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BEHAVIOURAL STUDY OF APHIDS

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An insect behavior refers to the various actions of an insect in response to a stimulus or to its environment. It describes a wide range of activities, such as feeding, locomotion, grooming, reproduction, learning, migration, and communication.

Aphids are major pests for all crops over the world and generally known as plant lice, green flies or black flies and they belong to the Super family- Aphidoidea and Order- Hemiptera. Most of the aphid species are polyphagous and feed on a wide range of host plants (Blackman and Eastop, 2000). Most of the female aphids are wingless but small numbers of aphids are winged that fly to the plant and find it to be a suitable host. After getting suitable host they produce several immature ones on the tender leaves. They are phloem feeder and attack all parts of plants including roots. Aphids directly damage the plant by sucking their nutrients resulting in curling and twisting of tender parts (Maji *et al.*, 2020).

In addition, aphids are often vectors of plant pathogens. Almost every crop is a host to at least one aphid species. Aphid behaviour can helps to know about the developed resistance to insecticides, they are difficult to control (Blackman & Eastop 2006). Previously, it has been demonstrated that plant resistance can be inferred from the behaviour of aphids (Pickett et al. 1992).

Patterns of Behaviour

1. **Innate behaviour-** Innate behavior is behavior that's genetically hardwired in an organism and can be performed in response to a cue without prior experience.
2. **Learned behaviour-** Learned behavior is behavior that occurs only after experience or practice. Learned behavior has an advantage over innate behavior. It is more flexible. Learned behavior can be changed if conditions change.

Importance to Study Insect Behaviour

- To understand interspecific and intraspecific interaction between insects.
- To know the reproductive strategies of different insects.
- To understand the social behaviour of insects.
- To determine the host preference by different insects.
- To understand the defensive mechanism of insects against their natural enemies.
- Insects can resist insecticides through changing their behaviour. So, understanding the behavioural resistance mechanism will help in development of IRM strategies.

1. Feeding Behaviour

Aphid antenna bears many sensilla which are used in chemoreception and for perception of leaf surface. Most of the aphid species make their colonies near mid rib on lower surface of the leaves. Younger nymphs make colonies on secondary and tertiary leaf veins. By making colonies around veins, aphids try to find place near to the phloem tissues (sun *et al.,* 2016). When aphid punctured the phloem tissue, the sap which is under positive hydrostatic pressure is forced into the aphid's food canal. Phloem sap is composed of only sugars.

Most of the time aphids are the phloem feeders but under certain stress condition they can also feed on xylem fluid. Because when they feed from phloem, high osmotic pressure created in stomach due to high sucrose concentration as a results water transfer from haemolymph to stomach and insect died. But, when they feed on xylem fluid which is much dilute as compared to phloem, helps to reduction of solute concentration and osmotic pressure (Guo *et al.,* 2016).

2. Locomotion or Movement of Aphid

Movement of Aphid

An aphid moves from its point of origin towards some other place by one of two types of transport mechanisms, either through '**inadvertent**' or '**intentional**' displacement (Awasthi, 2013).

Inadvertent displacement is an instinctive act, departure the aphid few options about its translocation. It is propelled by the force of impact, gravitational force, air currents, or a

blend of these. The inadvertently displaced aphid may, itself by walking or flying otherwise, it can be transported by animals, farm machinery or automobiles.

Intentional displacement is a pre-programmed movement, i.e. they are governed by the genetics of the organism. The environmentally sensed attack by a natural enemy or altered chemical composition of a deteriorating host plant, can create an urge in the aphid to flee, this desire might well stem from an intrinsic, genetically wired response to the initial disturbance.

Migratory Behaviour

Insect migration is the key process by which the population dynamics of many insect pests is being maintained over an enormous region. Aphid migration indicates that aphids migrate from high hill regions to plain lands of India to avoid lower temperature. In this migratory route, aphids spread their offspring both temporally and spatially, so that, a portion of their next generation can be able to build a seasonally favourable population in near future.

3. Life Cycle

There are two types of life cycle generally found on aphid species-

a. Holocyclic life cycle: it refers to those aphids which alternate parthenogenetic with sexual reproduction. Holocyclic life cycle seen in case of both heteroecy and monoecy.

b. Anholocyclic life cycle: In this type of life cycle only viviparous parthenogenetic females are present throughout the year. This is often seen in locations where winter conditions are gentle. Anholocycly is not confined to heteroecious species of aphids; approximately 3% of all aphids are completely anholocyclic throughout their range (Blackman, 1980).

4. Mechanisms of Colour Production in Aphids

There are so many factors which are responsible for coloration in aphids-

- In case of *Sitobion avenae* they change their body colour from green to pink or brown with changes in light intensity (Alkhedir *et al*., 2010).
- *Aphis gossypii* pale green colour at 25^{o}C and dark green or dark brown at 12^{o}C temperature (Dixon, 1972).

- Colour within a species can be a genetic trait, as is well documented for *Acyrthosiphon pisum*, *Myzus persicae* and various *Macrosiphum* sp. (Battaglia *et al*, 2000)
- Nutritional quality of diet also can influence the aphid colour.

Chemical coloration of aphids is determined by mainly three pigments, melanin, carotenoid, and aphin.

- **Melanin:** Melanin is one of the major pigments representing black or dark color. Melanin in the cuticle seems to purpose as a protectant from UV damage, and is synthesized from tyrosine through dihydroxyphenylalanine (DOPA) processes.

- **Carotenoids:** Carotenoids are tetraterpenes that are red to yellow in color. In some cases, carotenoid levels were shown to vary among the different color forms. For example, green aphid primarily contain yellow carotenoids, such as a-carotene, b-carotene org-carotene, whereas red clones mainly contain red carotenoids, such as lycopene, 3, 4-didehydrolycopene and torulene. Aphids have acquired capability to produce red Carotenoid by horizontal gene transfer from fungi.

- **Aphins:** Aphins are polycyclic quinone pigments present in haemolymph. Aphins exhibit colors that differ extensively, from very light yellow through orange and red to deep blue-green.

Colours for Defence

Generally three types of coloration can be found in aphid species-

Aposematic colouration (Warning colouration)

In this type of colouration aphid make them highly conspicuous as a result they can easily get noticed by predators and this aphid species contains toxic compound such as cyanoglycoside which produce hydro cyanate when consumed by the predators as a results predators avoided in next encountered (Benedek *et al.*, 2019). This type of colouration is displayed only by adults.

Cryptic Colouration in Aphids

Aphid can change their body on the basis of the plant surface colour if they colonise on leaves they are green, aphids that colonize on stem and woody part are brown, this form of

colour matching is called as homochromy. They do not match only colour but also pattern and texture (Dransfield and Brightwell, 2015).

The polymorphism appears to be maintained by balanced selection from two natural enemies- the predator, *Coccinella septempunctata* and the *parasitoid Aphidius ervi.*

Parasitoid prefers to attack green morphs generally but if the parasitoid population is high, more red morphs are born. Predator prefers to feed on red morphs but if predator population is high, more green morphs are produced.

Deimatic Behaviour

Deimatic behaviour is intimately associated to Aposematic behaviour, and means any pattern of threatening or startling behaviour. For example the sudden display of eyespots by moths. Several *Lachnus* and *Cinara* species of aphids show “leg kicking” response which is an example of Deimatic behaviour.

5. Ant mutualism

Some species of ants farm aphids in their colony and eating the honeydew which secreted by the aphids from their anal opening. Ants protect the aphids by fighting off aphid predators (Wimp and Whitham, 2001). Ants also feed on the aphids to get source of protein and sometimes to control aphid population when they can’t handle honeydew production capacity.

6. Escape and Defences in Aphids

- Aphids cannot fly for most of their lifecycle; they can escape from predators and parasitoids by dropping off the plant they are on.
- Some species of aphid, known as "woolly aphids “(Sugarcane wooly aphid, Apple wooly aphid), excrete a “fluffy wax coating” for protection from predators and parasitoids.
- Some species of aphid interact with plant tissues forming a gall, by secrete some chemicals. Aphids can live inside the gall, which provides protection from predators and parasitoids. Some gall forming aphid species are produce specialised "soldier “ forms, sterile nymphs with defensive features which defend the gall from invasion.

- The cabbage aphid, Brevicoryne brassicae, stores and releases chemicals (Iso-thiosynate) that produce a violent chemical reaction and strong mustard oil smell to repel predators.

Conclusion

In conclusion, several species of aphid infested on different crops and reduced the production. So, it is very important to control the pest population. Aphid behaviour helps to know about their mechanism of resist insecticides through changing their behaviour and helps to fixed management strategy. There is several defence strategy developed by several aphid species for escaped from their predators. The aphid behaviour needs to be assessed first in order to control the aphid species.

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