

Ecology and Diversity of Aphids: A Review

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ABSTRACT

Plant lice are tiny, soft-bodied arthropod insects which feed on sap of plants. Aphids are another name for these insects. They are members of the Aphidinae subfamily. Aphids fall into 60 genera and have roughly 400 species globally. In India, there are 25 genera with 125 species of aphids, while Uttarakhand (plains to very high altitudes) has 4 genera with 125 species of aphids. There are 65 different types of aphids, with the genus *Aphidius* having the most species overall. Aphids are greatly harming horticulture fruits and vegetables as well as agricultural crops. Temperature, humidity, and other environmental conditions affect its outbreak. Aphids are tiny, soft-bodied, viviparous, parasitic insects that lack wings and have wax secreting tubes on their abdomens. They can stunt plant growth, create plant galls, spread viral diseases to plants, and deform leaves, buds, and flowers. They have an impact on both plants, such as roses, lilies, and marigolds, as well as fruits and vegetables including mustard, cabbage, peas, potatoes, and beans. The mountainous area lacks data on the variety, ecology, and inventory of aphids. So an effort has been made to review the aphids diversity in India.

Key words : Cotton aphid, GPA, Pea aphid, Corn root aphid, Rose aphid, Mustard aphid.

Introduction

As anthracnose-feeding, soft-bodied insects, such as aphids (Hemiptera) of the Aphididae family (which includes plant lice, greenflies, and ant cows), which may decimate plant leaves, one of the most important components of photosynthesis, can cause significant damage to plants and their leaves. They get their common name from the pair of tube-like extensions on their abdomens known as cornicles or wax-secreting tubes. They are known as aphids because of these cornicles. Pesticides have a negative impact on flowering plants such as roses, lilies, and marigolds, among others. It is the Aphidiinae subfamily of the Aphididae family that is categorised as a phylum of arthropods, rather than the Aphididae family as a whole. About the course of history, the subfamily Aphidiinae has amassed over 400 species, which have been classified into 60 genera for easy

identification (Belshaw and Quicke, 2001). Previously, the Ephedrini, Praini, Aphidiini, and Trioxini tribes were assumed to be four distinct groups, but a molecular phylogenetic analysis has shown that there are really three (Smith *et al.*, 1999) or five tribes in this subfamily: the “Ephedrini, Praini, Monoctonini, Trioxini, and Aphidiini” (Sanchis *et al.*, 2005).

It is estimated that “India has 125 species, which are split into 22 genera by four tribes: The Ephedrini include Toxares, Ephedrus, Indoephedrus, and Neophedrus; the Praini include Areopraon and Praon; and the Aphidiini include 12 genera: Adialytus, Archaphidus, Diaeretiella, Diaeretus, Kashmiria, Lipolexis, and Lycopus. The Praini include Areopraon and Praon; and the Ephedrini include Tox Accordig to a review of the literature, 95 species have been identified in the northern states of Delhi, Himachal Pradesh, Jammu and Kashmir,

Punjab, Uttar Pradesh, and West Bengal; 41 species have been identified in the northern states of Assam, Manipur, Meghalaya, Nagaland, Sikkim, and Tripura; and 13 species have been identified in the southern states of Karnataka and Tamil Nadu. In an inventory of the biodiversity of aphidiini parasitoids done in India, 123 species belonging to 23 genera were shown to be actively and extensively controlling aphids. These species were found to be actively and broadly controlling aphids. Anthracnose aphids may be found around the globe, particularly in locations with a temperate climate, and they feed on a wide variety of plant species (De Barro and Carver, 1997).

For use as a starting point for developing any IPM strategy, including aphid bio-management, the inventory has been supplemented with all necessary data from original sources, such as zoogeographic distribution, parasitism potential attributes, and other relevant information" (Dey and Akhter, 2007). It is usually possible to keep aphids under control in gardens by using their natural enemies, which include ladybird beetles, aphid lions, and lacewings among others. Traditional pesticides, such as insecticidal soaps, horticultural oils, and other formulations, may be used to control pest populations that are economically or aesthetically damaging to the environment. Aphid infestations in agriculture and horticulture have a devastating effect on the fruits and vegetables grown there. Temperature, humidity, and other factors all have a part in the transmission of the disease (Bannerman and Roitberg, 2014). The mountain region is weak in aphid variety, ecology, and inventory, to name a few things. As a result, an effort has been made to conduct a review and analysis of aphid diversity.

Life cycle of Aphids:

Due to their fast pace of population expansion and the great variety of coping mechanisms that their phenotypic plasticity confers, aphids are among the insects that cause the most harm to plants (Dedryver *et al.*, 2008). Most aphid species finish their life cycle on a single species of host plant, however certain heteroecious species migrate from primary (woody) to secondary (herbaceous) host plants, alternating between them (Jousselin *et al.*, 2010). To complete the annual life cycle, which consists of the usual yearly life cycle of an aphid's reproduction depending on the season, cyclical parthenogenesis, which consists of a series of parthenogenetic generations

followed by a single sexual generation, is used (Ogawa and Miura, 2014; Gilabert *et al.*, 2015). Heteroecious species migrate to unrelated plant species in the summer (herbaceous secondary host), return to the primary host in the fall, and spend the winter on the same plant species (woody primary host). As opposed to nonhost-alternating aphids, which move between different host species during the year, nonhost-alternating aphids remain on the same or a closely related host species to complete both their sexual and parthenogenetic life cycles (Kumar, 2019).

The majority of aphid life cycles overwintered by utilising frost-resistant, diapausing eggs that gave birth to fundatrix (females) in April. Until fall, these females are generating viviparous females asexually. Males and oviparous females, which are generated by parthenogenetic viviparous females, mate and deposit overwintering eggs in late fall. While cyclical parthenogenesis is recorded in all Aphididae subfamilies, only around 3% of all aphid species (*Myzusascalonicus* and *Toxopteracitricidus*) are exclusively asexual generations (Ogawa and Miura, 2014). Furthermore, they exhibit cyclically (sexual) parthenogenetic lineages in hard winter and obligatory (asexual) parthenogenetic lineages in mild winter (Gilabert *et al.*, 2015). Aphids' life cycles include a sexual phase in between bouts of apomictic parthenogenesis (a full life cycle or holocycle), although some species have lost the sexual phase secondarily (i.e., they do not produce males; anholocycle) (Abbot *et al.*, 2018). Some species, particularly those with worldwide distribution, display both holocyclic and anholocyclic life, both in separate geographical areas at the same time, but only rarely both monoecy and heteroecy (Kumar, 2019).

Host plant and behaviour

Flying is the first stage of the aphid life cycle, and it signals the beginning of the dispersion phase. Prior to flight, there is a pre-flight phase that lasts anywhere between one and thirty-one hours, with the peak activity occurring between ten and twenty-four hours after moult in colonies raised on *Veronica persica*, with the peak activity occurring between ten and twenty-four hours after moult in colonies raised on *Veronica persica*. Temperatures plummeted from 28 to 12 degrees Celsius throughout the course of the overall pre-flight period, which lasted anywhere from 10 to more than 70 hours. Only a few birds flew after nightfall, although the majority of adults

flew from the time the sun rises to the time the sun sets in the afternoon. During this particular time period, there were no aircraft that were registered between the hours of 23:00 and 07:00. The amount of time spent in the air during flights to experimental colonies ranged anywhere from one to four days, depending on the conditions (Nozato, 1990). Six hours after the wings were created, the value of orientation to host plants was already considerable; but, after twenty-four hours, its significance became considerably more crucial. Alates were especially drawn to plants such as *Cucurbita pepo* and *Thunbergiilaurifolia*, which were also popular hosts for *A. gossypii* incubation when the disease was present in Cuba. Neither the non-host plant *Lantana camara* nor the non-host plant *Hibiscus rosea-sinensis* were attractive nor repellent to the insects. It has been shown that, in addition to Cuba, *L. camara* is a summer host for *A. gossypii* in a number of other locations. This seeming contradiction might be addressed by the fact that different regions of the globe have aphid populations and host plants that are genetically distinct from one another (Zepeda *et al.*, 2017).

Cotton aphid (*Aphis gossypii*)

The cotton or melon aphid may be found in a variety of colours ranging from green to black. When compared to warmer temperatures, when there is a breeding season, colder climates have an egg-laying period. Among the numerous possible hosts are melon, cotton, and cucumber, to name just a few. The majority of the time, parasites and predators in the environment keep it under control. An very small, adaptable, and easily distributed pest with a rapid reproductive rate, *Aphis gossypii* has the potential to inflict severe harm to plants in isolated locations. It is now considered that *Aphis gossypii* Glover is comprised of several holocyclic and anholocyclic phenotypes and genotypes, which differ in terms of their ability to breed, as well as their feeding preferences for different host plants. The plant families "Asteraceae, Cucurbitaceae, Fabaceae, Lamiaceae, Malvaceae, Polygonaceae, Rosaceae, and Solanaceae" are among the most extensively infested. Asteraceae is the most heavily infected plant family (Singh *et al.*, 2014).

In terms of taxonomy, *Aphis gossypii* and *Aphis frangulae* are difficult to identify from one another (Strogani, 1984). Aphids of cotton and melon are common. The short lifetime of *Aphis gossypii*, as well

as its many reproductive techniques and wide range of host plants, making it a good model organism for studying the evolution of feeding habits (Liu *et al.*, 2005). The genus *A. gossypii* was discovered based on the characteristics stated below. There is uniform sclerotization of the cornicles or siphunculi, starting at the apex and working their way down to the base, as well as dark pigmentation of the cornicles or siphunculi. There is a little dilatation towards the apex, which causes them to be somewhat longer than the cauda. A uniform pattern of sclerotization and depigmentation is seen in the dorsal abdominal segments. Incubated at or near the colour transition temperature, the *A. gossypii* plant may exhibit an uneven colouring that is both greenish in some areas and yellow-toned in others when it is exposed to high temperatures. The cauda has four to seven hairs and is lighter in hue than the cornicles, which are darker in colour. There is no stidulation equipment to be found in this room. Antennal tubercles have only developed in a few places. Despite being lengthier than the previous antennal portion, the duration of the terminal procedure is just three and a half times that of the prior antennal segment (Singh and Srivastava, 1989).

It's a little aphid by the name of *A. gossypii*. Adults have a body length that is less than a centimetre in circumference. The very minimal minimum is a little bit more than 0.34 mm. That *A. gossypii* may be eliminated by a screen with a mesh diameter of smaller than 0.34 mm implies that this is the case (Bethke and Paine, 1991). It may be possible to increase separation between instars by integrating additional characteristics, especially if temperatures are maintained steady. *A. gossypii* may be found in a broad range of colours, ranging from yellow to practically black in appearance. It is more common to see the yellow variety of this plant during the warmest months of the year. Temperatures are cooler in the spring and autumn, and there are less people around during these seasons. Color morphs have the potential to produce children that are of a different colour morph. The host plant may also have an impact on the colour of the aphid (Ebert and Cartwright, 1997). When *A. gossypii* infection is detected, the first symptom is a yellowing of the leaves. As their numbers expand, aphids are going to younger leaves, stalks, and flowers, where they will thrive (sepals mostly). Honeydew excreted by the aphid causes a black sooty mould to form on the plants as a result of its feeding habits.

When *A. gossypii* is present in very high numbers, it has the potential to kill its host. In warm environments, the life cycle of *A. gossypii* is anholocyclic, but in colder environments, it may be heteroecious or self-autonomous (Zhang and Zhong, 1990). It is a component of the heteroecious cycle that females migrate in the spring from their winter to their summer hosts and back again for egg-laying. There was a significant difference in the birth rates of *A. gossypii* cultivated on cotton, watermelons, and groundnuts and those of the other two species that were researched (Ekukole, 1990). It is possible for an aphid to produce an average of 2.8 nymphs per day when the temperature is between 20 and 25 degrees Celsius (Akey and Butler, 1989). Because of its propensity to transfer plant viruses, *A. gossypii* is the plant virus that has the most significant influence on agricultural production around the globe. Okra that had been infected with the Yellow-vein mosaic virus had a lower number of the bacteria *A. gossypii* than healthy okra did. This demonstrates that the reproduction rate of this bacterium is slower in infected okra than in healthy okra.

Green peach aphid (*Myzuspersicae*)

Myzuspersicae, often known as the spinach aphid, is a little aphid that has three black lines running down the back of its body. Other names for this aphid include the spinach aphid. During the life cycle of the parasite, two hosts are required. Females reproduce parthenogenetically over the summer, and in the autumn, they produce young that are sexually dimorphic in appearance. This pest may be responsible for the transmission of mosaic diseases. Female parthenogenetic adults with no wings have an oval body shape and vary in size from 1.2-2.1 mm in length. Its colour is highly varied, ranging from white to a range of colours of green, to dark green, to pink or red, and everything in between. Regardless of genetic variety, green or magenta pigmentation will be more conspicuous under cooler conditions for any one genotype than it would under warmer conditions. Adults have a duller appearance than juvenile stages. The dorsal patch of a black dot is located in the centre of the abdomen of winged versions. When it comes to winged females, particularly in fall populations, juvenile females are either pink or red colour, whilst immature males are a yellowish colour (Blackman and Eastop, 1984). This is especially true for winged females with winged ovaries. Both *Myzus persicae* and its princi-

pal host plant, *Prunus persica*, are assumed to have originated in Asia; nevertheless, *Myzuspersicae* may now be found all over the globe, with the exception of locations with very high or low temperatures or humidity.

Early spring is an excellent time to search for curled leaves, which indicate the presence of a budding colony of *Myzus persica*. Because *M. persicae* transmits sugar beet and potato viruses at low densities, it is difficult to identify in a field crop before it causes harm. This is because it makes it difficult to detect *M. persicae* before it causes damage. It is recommended to use suction and yellow traps as soon as flying aphids arrive in the field for the purpose of identifying them. This should be done as soon as possible. The Rothamsted Insect Survey in the United Kingdom and AGRAPHID in France (Hulle *et al.*, 2000), respectively, employ suction trap networks to track the movement of aphids across their respective countries. It is unclear if the sexual stage of the life cycle has been completed in any of the other species that have been investigated, with the exception of *P. persica* and *P. nigra*. There are about forty distinct plant families that have been identified as summer hosts for *M. persicae*. These families include Brassicaceae, Leguminosae, Solanaceae, Poaceae, Chenopodiaceae, Cyperaceae, Umbelliferae, Convolvulaceae and Cucurbitaceae. Throughout the summer, many economically relevant plants are in various phases of development, including flowering, post-harvest, seedling, and vegetative growth. The host plant, on the other hand, as well as the viruses that are transferred, have a crucial impact in the fate of an infestation. Peach spring populations have severe leaf curl and branch deformation, as seen in the images below. Leaf rolling and necrosis of the tuber stems are two of the signs of PLRV in potatoes. Ghosh and Verma (1991) discovered the first apterous oviparous females of "*M. persicae* on *Prunus persica*", which they named *M. persicae*apterous oviparous.

The process of thelytokous parthenogenesis, in which only females are involved, resulting in a succession of generations of wingless (apterous) and alatevirginoparae, who breed viviparously in their natural environments. During the autumn, gynoparae (autumn migrants) return to their original breeding grounds. A broad variety of trees and shrubs will attempt to colonise Gynoparae, which will only be successful if *Prunus persica* and its near relatives are used to complete the sexual cycle.

oviparae (mating females) are generated by gynoparae, and peach leaves are the principal food supply for these females. There are a lot of reasons that might cause winged forms to develop, including plant nutrition, temperature, and heredity. *M. persicae* is a hardy species that can endure freezing conditions. According to Howling and colleagues (1994), it has been shown that an aphid population of *M. persicae* that has been acclimated to overwintering at temperatures as low as -5°C each night for seven to ten days would not suffer significant mortality as a result of the low temperatures. It is possible to tell this species from others of its genus based on its outward appearance (colour), biology, host choice, capacity to transfer viruses (and resistance to pesticides), and a number of other distinguishing qualities (Field *et al.*, 1994). *M. persicae* has been shown to be capable of transmitting a wide range of plant viral diseases from one plant to another. These viruses include those that damage many of the most important crops grown across the globe. On the other hand, populations on the vast majority of crops do not reach levels that induce visual signs such as chlorosis or leaf scrunching, as well as the production of copious quantities of honeydew with auxiliary sooty mould and direct damage to potatoes (Sexson *et al.*, 2005). Chlorosis and leaf curling are two examples of symptoms that can be caused by honeydew. *M. persicae* is a significant problem in any area of the world that cultivates potatoes as a crop. The propagation of potato leaf roll virus is very dependent on it as a vector (PLRV). Sugar beet productivity losses due to beet yellows may reach 30–50 percent, with an associated rise in impurities in the harvested sugar as a consequence of the yellowing. Beet yellows are caused by a fungus that causes beets to become yellow. If it strikes at the beginning of the growing season, a season-long sickness might result in considerable crop losses. In the same way as it does with nectarines and peaches, the aphid causes pitting and browning of the immature fruits as well as twisting of the young leaves (Barbagallo *et al.*, 2007).

Corn root aphid (*Anura phismairadicis*)

It's vital to remember that the corn root aphid is significantly reliant on the cornfield ant for survival. Aphid eggs are kept in the ant colonies during the winter, and in the spring, the ants disperse the newly formed aphids to weed roots (and, if possible, to maize roots) via their network of tunnels. Aphids

cause reduced development in corn, as well as yellowing and wilting of the plants as a consequence of their presence on the plant. Unfortunately, other grasses may also be affected by corn root aphids, which is a common occurrence. The eastern spruce gall adelgid (*Adelgesabietis*) develops pineapple-shaped galls that range in length from 1 to 2.5 cm (0.4 to 1 inch).

Each gall contains around 12 aphid nymphs, which is where the adelgid gets its name. Each year, in the middle of summer, the galls break open, releasing adult aphids that infest neighbouring spruces and spread across the forest. While the mortality of infected limbs is a typical occurrence, the susceptibility of each tree differs. Yellow spots appear on the plant and have the potential to cause devastation over a whole area. Pale-green adults have dark green stripes on the backs of their bodies. There are roughly 20 generations each year, with each female producing 50 to 60 offspring. Each generation has approximately 50 to 60 offspring. It is rather widespread, and it is kept under control with the use of parasites and pesticides.

Pea aphid

The pea aphid (*Acyrtho siphonpisum*) may be distinguished by its two colour variations: bright green and pinkish red. It feeds on alfalfa and clover throughout the winter months before switching to peas during the spring months. Yellow bean mosaic virus, which infects pea plants, often causes them to die. Every single female is responsible for the production of more than a half-dozen generations every year. Insecticides and changing weather patterns are utilised to keep it under control. Naturally occurring predators and parasites, such as the caustic *Allothrombium pulvinum*, may prey on it, as well as ladybugs. The colour of the pea aphid is altered by variations in the genes which secrete carotenoid pigments, and allows it to dodge predators and parasites and survive. The pea aphid was able to acquire carotenoid genes from fungus tens of millions of years ago via a method called as horizontal gene transfer, that enabled it to produce carotenoids for the first time. The production of carotenoid pigments by pea aphids has been linked to the production of aphid energy (ATP; adenosine triphosphate).

Aphid life tables were created based on observations of juvenile development and mortality, as well as adult aphid life duration, age-specific fertility, and survival, among other things. Scouts and

Sanchos needed 16.8 days and 16.2 days, respectively, to attain maturity when grown at 11.9°C and 26.7 °C, respectively, according to the results (8.5 days on cv. Scout and 8.8 days on cv. Sancho). The highest levels of juvenile mortality were seen at temperatures over 19.6 °C, whereas the lowest levels were observed at temperatures below 19.6 °C in both pea varieties. At 26.7 °C, the Cv. Scout aphid showed the greatest cumulative juvenile mortality, with just 9 percent of the aphids surviving to reach reproductive maturity. In the range of 11.9 to 19.6 °C, fecundity rates on cv. Scout increased in tandem with temperature increases on Sancho, but not on the other strain. In response to rising temperatures, aphid population growth (rm) on both pea cultivars increased between 11.9 and 23.1 °C on cv. Scout and between 11.9 and 19.6 °C on cv. Sancho, but subsequently dropped beyond that point. At all temperatures, the increase of the aphid population on Sancho was consistently larger than that on Scout.

The potato aphid (*Macrosiphum euphorbiae*) larvae that feed on rosebuds and leaves, which hatch from black eggs laid by the potato aphid on the rose plant. In the spring, they go to potatoes, which serve as a host for the duration of the summer season. A new generation is born every two to three weeks, on average. This virus is responsible for the transmission of tomato and potato mosaic virus infections, which result in the death of plants and blossoms. Aphids that prey on other aphids are frequent in numerous species. Throughout the year, most animals eat a range of different meals. Adult wingless birds choose new host plants based on visual cues, which are then followed by an olfactory assessment of the plant conducted with their antennae. If they come to a plant that smells good, they will begin probing the plant's surface.

The stylet is used to collect samples of the sap, xylem, and phloem, and saliva is expelled after each sample is obtained. In aphid saliva, there is an enzyme called pectinase, which aids in penetration and may interfere with phloem sealing mechanisms. The findings revealed that when the aphids are not dehydrated and their fecundity is dropping, they consume far more xylem sap than was projected. Because of the high sucrose concentration of plant sap, aphids find it to be an unbalanced food supply, since they are unable to synthesise the essential amino acids that are absent from plant sap. Aphids benefit from antibiotic-resistant bacteria that grow inside special cells known as bacteriocytes because

they provide them with vital amino acids.

Rose aphid

Aphids of the rose family, *Macrosiphum rosae*, are a large green bug with pink markings on its legs that may be seen in large numbers in the garden. The cultivated rose is the only host on which it can survive and grow. Natural predators that prey on ladybird larvae and aphid lions are the most prevalent (lacewing larvae). Depending on the species, the aptera of *Macrosiphum roseum* are green, deep pink to red-brown, or a combination of these colours. The tips of the tibiae and femora, as well as the antennae and, in rare occasions, the head, are entirely black. An examination of the abdomen will reveal the presence or absence of small marginal sclerites as well as antesiphuncular sclerites. Their colour is dark and their shape is curled outwards in the apical 10 percent to 17 percent of the siphunculi. Compared to the cauda, they are 1.9-2.4 times longer and have a length that is 0.27-0.41 times longer than the body. Cauda is a light yellow colour. The adult aptera of *Macrosiphum rosae* range in length from 1.7 to 3.6 mm in length. The presence of black sclerites on the sides of the abdomen of *Macrosiphum rosae* alatae may be plainly noticed in this illustration (see third picture above). They are also available in several colours, including green and red. Despite the fact that some adults may be able to reproduce parthenogenetically in mild winters. During the spring blooming season, when alates colonise the new rose growth, a large number of alates are formed. Primary hosts for these parasites are teasels (Dipsacaceae) and valerians (Asteraceae), which are both flowering plants (Valerianaceae). The species is a serious horticultural pest, and it may be seen on roses throughout the summer months. *Macrosiphum rosae* is a species of fungus that is found all over the world.

The Mustard aphid (*Lipapiserysemi*)

They are pearl-shaped insects with honey tubes. Nymphs have 4 life stages. Female one without wings are yellowish green, grey green, or olive green in colour, with a white waxy bloom covering their bodies. The abdomen of female aphids with wings is dark green, with black lateral lines distinguishing the body segments and dusky wing veins. Male aphids are olive-green to brown in colour. Adults and nymphs both drink sap from leaves, inflorescences, or developing pods. The leaves pucker and curl as the aphid population grows. Curling

may appear on damaged leaves, and plants may wilt and die if the disease progresses. The aphid attacks begin in December and continue upto March. 200 degrees Celsius is the optimal temperature. Cloudy and frigid weather both encourage the growth of insects.

Conclusion

Therefore, the preceding discussion demonstrated that the aphid population plays an essential role in the agricultural ecology. Several natural and manmade causes are currently affecting aphid populations. However, aphids cause harm to crops such as mustard, pea, cabbage, lemon, potato, bean, cotton, and so on, as well as flowers such as rose, marigold and lily. This review provides information on aphid diversity and ecology for researchers.

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