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Variations in certain biological aspects of the cotton aphid, *Aphis gossypii* Glover (Homoptera: Aphididae) in relation to color of its forms

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Abstract

The stock populations of two groups of *Aphis gossypii* Glover (Homoptera: Aphididae) were collected from cucurbitaceous plant leaves cultivated in Assiut and the New Valley Governorates, Egypt. Both aphid groups were brought into the laboratory and used as base line of pirimicarb resistance. Pirimicarb LC_{50} base line was determined by the dipping technique in successive concentrations of the trade form of pirimicarb mixed in water. The LC_{25} was determined monthly throughout two years and used in the selection.. This procedure resulted four aphid forms at each location (i.e., base line, mixed, light color, and dark color). It was found that the total nymphal duration of dark forms collected from both locations did not vary significantly from the base line forms. Data of the reproductive biology of aphids from both locations showed that the fecundity period, longevity and productivity of the dark morphs were significantly higher than those of the base line ones.

Key words: cotton aphid colored forms, biological aspects, pirimicarb, *Aphis gossypii*

Introduction

The cotton aphid, *Aphis gossypii* Glover (Homoptera: Aphididae) is a cosmopolitan polyphagous species widely distributed in tropical,subtropical and temperate regions (Kresting et al.,1999). This aphid species is a vector of about 76 viral diseases across a very large range of plants (Raworth et al., 1991). Problems associated with aphid in Egyptian cotton include transmission of certain cotton diseases, yield reductions due to the large early season infestations and the effect of honeydew on fiber quality at the late season infestations (Georghiou, 1981; Rizk et al., 2014). Generally,chemical control has been the major tool for the control of aphids (Parrella et al., 1999). Even though resistance of *A. gossypii* to some insecticides has been documented (Delorme et al., 1997; Herron et al., 2001; Wang et al., 2002). The use of selective insecticides is needed for successful integrated pest management (IPM) programs (Talebi, 2007). Pirimicarb is a selective carbamate insecticide that inhibits acetylcholinesterase (AChE) activity in the insect nervous system, it is used against the targeted aphids in particular (Hassall, 1990;Talebi, 2007). Resistance to insecticides was detected in approximately 20 aphid species including *A. gossypii* (Georghiou, 1981; Jam et al., 2014).

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Resistance of *A. gossypii* to carbamates was first reported by Kung et al., (1964) who described this phenomenon to be associated with some morphological and physiological characteristics. The extensive application of pirimicarb for aphids control causes an increase in the reproductive capacity of aphids up to 30% as compared with that of the control treatment (Rongai et al., 1998). In North America, red morphs on tobacco plants were deemed to be more resistant to organophosphorus insecticides than the green ones (Harlow and Lampert 1990). Elsewhere in the world, the red form of the tobacco aphid was observed as far back as 1985 in North Carolina, USA and appeared to be more serious pest than the green form (Harlow and Lampert, 1990).

The sudden shift from the green morph to the red morph is common as reported in insecticide resistance data (Masukwedza et al., 2013). The present work was conducted to find out an easy way for continued monitoring in addition to the use of rotation in chemical application to minimize the chance of aphids resistance build up. It also gives an alarm to those who work in the field of plant protection to pay attention about color transformation of an isect pest after the current use of insecticides.

Materials and methods

Insects: Two population groups of *A. gossypii* were collected from cucurbitaceous plant leaves cultivated in Assiut and the New Valley Governorates. The latter is at 220 km South West of Assiut (Plate 1). Both groups of aphids were brought into the laboratory at Plant Protection Department, Faculty of Agriculture, Assiut University and used as base line of pirimicarb resistance. Aphid individuals were maintained on squash plants in isolated boxes for the protection from the invasion of predators and parasites.

Laboratory Experiment: Pirimicarb LC_{50} base line was determined by the dipping technique in successive concentrations of the trade form of pirimicarb mixed in water. Twenty full grown aphids were used for every concentration. The LC_{25} was determined monthly throughout two years and used in the selection of aphid forms. The insecticide selection was stopped whenever the aphid population was in stress. This procedure resulted to four aphid forms (i.e. base line, mixed colored group, light color, and dark color). The technique described by Rongai et al., (1998) was used to study the effect of primicarb on certain biological aspects of the cotton aphid with minor modifications.

A. gossypii adults were transferred from the isolated boxes (plate 2) and put on squash plant leaves in Petri dishes (9cm in diameter). One day after the new-born aphids were collected and then placed on young leaves settled on wetted filter papers in Petri dishes (Plate 3). One day after, setelled healthy offspring was kept and the other was removed. Two aphids were put on the lower surface of each leaf by using a very fine camel hair brush and ten replicates were used**.** These units were daily observed until the offspring reach to the adult stage. Alive individual-molt skins and matured aphids were counted and recorded. Replications in which nymphs died within 24 h after transfer were deleted. The filter paper in the Petri dish was wetted daily and

aphids were transferred every 3-5 days to new squash leaf disks.

Experiments were conducted under room conditions at a temperature range of 25-28^{o}C, relative humidity of 60-65% and 16 hrs of artificial light (5,000 Lux).

Statistical analysis: The variations in developmental time, longevity, nymphal duration, and reproduction were tested by analysis of variance and means were separated by LSD using Advanced Statistical Analysis Package (ASAP)®.

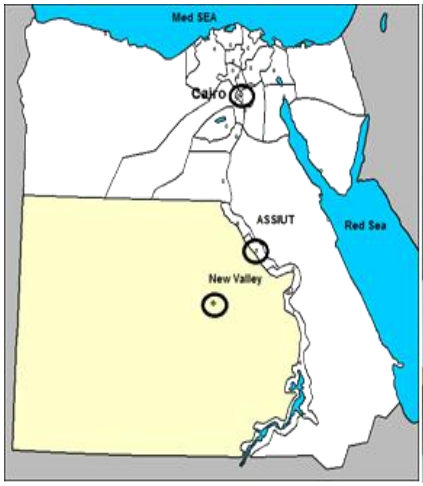

Plate 1: Sites of experiments

Plate 2: Rearing box

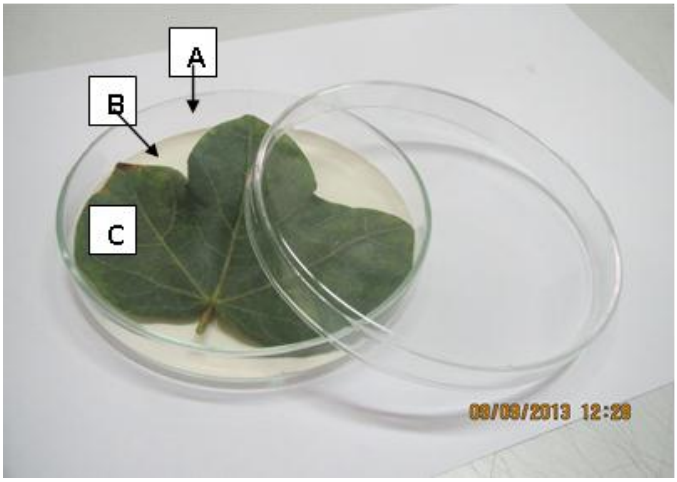

Plate 3: Experimental unit; Petri dish A, wetted filter paper B and detached plant leaf C.

Results

Assiut Culture

Nymphal duration: Data presented in Table 1, indicate that the first instar periods of the four aphid forms were varied significantly. These data indicate that the first nymphal instar of the base line lasted for a longer time than those of the pirimicarb selected ones. After the first molt, nymphs reached the second instar. In this instar, the pirimicarb selected aphids showed reversed

evidence of the base line. The base line aphid lasted for a lesser period than those of the pirimicarb selected groups. These periods were 1, 1.06, 1.04 and 1.15 days for base line, mixed color, light color and dark color groups, respectively. Data of the same table indicated also that the third and fourth nymphal instars, subsequently the total nymphal periods did not show significant difference. The nymphal periods of the four tested groups were ranged from 4.11 to 4.22 days with insignificant differences.

Table 1: Nymphal duration of base line after one year of pirimicarb insecticide selection of the cotton aphid, *Aphis gossypii* Glover ,(Assiut culture) under laboratory conditions.

	After 1 year of selection						LSD	
Nymphal instars	Base line	Mixed color	Light form	Dark form	F- value	Significant	0.05	0.01
1st instar	1.19	1.06	1	1	19.39	**	0.072	0.103
2nd instar	1	1.06	1.04	1.15	5.337	*	0.088	1.26
3rd instar	1.13	1.06	1.04	1	3.34	ns	0.101	0.145
4th instar	1.08	1.06	1.04	1.05	0.665	ns	0.072	0.103
Nymphal period	4.17	4.22	4.11	4.17	0.013	ns	1.26	1.809

Reproductive biology

Fecundity period of females: Data presented in Table 2 indicate that the fecundity periods of aphid females were varied significantly. These periods were 2, 2.27, 4.61 and 7.65 days for the base line, mixed, light, and dark color forms, respectively. These data demonstrate that the fecundity period of the dark form was longer than that of the base line and mixed color forms by approximately 4 folds and it was about two folds longer than that of the light color form.

Female longevity: Data in Table 2 show that the longevity periods of the one year pirimicarb selected forms (light and dark) were found to be four folds longer than that of the base line form. The longevity periods of the four tested aphid groups were 4.48, 6.17, 9.11 and 9 days. The statistical analysis proved that this variability is highly significant.

Female production: Our results indicate that the productivity of females of both light and dark forms was higher by about five folds than those of the base line ones (Table 2). The productions of a single female were 4.05, 5.67, 19.96 and 21.57 individuals for base line, mixed, light color and dark color, respectively. The statistical analysis indicated that the variability was highly significant.

New Valley Culture

Nymphal duration: Data observed in Table 3 indicate that the nymphal periods of the four aphid groups were varied from 4 to 4.5 days. The statistical analysis proved insignificant differences between the four tested groups.

Table 2: Fecundity, Longevity and Reproductive of Assiut cotton aphid, *A. gossypii* selected by pirimicarb under laboratory conditions.

Biological aspects	After 1 year of selection						LSD	
	Base line	Mixed color	Light form	Dark form	F- value	Significant	0.05	0.01
Fecundity period [(1)]	2	2.27	4.61	7.65	23.768	**	1.69	2.432
Longevity [(2)]	4.48	6.17	9.11	9	41.568	**	1.22	1.612
Productivity [(3)]	4.05	5.67	19.96	21.57	65.216	**	1.157	1.662

[(1)] Period of birthing progenies in days

[(2)] Period from birth to death in days

[(3)] Number of progeny per one female

Table 3: Nymphal duration of the base line form after one year of pirimicarb insecticide selection of cotton aphid, *Aphis gossypii* Glover (New Valley group) under laboratory conditions.

Nymphal instar	After 1 year of selection						LSD	
	Base line	Mixed color	Light form	Dark form	F- value	Significant	0.05	0.01
1st instar	1	1	0.96	0.96	2.33	ns	0.051	0.073
2nd instar	1.18	1.11	1.04	1.04	2.467	ns	0.134	0.192
3rd instar	1.21	1.13	1.09	1.04	1.434	ns	0.189	0.272
4th instar	1.25	1.13	1.05	1.04	2.96	ns	0.209	0.3
Nymphal period	4.5	4.38	4.1	4	0.343	ns	1.279	1.837

Reproductive Biology

Fecundity periods of females: Data given in Table 4 clarify that the fecundity periods through which aphid females were able to produce progenies varied significantly. These periods were 1.42, 2.88, 2.95, and 6.1 days for the base line, mixed color, light, and dark color forms, respectively. These data elucidate that the fecundity period of the dark form female was longer by about 3 folds than that of the base line form and it was about two folds longer than that of the light color form.

Female longevity: Data in Table 4 show that the longevity period of the one year pirimicarb selected dark form female was about two folds longer than that of the base line one. The longevity periods of the four tested aphid groups were 4.65, 6.4, 6.63 and 9.77 days, for the base line, mixed, light and dark color forms, respectively. The statistical analysis indicated highly significant differences between longevities of the four aphid forms.

Productivity: Data in Table 4 indicated that the productivity of dark form was found to be two folds higher than that of the base line form. The productions of a single female were 3.7, 4.06, 4.86 and 8.2 individuals for the base line, mixed color, light color and dark color forms, respectively. The statistical analysis proved that this variability was highly significant.

Table 4: Fecundity, longevity and reproduction of New Valley cotton aphids selected by pirimicarb under laboratory conditions.

Biological aspects	After 1 year of selection						LSD	
	Base line	Mixed color	Light form	Dark form	F- value	Significant	0.05	0.01
Fecundity period [1]	1.42	2.88	2.95	6.1	41.803	**	0.976	1.401
Longevity [2]	4.65	6.4	6.63	9.77	30.836	**	1.228	1.764
Reproduction [3]	3.7	4.06	4.86	8.2	56.467	**	0.896	1.288

[1] Period of birthing progenies in days

[2] Period from birth to death in days

[3] Number of progenies per a single female

Discussion

From the privous results it was found that the longevity , fecundity and productivity of dark colored morph of the cotton aphid which seemed to be Pirimicarb resistsnt are significantly higher than that of the the base line aphids (pirimicarb susceptible group). These results are supported with those of O'Brien and Graves, (1992) who noted that *A. gossypii* resistant to organophosphates had a higher reproduction rate at the first and second days of life than susceptible one. Jam et al., (2014) found that the level pf sensitivity of *A.gossypii* to the pirimicarb tested insecticide depends on developmental stage with first and second nymphal instars being the most susceptible and susceptibility decreasing with increasing age. The critical time for treatment with insecticides is,therefore,during the earliest instars. Similar findings were reported by several investigators who found that the higher sensitivity to insecticides was observed in the earliest instars of aphids and other related pests (Lowery et al. 2005;Walthall and Stark, 1997; Prabhaker et al., 2006; Sohrabi et al., 2011).Those investigators added that pirimicarb affected early instars of *A. gossypii* at lower concentrations than the recommended rate of application currently used in the field. In case of fourth instars and adults the LC50 values were greater than those of the concentrations recommended for field application.

It was found also that the characteristics associated with pirimicarb selection were more pronounced in Assiut aphids than those of the New Valley ones. This phenomenon was supported by the study of Atta et al., (2011), who found that cotton aphid populations of Assiut were more tolerance (2.17 folds) to pirimicarb than

those of the New Valley. This substantiation may be attributed to the recurrent use of insecticides at Assiut farms which caused the onset of resistance phenomena in many insects, including aphids. However, certain significant differences in pirimicarb response were existed. Cotton growers and pest control mangers should avoid using pirimicarb as a curative treatment where dark morphs occur. Cotton growers are also advised to rotate curative aphicide sprays if necessary at concentrations just sufficient to achieve an effective control against early instars in addition to minimize the development of pesticide resistance.

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