf W.V. and Rabbinge R., Influence of temperature on bionomics of cotton aphid, *Aphis gossypii*, on cotton. Ent. Exp. Appl. 90(1), 25-35 (1999).

[41]. Liu Y.C. and Hwang Y.B., Life table of the cotton aphid, *Aphis gossypii* Glover, at various photoperiods. Chinese J. Ent. 11(2), 106-116 (1991).

[42]. Perng J.J., Hou H.H., Hwang Y.B. and Liu Y.C., Influence of temperature and host plant on the development, survivorship, and reproduction of *Aphis gossypii* (Homoptera: Aphididae). Plant Prot. Bull. Taipei 44(4), 317-327 (2002).

[43]. Fuller S.J., Chavigny P. and Vanlerberghe-Masutti F. Variation in clonal diversity in greenhouse infestations of the aphid, *Aphis gossypii* Glover in southern France. Molec. Ecol. 8, 1867-1877 (1999).

[44]. Vanlerberghe-Masutti F. and Chavigny O. Host based genetic differentiations in aphid species, *Aphis gossypii* Glover, evidence from RAPD fingerprints. Molec. Biol. 7, 905-914 (1998).

AUTHORS' BIOGRAPHY

Dr. Rajendra Singh, is Professor & Head of the Department of Zoology and Department of Biotechnology, D.D.U. Gorakhpur University, Gorakhpur and has 38 years of experience in the fields of bioecology and biosystematics of aphids and their parasitoids and predators, published about 200 research articles of international repute, authored 6 text/reference books, supervised one D.Sc. and 25 Ph. D. students, and completed 12 research projects. He is fellow/life member of several scientific organizations/societies, Chief Editor of *Journal of Aphidology* and is on the editorial/reviewer panel of several International Journals. Prof. Singh also served in the university as Pro-Vice Chancellor.

Dr. Kusum Singh, has completed her Ph.D. on biosystematics and bioecology of *Aphis gossypii* Glover in eastern Uttar Pradesh. During her Ph.D. Course she worked on the taxonomy of aphids in and around Gorakhpur and studied the pattern of diversity and effect of food plants on the life-table of *A. gossypii*. She has skill in statistical analysis, diversity analysis etc. During her research period she had presented papers in several national and international seminars and symposia.