

Research Article

**INTERACTIONS BETWEEN SPECIES IN WALNUT ORCHARD
ECOSYSTEM OF KASHMIR VALLEY, INDIA**

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Article History: Received 3rd June 2014; Revised 21st June 2014; Accepted 23rd June 2014; Published 3rd July 2014

ABSTRACT

The paper discusses some important biotic interactions with typical examples from walnut orchard ecosystem of Kashmir valley. The ones that have been discussed are competition, predation, herbivory and symbiosis. Two walnut aphids viz. *Chromaphis juglandicola* and *Panaphis juglandis* are primary herbivores, sucking the phloem sap, of walnut orchards in Kashmir valley. These aphids show mutualistic relationship with ants. Also, these aphids are preyed upon by Lacewings and Ladybird beetles. An aphidiid, *Trioxys pallidus* parasitizes *C. juglandicola* and is its primary parasitoid. These species interactions can be used as a framework for studying walnut orchard ecosystem properties and may aid in predicting impact of anthropogenic interferences on the same.

Keywords: Orchard ecosystem, Species Interactions, Predation, Symbiosis.

INTRODUCTION

Biological interactions are the effects organisms in a community have on one another. In nature no organism exists in absolute isolation, and thus every organism must interact with the environment and other organisms (Elton 1968). Ecological community can be defined as an assemblage of populations in which organisms of different species interact directly or indirectly within a defined geographic area (Agrawal *et al.*, 2007; Ricklefs 2008; Brooker *et al.*, 2009). Interactions between species form the basis for many ecosystem properties and processes such as nutrient cycling and food webs. There are a number of interactions depending upon the evolutionary context and environmental conditions in which they occur. As a result, these interactions between individual organisms and entire species are often difficult to define and measure and are frequently dependent on the scale and context of the interactions (Harrison and Cornell 2008; Ricklefs 2008; Brooker *et al.*, 2009). Nonetheless, there are several classes of interactions among organisms that are found throughout many habitats and ecosystems. These ecological interactions can be used as a

framework for studying naturally occurring processes within an ecological community and aids in predicting how human alterations to the natural world may affect ecosystem properties and processes (Jennifer *et al.*, 2013).

Preliminarily ecological interactions can be defined as either intra-specific or inter-specific. Intra-specific interactions occur between individuals of the same species, while interactions that occur between two or more species are called inter-specific interactions. However, since most species occur within ecological communities, these interactions can be affected by, and indirectly influence, other species and their interactions. The ones that will be discussed in this article are competition, predation, herbivory and symbiosis. These are not the only types of species interactions, just the most studied and they are all parts of a larger network of interactions that make up the complex relationships occurring in nature.

METHODOLOGY

The present paper is a part of research work entitled "Survey and Studies of Insects of Walnut

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orchards of Kashmir Valley". All the major zones of Kashmir valley were covered and on average five sites were selected in every district. At every site, 20 trees were sampled. Insect species were collected and brought to lab for identification and further processing. Interactions were studied both under field and laboratory conditions.

RESULTS

Like any kind of ecosystem, walnut orchards harbor different types of species. Some of these organisms feed directly or indirectly on plant material and are called pests. Insects are among the prominent ones in this category. These primary pests have some natural enemies feeding on them which in turn are eaten by other organisms, forming a complex web of interactions. Some of the prominent ones are discussed below:

1. Competition

Competition can be defined as an interaction between organisms or species, in which the fitness of one is lowered by the presence of another. Competition is most typically considered the interaction of individuals that vie for a common resource that is in limited supply, but more generally can be defined as the direct or indirect interaction of organisms that leads to a change in fitness when the organisms share the same resource. The outcome usually has negative effects on the weaker competitors. There are three major forms of competition. Two of them, interference competition and exploitation competition, are categorized as real competition. A third form, apparent competition, is not. Interference competition occurs directly between individuals, while exploitation competition and apparent competition occur indirectly between individuals (Holomuzki *et al.*, 2010).

When an individual directly alters the resource-attaining behavior of other individuals, the interaction is considered interference competition. For example, when walnut green aphid exudes acidic honey dew and limits the growth of dusky-veined aphid. Exploitation competition occurs when individuals interact indirectly as they compete for common

resources, like territory, prey or food. Simply put, the use of the resource by one individual will decrease the amount available for other individuals. Whether by interference or exploitation, over time a superior competitor can eliminate an inferior one from the area, resulting in competitive exclusion (Hardin 1960). The outcomes of competition between two species can be predicted using equations and one of the most well known is the Lotka-Volterra model (Volterra 1926). This model relates the population density and carrying capacity of two species to each other and includes their overall effect on each other. The four outcomes of this model are: 1) species A competitively excludes species B; 2) species B competitively excludes species A; 3) either species wins based on population densities; or 4) coexistence occurs. Species can survive together if intra-specific is stronger than inter-specific competition. This means that each species will inhibit their own population growth before they inhibit that of the competitor, leading to coexistence.

A typical example is competition and niche partitioning in two species of walnut aphids. Two species of aphids colonize walnut orchards, Walnut green aphid (*Chromaphis juglandicola* Kalt.) and Dusky veined aphid (*Panaphis juglandis* Goeze). *P. juglandis* is much larger than the *C. juglandicola* and works entirely on the upper surface of leaves while *C. juglandicola* feeds on lower surface of leaves. Both aphids obtain their nutrition from the phloem tissue. These two aphid species are not usually found together on same trees or orchards. Walnut orchards infested with one species usually do not have other. In laboratory studies, using potted walnut seedlings, competition with *C. juglandicola* has been proved to be an important factor limiting population growth rate of *P. juglandis*, which survived an average of 12 days when competing for nutrients. The preference of *P. juglandis* for upper leaf surface subjects it to a constant rain of honey dew and debris from colonies of *C. juglandicola* on the lower surface of higher leaflets. Contamination of upper leaf surface with *C. juglandicola* honeydew also helps limit the population of *P. juglandis*, which survived an average of eight days when exposed

to *C. juglandicola* honeydew. *P. juglandis* not exposed to honeydew or nutrient competition survived an average of 20 days. *C. juglandicola* is better competitor than *P. juglandis* (Barnes and Sibbet 1971).

Apparent competition occurs when two individuals that do not directly compete for resources affect each other indirectly by being prey for the same predator (Hatcher *et al.* 2006). In walnut orchards, Green lacewing preys both on walnut green aphids and dusky-veined aphids. If the walnut green aphid population increases, then the dusky-veined aphid population may be positively affected since more walnut green aphid will be available as prey for the lacewings. However, an increased walnut green aphid population may eventually lead to a higher population of lacewings requiring more prey, thus, negatively affecting the dusky-veined aphid through increased predation pressure as the walnut green aphid population declines. The opposite effect could also occur through a decrease in food resources for the predator. If the walnut green aphid population decreases, it can indirectly lead to a reduction in the dusky-veined aphid population since they will be the more abundant food source for the lacewings. Apparent competition can be difficult to identify in nature, often because of the complexity of indirect interactions that involve multiple species and changing environmental conditions.

2. Predation and Herbivory

Predation is a biological interaction where a predator (an organism that is hunting) feeds on its prey (the organism that is attacked). In most examples of this relationship, the predator and prey are both animals; however, protozoans are known to prey on bacteria and other protozoans and some plants are known to trap and digest insects (for example, pitcher plant) (Figure 4). Typically, this interaction occurs between species (inter-specific); but when it occurs within a species (intra-specific) it is cannibalism. Cannibalism is actually quite common in both aquatic and terrestrial food webs (Huss *et al.*, 2010; Greenwood *et al.*, 2010). It often occurs when food resources are scarce, forcing organisms of the same species to feed on

each other. Surprisingly, this can actually benefit the species (though not the prey) as a whole by sustaining the population through times of limited resources while simultaneously allowing the scarce resources to rebound through reduced feeding pressure (Huss *et al.*, 2010). The predator-prey relationship can be complex through sophisticated adaptations by both predators and prey, in what has been called an "evolutionary arms race." Typical predatory adaptations are sharp teeth and claws, stingers or poison, quick and agile bodies, camouflage coloration and excellent olfactory, visual or aural acuity. Prey species have evolved a variety of defenses including behavioral, morphological, physiological, mechanical, life-history synchrony and chemical defenses to avoid being preyed upon (Aaron and Farnsworth, 1996).

There are many instances of predation in walnut orchards in which one insect species is preyed upon by another species. These predators at times serve as biological control agents if former is a pest. Brown lacewings, Convergent ladybeetle, Green lacewing, Syrphid fly larva preys upon walnut green aphid and dusky veined aphid (Figure 1 and 2).



Figure 1. Convergent ladybeetle.



Figure 2. Syrphid fly larva feeding on *C. juglandicola*.

A sub-type of predation is parasitoidism in which a free living adult lays eggs in larval stages of host. These eggs on hatching feed on the host and kill them. For example, the female wasp (*Trioxys pallidus*) lays an egg inside nymph of walnut green aphid (Figure 3). The eggs hatch into larvae that consume the internal contents. Eventually the larva pupates and becomes an adult, which chews out an emergence hole. Parasitized aphids are swollen, brown to gray, and are called mummies.



Figure 3. *Trioxys pallidus* ovipositing on aphid.

Another interaction that is much like predation is herbivory, which is when an individual feeds on all or part of a photosynthetic organism (plant or algae), possibly killing it (Gurevitch *et al.*, 2006). An important difference between herbivory and predation is that herbivory does not always lead to the death of the individual. Herbivory is often the foundation of food webs since it involves the consumption of primary producers (organisms that convert light energy to chemical energy through photosynthesis). Plants, like prey, also have evolved adaptations to herbivory. Tolerance is the ability to minimize negative effects resulting from herbivory, while resistance means that plants use defenses to avoid being consumed. Physical (for example, thorns, tough material, sticky substances) and chemical adaptations (for example, irritating toxins on piercing structures, and bad-tasting chemicals in leaves) are two common types of plant defenses (Gurevitch *et al.*, 2006).

Insects feed on variety of plants. Many insect species feed on walnut trees and subsequently are called pests, such as walnut weevil (*Alcidis Porrectirostris* Marsha), walnut blue beetle (*Monolepta erythrecephale*), Sanjose scale

(*Quadraspidiotus perniciosus* Comst), Dusky veined aphid (*Panaphis juglandis* Goeze) and walnut green aphid (*Chromaphis juglandicola* Kalt).

3. Symbiosis: Mutualism

Symbiosis is an interaction characterized by two or more species living purposefully in direct contact with each other. The term "symbiosis" includes a broad range of species interactions but typically refers mutualism. Mutualism is a symbiotic interaction where both or all individuals benefit from the relationship. Mutualism can be considered obligate or facultative. Species involved in obligate mutualism cannot survive without the relationship, while facultative mutualistic species can survive individually when separated but often not as well (Aaron *et al.*, 1996). For example, leafcutter ants and certain fungi have an obligate mutualistic relationship. The ant larvae eat only one kind of fungi, and the fungi cannot survive without the constant care of the ants. As a result, the colonies activities revolve around cultivating the fungi. They provide it with digested leaf material, can sense if a leaf species is harmful to the fungi, and keep it free from pests. A good example of a facultative mutualistic relationship is found between black ants and dusky-veined aphid in which ants feed on the sugar rich honey-dew exuded by aphid. The ants in return relieve and protect them from parasitoids.

DISCUSSION

The species interactions discussed above are only some of the known interactions that occur in nature and can be difficult to identify because they can directly or indirectly influence other intra-specific and inter-specific interactions. Additionally, the role of abiotic factors adds complexity to species interactions and how we understand them. That is to say, species interactions are part of the framework that forms the complexity of ecological communities. Species interactions are extremely important in shaping community dynamics. It was originally thought that competition was the driving force of community structure, but it is now understood that all of the interactions discussed in this article, along with their indirect effects and the variation of responses within and between species, define communities and ecosystems (Agrawal 2007).

CONCLUSIONS

The present study revealed that organisms interact with one another. The outcome of the interaction either benefits both of the partners or one of them or it may harm one of them and benefit other one. The species interact with one another and thus there is a web of interactions in a community. These interactions pose new challenges to the species. To cope up these challenges, the species may have to develop new traits (Adaptation). Many a times it leads to co-evolution. Many a times, these traits during long period of time are favoured by nature, leading to the formation of new species.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest associated with this article.

ACKNOWLEDGEMENTS

We thank Council of Scientific and Industrial Research (CSIR) for providing financial help (Vide Sanction no. 09/251(0048)/2012-EMR-I). We also thank Head, Department of Zoology, University of Kashmir, Srinagar for providing the necessary laboratory facility.

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