HOST SEEKING BEHAVIORS OF INSECT PARASITOIDS AND THEIR IMPORTANCE IN INSECT PEST MANAGEMENT

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ABSTRACT

Parasitoids plays vital role in controlling insect pests of agriculture. Understanding host location behavior is crucial for a targeted application of parasitoids in targeted locations. Egg parasitoids have developed various info-chemical detour strategies to locate their hidden hosts. This info-chemical detour via specific cues from the adult host stage solely, sometimes in combination with phoresy, or via cues released from plants induced by larval or adult feeding implies a wide spread exploitation of host-specific info-chemicals by egg parasitoids to locate their hosts. The use of oviposition induced plant cues indicating the presence of the host eggs is another elegant solution to the reliability-detectability problem. Semio-chemicals of importance have been described for a particular system and these often differ among natural enemy species. All species are embedded in a network of ecological interactions that shape the evolution of all traits.

Keywords:- Phoresy, Oviposition, Semio-chemicals, Info-chemical and Cues

INTRODUCTION

Parasitoids are insects which feed on other insects and arthropods, mainly wasps (Hymenoptera) that mature by feeding on the body of another host arthropod, eventually killing it. The parasitoid are extremely species rich and essential to the maintenance of species diversity in other organisms [16].Those insects that parasitize other insects have the following biological characteristics: They are slightly to substantially smaller than their host insect; all parasitoids have a complex immature development stages that parasitize its host; each larva kills only one host during in its life stage; the larvae are totally restricted to parasitizing the single host insect and are often found internally and therefore are not mobile (wingless) in the environment; however, the adult stage is usually winged and mobile, and seeks the appropriate environment or host for its offspring; and they tend to be more host-specific than predators [13]. Parasitoids are insects whose larvae develop by feeding on the bodies of other arthropods, usually insects, but also spiders and centipedes. Parasitoids are many in number and estimated that parasitoids may make up 20–25% of all insects. There are likely to be one to two million parasitoid species (based upon an estimate of eight million insect species). These are predominantly in the Hymenoptera (the ants, bees, sawflies and wasps), but there are also species of other parasitoids among the Diptera (true flies), Coleoptera (beetles), Lepidoptera (moths), Neuroptera (lacewings) and also Trichoptera (caddisflies) parastize insects. To a large extent, the different parasitoid life styles are defined by the larval feeding habits [23].

TYPES OF PARASITOIDS

Parasitoids can be grouped based on the number and type of species that they are able to parasitize. Some parasitoid species are species non-specific, being able to use several host species, while others are species specific, being able to develop on only one host species. Some parasitoids parasitize other parasitoids, and called hyperparasitoids. Obligate hyperparasitoids can only develop as parasitoids of parasitoids, are widely considered an important ecological disturbance to biological control of insect pests, as they develop at the expense of primary parasitoids [18]. Facultative hyperparasitoids are also able to attack unparasitized hosts and often referred to as secondary parasitoids and cases have been recorded of tertiary parasitoids: parasitoids of parasitoids of parasitoids [23]. Idiobiont and Koinobiont parasitoids are the two common types of parasitoids. 10% of insect species are parasitoids, but as many parasitoid groups are poorly known taxonomically the true figure is probably nearer 20% [14].

PARASITOIDS AGGREGATION

Aggregation of parasitoids may occur for two common reasons. First, parasitoids may aggregate in patches of high host density; and secondly, parasitoids may aggregate in certain patches irrespective of high host density. These two types of parasitoid aggregation have been termed host density dependent (HDD) and host density independent (HDI). Parasitoid aggregation leads to competition between individual parasitoids for hosts or resource and a reduction in the average parasitoid searching efficiency. The reduction in the average parasitoid searching efficiency caused by aggregation increases as the average parasitoid density increases, and so introduces temporal density dependence into the system, which can stabilize the host–parasitoid interaction [23].

HOST LOCATION

Prey location in a complex environment, filled with different plants and animal species, is a complex task. Predatory and parasitic insects have specialized sensory nervous systems that allow them to use a variety of cues to find and identify target organisms. Cues can be physical such as color, sound, shape and size as well as chemical and these may be useful for long or short range attraction to prey. Herbivore-induced plant volatiles provide important information in the host location process of different parasitoids. They can vary considerably between and within plant species but can also differ between the herbivore species causing the damage. The specificity of these volatiles together with the ability of parasitoids to distinguish different blends determines the foraging efficiency of parasitoids. In this perspective a theoretical distinction is drawn between specialist and generalist parasitoids. The specialist is thought to be superior in exploring specific volatile cues whereas the generalist is thought to be superior in adapting its foraging behavior in a more variable environment by means of associative learning [4].

MECHANISM OF HOST LOCATION

Parasitoid uses different host locating mechanism to parasitize and oviposit their eggs inside or near host insects. Host selection may be the female response to the selected attributes that distinguish hosts from others organisms [17]. Host location is not simply a matter of homing in on chemical cues, but may also involve signs from vision, sound, touch and even heat [22]. Host recognition may involve changes in the female's behaviour, and directed responses towards a host. Once a female comewith a potential host, she examines its quality and suitability for oviposition, by antennation and ovipositor probing, for offspring development.

Egg parasitoids play an important role in biological control programs of egg laying pest insects. Understanding their host location behavior is a crucial step for a targeted application of parasitoids in crop fields and greenhouses. A general pattern of strategies has been highlighted here: due to the inconspicuousness of host eggs, egg parasitoids have developed various so-called infochemical detour strategies to locate their hidden hosts. This infochemical detour via specific cues from the adult host stage, sometimes in combination with phoresy, or via cues from plants induced by larval or adult feeding implies a wide- spread exploitation of host-specific infochemicals by egg para- sitoids. The use of oviposition-induced plant cues indicating the presence of the host eggs is another elegant solution to the reliability-detectability problem [7].

CUES FROM MICROHABITAT AND FROM THE HOST PLANTS

The pattern of host-plant dependence varies among species of different caterpillars, and some other parasitoid species themselves are specialized with respect to some tree species (Lill *et al*., 2002). When attacked by herbivorous insects, many plants emit volatile compounds that are used as cues by predators and parasitoids foraging for prey and hosts, respectively. After landing on a host plant, egg parasitoids mainly use contact or short-range volatiles that indicate the presence of the host or more specifically its eggs.

Tri-tropic is situations where by host plants that can be eaten by pests call the parasitoids to come and protect them. Calling is through production of different chemical which used to attract parasitoids (figure 1).

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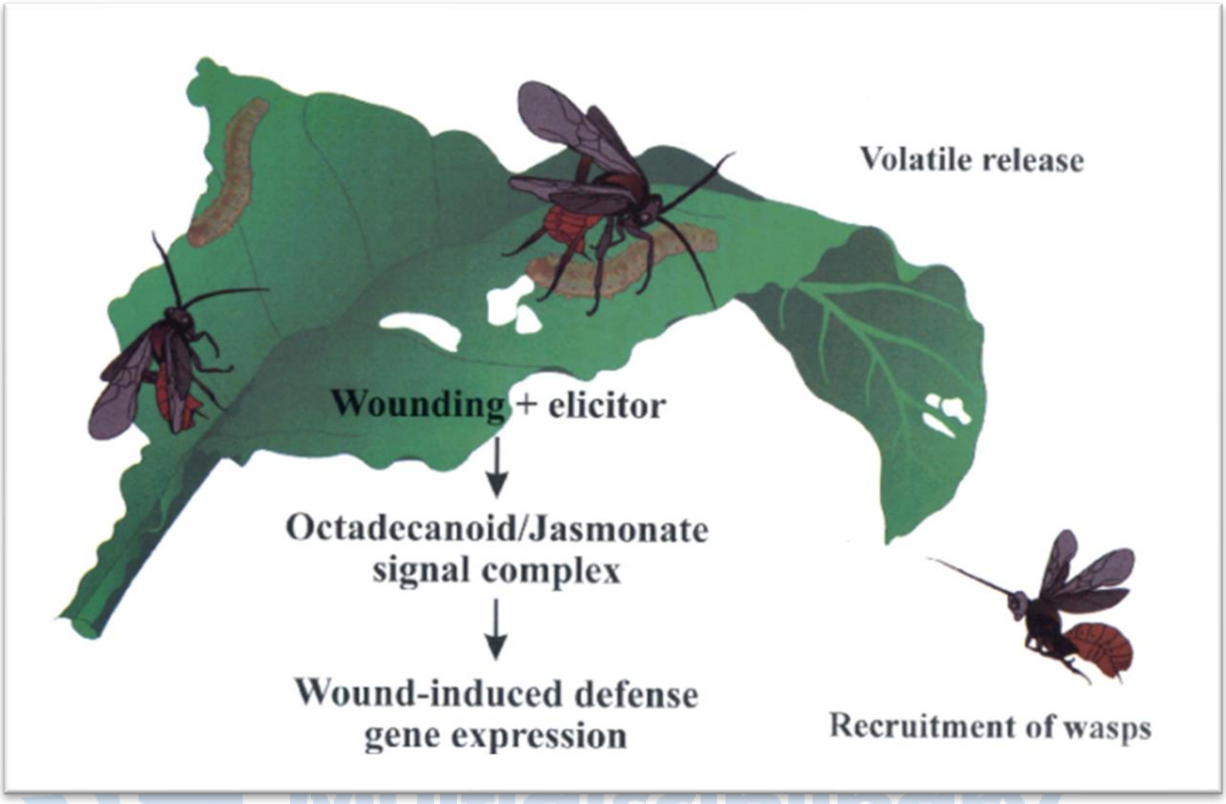

Figure 1. Volatile compounds are released by plants in response to insect feeding triggered by an interaction of elicitors from the oral secretions of insect behaviors with damaged plant tissue. The volatiles are used by some parasitoid wasps to locate their hosts.

Source :[15].

INDIRECT CUES FROM THE HOST

During the host location process, egg parasitoids can eavesdrop (listen in) on chemical cues released from immature and adult hosts. These indirect host-related cues are highly detectable, but of low reliability because they lead egg parasitoid females to an area where oviposition is likely to occur rather than providing wasps with direct information on the presence of eggs and their location. In the host-parasitoid associations between host and their parasitoids, female parasitoid perceive the chemical residues left by host adults walking on substrates as contact kairomones, displaying a characteristic arrestment posture [10]. M. digitata females reacted to cues emitted by fresh mud + spiders and fresh mud alone, but not to old mud from nests of *T.*

politum. (Hymenoptera: Crabronidae). This clearly indicates that volatiles emitted by recently built nests attract the parasitoids to their surroundings. Such volatiles do not appear in old mud from old nests. Because a *T. politum* adult female uses moist, pliable mud manipulated by her mouthparts to build a nest, it is possible that chemicals associated with female mouthparts could be acting as a kairomone, thus explaining why fresh mud is attractive but old mud is not [5]. Currently, there is increasing evidence that volatile blends from aphid- damaged plants play a pivotal role in habitat location by both parasitoids and predators, although only a few model systems have been investigated in detail [12].

DIRECT CUES FROM THE HOST

There are different direct cues that facilitate conditions for parasitoids to locate hosts. These are substances which can produce by the host organism as primary metabolites or as secondary metabolites and attracts or indicates the presence of the host through different mechanism. Chemical and physical compounds in cornicle secretions are active at very short range or in direct contact with an aphid, usually stimulating attacks by parasitoids. This response to cornicle secretion appears to be innate and host specific [2].

PHORESY BY ADULT PARASITOIDS

Phoresy is an interaction in which a phoretic animal (or phoront) latches itself onto a host animal for the purpose of disperse (Signe *et al*.,2017). Phoretic insects utilize other animals to disperse to new environments [6]. Small animals with low mobility often seek out vehicles to migrate to new environments, for further development or reproduction. Females of many egg parasitoid species are known to hitch-hike with adult hosts to reach their egg-laying sites [6].

OVIPOSITION AWAY FROM THE HOST

Phytophagous isects prefer risk free areas from predators. Many species avoids risk from predators by laying eggs away from enemies by selecting hidden places and also lay their eggs on plants and its part which are not suitable for larval food eg. Peruvian butterfly, Oleria onega Hewitson (Lepidoptera: Nymphalidae: Danainae: Ithomiini) [21]. As stated by[8] and David R. Nash(2010) some insects oviposit near the colony of ants and oviposition is not influenced by the presence of ants rather the oviposition takes place near small buds.

INSECT'S PARASITOIDS COMPETITION

Competition is commonly widespread in parasitoids. Simultaneous patch depletion involves a dilemma: individuals that leave the patch early get less than the ones which remain, who get more than the expected gain in the environment. However, all payoffs decrease in time. Thus, the longer an individual remains in a patch the lower its payoff will be but, on the other hand, if it manages to remain longer than the rest, it might win a lot. Competing parasitoids may respond to an encounter with a host already parasitized by a conspecific female either by rejecting it or by laying additional eggs, an act called superparasitism. Superparasitism is a common means of competition in parasitoids [11]. Superparasitism is not the only way in which parasitoids compete patch defense involves patroling of the patch edge, pursuit, and fightin with intruding competitors. Like superparasitism, this form of competition induces interference and, therefore, situations similar to a generalized war of attrition are expected to occur.

PARASITOIDS SEX RATIO

Some parasitoids are sexual, producing males and females, others reproduce asexually through parthenogenesis. In some cases parthenogenetic reproduction is forced upon the species by intracellular bacteria, while in others the cause is not known. Within the Hymenoptera, sex determination is haplodiploid, with diploid females developing from fertilized eggs, and haploid males developing from unfertilized eggs. One important consequence of this is that by altering the proportion of eggs that she has fertilized a female is able to control the sex ratio of her offspring [23]. Many females of insect species have been shown to lay a less female-biased

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sex ratio if other females are simultaneously laying eggs on the same patch; shift in offspring sex ratios is primarily caused by the presence of eggs laid by other females, and to a lesser extent by the presence of other females [20].

IMPORTANCE OF PARASITOIDS IN PEST MANAGEMENT

Parasitoids are important natural enemies of insects pests and help keep their populations in check, and therefore represent a common source of biological control agents. Our ability to achieve consistent and effective pest suppression through biological control depends on our ability to understand the complex interactions between natural enemies, herbivores and plants and to develop effective techniques for managing the genetic makeup and phenotypic expression of host plants and natural enemy populations as well as critical components of the target environment to optimize the performance of natural enemies. While a considerable amount of practical development remains to be done, it appears that parasitoids may be managed to enhance their effectiveness as biological control agents. Given the current decline in the effectiveness of available pesticides and the growing concern over their effects on ecological and human health, it is imperative that we develop the technology that is necessary to implement effective biological control methods as quickly as possible. Foraging effectiveness to use in integrated pest management will be by manipulating the behavior of parasitoids [15].

The advantages and limitations of biological control are often expressed by comparisons with pesticides. Thus, predators and parasitoids are naturally occurring organisms and usually fairly specific in the range of prey that they will attack. Natural enemies actively seek out their prey and can increase the level of control over time. It is unlikely that resistance will develop to a control agent, and in many cases, the control can be self-perpetuating over long periods of time.

Chemical pesticides are not limited to target pests rather it can affect other beneficial insects and even mammals but, insect parasitoids are relatively selective and even species specific. Further- more, chemical control is limited to specific areas, frequent application may be required, and this selects for pest resistance [1]. natural regulation of the apple sawfly by *Lathrolestes ensator* and *Aptesis nigrocincta*, of the summer fruit tort rix moth by *Colpoclypeus florus* and *Teleutaea striata*, of leaf midges by *Platygaster demades*, of woolly aphid by

Aphelinus mali and of leaf mining moths by guilds of parasitoid species [3]. Parasitoid wasps were provided the most important contribution towards suppression of aphid densities [19].

Table 1. Few important parasitoids example

Parasitoid group	Pest attacked	Impact on pest
Aphid Parasitoids	Aphids	Wasp inserts egg into aphid. The developing larvae eventually killing the aphid "mummy" as the adult wasp emerges
Caterpillar Parasitoids	Heliothis and other moth larvae	Female lays eggs in host pupae as the parisitoid larvae develop in the host it causes the death of the pupa.
Caterpillar Parasitoids	Sorghum midge	Wasp lays eggs in midge larvae and emerges at pupal stage
Caterpillar Parasitoids	Heliothis, looper, armyworm, grasshopper and other larvae	Female lays eggs in host pupae as the parisitoid larvae develop in the host it causes the death of the pupa
Helicoverpa Egg parasitoids	Helicoverpa and other Lepidoptera	Tiny wasps that parasitise Lepidopteran
White fly parasitoids	White fly	Small parasitoid wasps that attack whitefly nymphs
GVB egg Parasitoids	Green vegetable bug	Small black wasp that parasitises GVB; doesn't distinguish between eggs of pests and beneficials and will also parasitise eggs of predatory shield bugs.

Source [9].

CONCLUSION

This paper summarizes the extensive research conducted so far on host seeking behaviors, factors affecting host location and the role of info-chemical use by different parasitoids during host foraging. Parasitoids play an important role in biological control programs of insect pests to keep pests below damaging level. Understanding their different host location behavior is a crucial step for a targeted application of parasitoids in crop fields and greenhouses. A general pattern of strategies has been highlighted here: due to the inconspicuousness of host eggs, egg parasitoids have developed various so called info-chemical detour strategies to locate their hidden hosts. This info-chemical detour via specific cues from the adult host stage, sometimes in combination with phoresy, or via cues from plants induced by larval or adult feeding implies a wide spread exploitation of host-specific info-chemicals by egg parasitoids. The use of oviposition induced plant cues indicating the presence of the host eggs is another elegant solution to the reliability-detectability problem. A previous experience with the plant stimuli in association with a host cue seems to play a role in the exploitation of induced plant cues especially in variable environments. In most cases, one or only a few semiochemicals of importance have been described for a particular system and these often differ among natural enemy species. Finally, all species are embedded in a network of ecological interactions that shape the evolution of all traits. Understanding the evolution of the semiochemicals requires taking into account the interactions of insect pests with hosts, competitors, natural enemies and mutualisms.

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