Laboratory Study of Parthenogenesis and Fecundity of Dusky-veined Aphid, *Panaphis Juglandis* Geoze (Hemiptera: Aphididae)

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Abstract: Aphids are the cloning experts. They have, moreover, hundreds of millions of years' experience of cloning, hundreds of millions of years in which evolution and natural selection have enabled them to overcome the problems and exploit all the advantages of clonal reproduction. . Colonies of thousands of individuals can appear on plants in a few days, as if by magic. This phenomenal rate of reproduction is only possible because no time or energy is wasted on sex. All the aphids in these colonies are female. Dispense with males and there is no need to expend time and energy on finding mates, courting, and the laying and incubation of eggs. Parthenogenesis - the development of unfertilised eggs - enables female aphids to give birth as soon as they are adult. Their progeny are born alive and kicking like human young, but nothing like so helpless, and what is more they are all female, ready in a matter of days to give birth themselves. An experiment was carried out in laboratory to study the same phenomenon in dusky veined aphid, *Panaphis juglandis.* Newly born nymphs were separated and put into separate clip cages individually. After 14-17 days they became alates and start giving birth to young ones which were all females. Studies on female fecundity revealed that mean fecundity of *P. juglandis* were 66.8 larvae /female.

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1. Introduction

Walnut (*Juglans regia* L.) the royal species from family Juglandaceae, rank third in nut production after cashews and almonds (FAOSTAT, 2011). Walnut industry is one of the rising industries in Kashmir. All the walnuts exported by India are produced in the valley. Walnut trees are susceptible to pests and diseases such as walnut weevil *(Alcides Porrectirostris* Marsha), walnut blue beetle *(Monolepta erythrecephale),* Sanjose scale *(Quadraspidiotus pernicious* Comst), Dusky veined aphid (*Panaphis juglandis* Goeze) and walnut green aphid *(Chromaphis juglandicola* Kalt). Among the different pests prevalent in the walnut-producing areas, walnut aphids' viz. *P. juglandis* and *C. juglandicola* damage walnut orchards most seriously. Their feeding reduces tree vigour, nut size, yield, and quality. In addition to direct feeding damage, they excrete copious amounts of honey-dew that falls onto nuts, leaves and shoots. Honey-dew supports growth of the black sooty mould fungus. This fungus reduces light penetration to the leaf surface reducing its photosynthetic capacity. Being black, it also absorbs heat to predispose nuts to sunburn and subsequent kernel quality loss due to high temperatures. High populations of aphids may also cause leaf drop, exposing more nuts to sunburn. If heavy populations are allowed to develop (i.e. > 15 aphids per walnut leaflet) and remain for as little as 14 days uncontrolled, current season's nut quality is reduced along with a substantial reduction in the following season's crop (Barnes & Sibbett, 1990).

The dusky veined aphid, *P. juglandis* (Fig. 1 &2) is one of the potential walnut pests in the valley. The life cycle of dusky veined aphid is similar to walnut green aphid. It overwinters in the egg stage on twigs. Eggs hatch as soon as leaf buds begin to open where the young aphids settle on the leaflets, and they mature into larger, yellow aphids with dusky black spots, and reproduce without mating, giving birth to live nymphs. The aphids pass through many generations a year, depending upon temperature. In fall, wingless females mate with smaller, winged males and lay the overwinter eggs. In contrast to walnut aphid however, dusky veined aphids feed on the upper sides of leaves at the midrib. If 25% of a leaflet sample contains colonies of dusky veined aphids, economic quality damaged has been measured. As walnut aphids decrease the vigour of walnut trees so there is a need to study and manage these serious pests in all its respects. Natural enemies play an important role in the natural control of walnut aphids. As these two aphids feed on exposed parts (leaves), they are susceptible to a variety of natural enemies such as predators and parasitoids.

Aphids reproduce by parthenogenesis. The extraordinary powers of multiplication unleashed by parthenogenesis could within a year produce a layer of aphids about 150 km deep over the entire surface of the earth, if they were allowed to go unchecked

(Harrington 1994). Obviously it is not in the aphids' own interests to realise this full potential, or even the minute fraction of it that would cause them to over-run their host plants. So they have developed their own means of restricting population growth, by interacting with one another, rather than relying on external agencies such as the weather and natural enemies.

Populations that reproduce clonally can more readily evolve mechanisms for restricting their own population growth, because it is the survival of the clone that matters, not that of any one individual. In the world of aphids, natural selection acts on clones, and the individual is of little consequence, so thousands of individuals can be sacrificed as long as the clone survives to perpetuate its particular genetic constitution (its *genotype*). An aphid clone is in this sense a "super-individual", with all its parts – the individual aphids – acting in support of the whole. During the course of its life a successful clone may disperse over a large area, so that the "super-individual" becomes a diffuse organism that mortality factors acting at any one time or place are unlikely to kill.

There is another important advantage of being a "super-individual". All its individual aphid parts do not have to do the same thing. Just as genes may be switched on or off during the development of an organism to produce organs with different bodily functions, individual aphids can be induced to develop in different ways resulting in different forms or *phenotypes*, with different roles to play in the life of the clone. The two most important of these roles are feeding and dispersal. Feeding aims at converting plant biomass into aphid biomass as quickly and efficiently as possible, and as any one aphid can only grow to a certain size, feeding is linked to rapid multiplication. Dispersal means spreading the clone around and, as most aphids are very fussy about what they eat, this also involves finding the right host plant. These two basic roles differ fundamentally. The feeding and multiplication role requires an aphid to spend all its life sucking plant sap and devote all its energy to motherhood. A body specifically designed to fulfil such a role would be a wingless, sedentary, membranous sac, with most of the body cavity occupied by developing embryos, to which it continuously gives birth. The dispersal and host-finding role requires an active winged insect with its thoracic skeleton and musculature fully developed to provide the power for extensive flight, and the appropriate sense organs and behavioural systems to enable it to recognise and respond to a host plant.

2. Material and Methods

Methodology for sample collection: Three sites were selected viz. Botanical Garden University Campus, Batpora and Danwethpora. In each of the selected locations a sample of 100 leaves was collected at random. The samples were collected every 14 days from May to October. The collected material was viewed in a laboratory, under a stereoscopic microscope and the collected specimens of examined aphid species were counted. Identification of this aphid as to species was conducted on the basis of durable slides. Blacman and Eastop [2000] and Cichocka [1980] keys were used for determinations.

Methodology for studying parthenogenesis: Newly born nymphs were separated and put into clip cages tied on fresh leaves and observed under microscope on daily basis. Utmost care was taken for complete separation for this sample by placing the twig in Glass boxes covered with muslin cloth. Methodology of fecundity determination: In each of the selected locations 10 leaves were sampled with females who had already had some of their larvae. Those leaves were chosen, on which single females were observed together with their offspring. Larvae present on the leaves were totted up. Females were put into 70% alcohol and skeletonized with a laboratory needle in order to isolate embryos. The number of larvae were totalized with the number of embryos. In this way fecundity per one female was obtained. Studies were performed every 10–14 days for family founders, as well as for spring and summer virginiparous females.

3. Results

P. juglandis is parthenogenetic and viviparous (Fig. 3) i.e, the youngones of this aphid develops from unfertilized eggs. Females give birth to young ones directly. Laboratory studies revealed that it gives birth to young ones during spring and summer. As only females are present, nymphs develop from unfertilized eggs. Newly born nymphs when allowed to grow separately in clip cages after 9-11 days of larval life became alate adults and start giving birth to young ones.

The mean fecundity of the family founders was 82 larvae and the maximum observed number was 88 larvae female^{-1}. Spring virginiparous females have the mean fecundity of 69.7 larvae female^{-1}. The virginiparous females of summer generations were also less fertile compared to the family founders and spring virginiparous females. The number of larvae born by these females often reached 61 specimens. (Fig. 4). Family founders develop from overwintering eggs during spring under field conditions. The number of aphids feeding walnut leaves arises tremendously after few months due to high rate of reproduction under field conditions.

Fig.3. Aphid being born

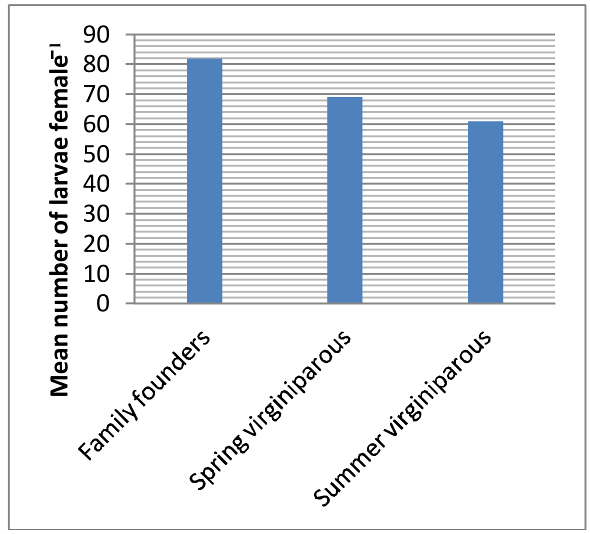

Fig4. Graph showing fecundity of *P. juglandis*

4. Discussions

There is a story loved by mathematicians, of an ancient emperor of India who was so pleased with one of his palace wise men, who had just invented the game of chess, that he offered this sage a reward of his own choosing. The sage, who was also a good mathematician, told his ruler that he would like just one grain of rice on the first square of his chess board, two grains on the second square, four on the third, and so on, doubling the number of grains of rice each time until all 64 squares of the chessboard had grains on them. This seemed to the emperor to be a very modest request, so he readily agreed, and called for his servants to bring some rice. He was surprised to find that the rice quickly covered the chess board, and then filled the entire palace. It soon became apparent that the emperor would be unable keep his promise

In fact the first half of the chessboard would have to accommodate a heap of rice weighing 100,000 kilograms, but it is on the second half of the board that the amount of rice reaches astronomical proportions; literally, because if the rice grains on the whole board were placed end-to-end they would reach to the nearest star (Alpha Centauri) and back again. Piled up, the heap of rice would be larger than Mount Everest. On the 64th square of the chessboard alone there would be 2^{63} = 9,223,372,036,854,775,808 grains of rice, more than two billion times as much as on the whole of the first half of the board.

To get back to aphids, parthenogenesis coupled with viviparity has given them the ability to double their population size is less than 3 days, given favourable conditions, so that starting from a single aphid, in about three months they would be beginning to populate the second half of the chessboard. In a year they would be nearing the end of their *second* chessboard, and we would not just be "knee-deep in aphids", the whole world would be buried under a layer of aphids nearly 150 km thick (Harrington 1994). The crux is that aphids can be disastrous if not controlled. P. juglandis populations are maintained at low by natural enemies under natural conditions. However, anthropogenic interference in present times has altered the pest-predator balance in favour of pests.

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