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Indirect effect of spiders on herbivory of insects: A review

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Abstract
Herbivory can be very overpricing as it causes great losses in agricultural industry. Entomologists are concerning for replacement of synthetic chemicals with natural methods of controlling pests to avoid environmental hazards. Spiders are considered as a natural enemy of a wide range of insect pests. The chemical cues as pheromones and spider's silk on plants may also cause a fear among herbivorous insects; hence they avoid the plants that bear spiders or their cues. Which cause prolonged starvation in herbivorous and ultimately leads to death. In this way, presence of spiders alters the foraging behavior of insect pests. This predatory phenomenon is the combination of induced migration and consumption. The objective of current review is to explore factors, mechanisms and responses of spider toward herbivory of insects. So that introduction, augmentation or conservation of spiders in agro-ecosystem can be adopted to keep natural check on herbivory of economically important insect pests.

Keywords: Spiders, herbivory, insect pests, agro-ecosystem, plant productivity

1. Introduction

Herbivory can be costly to plants because of removing valuable photosynthetic material that would otherwise be used to support growth and reproduction. Millions of dollars' loss every year in agriculture due to herbivory so it is especially important within agriculture industry. Usually herbivory can be reduced by applying pesticides but for environment friendly concerns, an increased interest in utilizing the natural remedies for pest reduction is need of the day. A good number of biological control agents showed promising results as an alternatives of pesticides [38, 39].

In agricultural ecosystem the members of cursorial "non-web building" wolf spider of family Lycosidae are often the dominant predatory arthropods [59] and are a good candidate for biological control measures. They are generalist predators and within arthropods communities they impact populations of many insect species. Spiders have the potential to effect on crop production indirectly through reduction of insect herbivory [3, 59]. Their presence can suppress pest population through predation and chemical cues left in the environment. Silk draglines produced by wolf spider serve as a chemical cues detectable by insects as well as other wolf spiders [3, 26]. These cues also indirectly affect the behavior of herbivore insects, thus limit their feeding activities in agricultural systems [26]. Ground hunting spiders maintain pest populations below an ETL and play an important role as stabilizing agent of pests in agro-ecosystem [54]. Webs are not build by active ground hunter wolf spiders. They have the largest body size and the most abundant family of ground spiders in many agro ecosystems [46, 43, 45].

2. Responsive behaviour of prey and predators

Non-consumptive effects of spiders happen through morphological, developmental or life histories changes in the prey in reaction to the predator [78]. For example, if in the occurrence of predators' herbivore stops feeding, this behavior may have in-depth environmental effects even in the lack of an effective predation incident [75]. Non-consumptive effects can be classified in different mechanisms i.e. (a) the kind of characteristic that is altered in response to predation threat and (b) the way in which characteristic variations effect prey population growth [50]. By imposing prey to accept costly self-protective tactics, Predators can also decrease prey concentrations [50]. By bringing protective responses in prey structure, composition, or behavior Predators can also cause variations in prey features [35, 36, 31, 42, 49]. Defensive responses induced by predators can help prey to be consumed by the predator [36, 42].

Predators can minimize individual reproduction and existence by their presence alone. The costliness of anti-predator behavior suggests the hypothesis that the adverse effect of predators on prey population growth may be mediated not only through consumption of prey individuals, but also through the induction of prey defensive behavior [36, 42]. Sensory modalities and cues that prey use to detect predators is critical to understand for predicting the strength of predator prey encounter effected by non-consumptive effect [25].

3. Chemical cues in predation

The ability of prey to perceive predators before being eaten relies on ability of Non-consumptive effects. Prey are perceived by predators by chemical cues [31]. Determining the cues used by prey is essential in predicting the ecological consequences of predator–prey encounters [67]. If confronted with cues of different spider species crickets, in particular, show strong behavioral response [9]. In the presence of a predator stress the mortality of the pest prey increase, their defense system, or by development changes that bring fitness, such as reduced energy intake, contact to hazardous environmental conditions and increased risk from other predators, parasitoids, or pathogens [61, 53].

4. Effects of prey habitat on predation

When no mortality involved (non-lethal non-consumption) and result of hazard is balanced which reduce the risk of predation, the choice of habitat, behaviour of foraging and physiology [35, 69], or larval development [17] are involved. In *Helicoverpa armigera* (Lepedoptera: Noctuidae), the predator presence related with changes in place of food on host plant, energy spending increase is associated with the crawling of larvae and fall down the host plant and minimize food intake [29]. Effects of the non-consumption have stronger as compared to effect of consumption on prey population because predator consume small amount of prey but the occurrence of predator can change the behaviour of numerous potential prey [4, 79, 49].

5. Effect of plant volatiles toward predators prey interaction

Plant growth is improved in the occurrence of chemical signals, that make non- consumption effect on plant feeder insects [26]. The damage of grasshopper was low in enclosures in the presence of the wolf spiders as compared to those enclosures where wolf spiders were absent [4]. In the presence of Lynx spiders cotton bolls cause smaller amount of damage from mirids (Miridae) in cotton [80]. If predators cause herbivorous to change foraging activity, then they could change the effect of herbivorous on plants to a level as an excessive as that from density alterations [79].

Antixenosis effect including repellency or deterrent odors reduce probability and the defending individual is killed or loses its resources, it’s a common mechanism among the myriad variations that have been established in the response to selection by natural enemies [33, 40, 73]. The pyrrolidine alkaloids are the defensive chemicals of arthropods. That is the class of protective mixtures that many arthropods get from food. These are dangerous and toxic to a massive range of predators [77, 14]. The central finding in the tri-trophic interactions is to understand how plants traits affect interplay between and predators and herbivores [79, 70]. Some spiders might quickly affect potential prey species with substantial effects on resources [66]. The non-consumptive effect of some spiders depend more on distribution and density of their silk and their diversity or density [58]. Change in the quality of plant has been well known effect on the capacity of natural enemies to reduce plant feeder’s population and ultimately benefits plants [10, 21, 32, 73]. The effect of fear was found as essential as killing prey and the amount of non- consumptive effect as much stronger as compared to effects of consumption [49]. Under risk of predation organisms are forecast to respond a smaller amount of the predators when their physiological state or quality of resource is poor [35, 32, 71]. In theoretical expectation and many studies tells us that when organism is feeding completely then the behavior would be stronger as compared to those organisms that have food shortage [27, 2, 32, 76]. Insect pest population damage crops and practitioners have interest to control pest natural enemies. Modeling approaches indicate that pest control by predator comes when pest population is kept at equilibrium between the pest ad predator numbers. In practice successful control of pest is violated of the assumption of stable equilibrium [41, 56, 24]. Predation number increase competently more Predators become progressively more active at capturing prey, while prey have developed responses to predatory signals that authority to escape from predation [52, 50, 20].

6. Effect of presences of predators in foraging vicinity

The presence of predator cause, stop the food intake at less favorable site. The result shows that prey population reduction, and delay pest outbreak phase, however dropping from the plant may result the mortality of generalist predator [1]. The evidence of waterfall gives indirect predator impact on herbivores in the perceived risk of predation. The foraging strategy of prey is functional trait of explaining the efficiency of the natural control [65, 68]. The Spiders are the great biological control agent and generalist predator [55]. Spiders have different effect on victim and their prey foraging approaches [65]. Those spiders which are active predators reduce the concentration of grasshoppers by catching and feeding them, they sit and wait grasshopper searching activity and reduce the population [65].

The production of tea in china is affected by false-eye leafhopper, *Empoasca vitis* (Homoptera: Cicadellidae) which is a key insect pest [82]. Both adult and immature are sucking pest and mostly attack on the upper branches of tea plant which is purchased as high quality tea products. They damage and curl the leaves and make spots on tea leaves which cause reduction in yield and excellence [82]. The *E. vitis* population is at peak in summer and often extremely destructive [51, 37]. The pests are controlled by the pesticides applications for last few decades in tea plantations. For the organic tea production is to reduce the attack of tea leafhopper in china [51]. Spider increases the biological population in tea and perform significant role in the regulating *Empoascan vitis* [82]. At different foraging strategies leaf hopper populations were affected by the spider. Prey affected by the predators through non-lethal effects where social compensation to predation danger occurs [15]. Identification of prey species is a significant aspect in prey reduction [13, 74]. Spiders have hunting approach other than sit and wait or hunting they also form detecting web weaves and ground spiders have effect on the other species for interference [11].

7. Consumption and non-consumptive effect of predators

Abundance of prey is directly reduced by predators (Consumption) and indirectly by non-consumption like by fear, Predators change the time budget and activity of foraging if less time spent by predator on plant it would result less damage to plant [18, 61]. Consequently, as predators reduce prey densities may increase plant biomass. Spider predator and grasshopper have positive and negative effect on trophic waterfall in old field [61, 62]. Non-consumptive effects of predators have indirect result that waterfall through the public [49, 23, 48, 72] and these properties affect ecosystem [65]. The outcome of these non-consumptive interactions is occasionally counterintuitive [47, 22, 64]. For example, occurrence biological control causes self-protective behavior that cause feeding time loss of prey, Plant productivity is increased when abundance of plant yield does not change [72]. Trophic levels are directly and indirectly affected by the spider and grasshopper interaction [61, 44, 17, 57, 34].

8. Conclusion

The current review concludes, that spider is a deleterious predator to the tiny insect pests. Their presence makes the insect pests so dreadful, that the herbivorous avoid coming in contact with plants which has been colonized by spiders. The most attractive thing about spiders is that they have no adverse effect on plants or their byproduct, instead they work as guards for a plant against insect pests. Hence, the practice of using spider is quite simple, less toxic and entirely a natural remedy to reduce the herbivory of insects. In addition to that the indirect effects of spiders have even greater impact on prey population than direct effect as it may instantaneously alter the behaviour of much potential prey.

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