Review Article

Egg Parasitoids of Hemipteran Insects: A special account on Scelionidae (Platygastroidea: Hymenoptera)

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Abstract: Parasitoids are considered as one of the key biotic factors regulating the population dynamics of other insects in the natural settings. This makes them effective candidates for augmentative biological control of insect pests in the agroecosystems. The insect parasitoids are classified as egg, egg-larval, larval, pupal, nymphal and adult parasitoids based on the stage of the host attacked. Among these, egg parasitoids are often more dominant and effective natural enemies of certain pests compared to other parasitoids and predators. Egg parasitoids are small insects that lay their eggs within the eggs of their host insects, ultimately killing the host embryo thereby reducing the number of individuals surviving to the next generation. Egg parasitoids have been used successfully for many decades as inundative and augmentative biological control agents against a wide range of economically important agricultural and forest pests; they are currently the most widely produced and released natural enemies in biological control throughout the world. Scelionidae is a family of egg parasitoids which mainly parasitize the eggs of several Hemipteran species. Research has identified many species in this family, including *Trissolcus* and *Telenomus*, that show both generalist and specialist parasitism behaviours. For example, *Trissolcus urichi* and *Telenomus podisi* have been known as generalists, parasitizing several stink bug species, while others, such as *Trissolcus teretis* and *Phanuropsis semiflaviventris*, exhibit specialization, targeting specific host eggs. An efferent is made to pool the information on the parasitoid species involved and the host insects associated with them to understand their diversity and biocontrol potential.

Comment [U2]: This section is excessively introductory. Abstracts should include an overall synopsis of the manuscript. It is best to follow the Journal's abstract guidelines.

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Introduction

Maintaining the health of crops and protecting them from insect pests is a major concern for the farmers (Kataria and Kumar 2012). Insect pests belonging to diverse taxa with different feeding habits cause various kinds of injury to crop plants. Among these, the sucking insects belonging to order Hemiptera causes serious injury to plants directly by sucking the sap, and indirectly by transmitting plant diseases leading to sever yield losses. For instance, Pea aphid, *Acyrthosiphon pisum* (Hemiptera: Aphididae) poses a serious threat to commercial pulse production as it can cause direct damage to crops by extracting sap from leaves, stems, and pods. Additionally, it serves as a vector for transmitting over 30 plant viruses, including cucumber mosaic virus, beet yellows virus, pea enation mosaic virus, and bean leafroll virus (Paudel *et al*., 2018). In Okra, leafhoppers and whiteflies causes 54-66% loss of yield (Rai *et al*., 2014). After pod borers, the pigeon pea pod sucking bug, *Clavigralla gibbosa* (Hemiptera: Coreidae), has emerged as a significant menace to pigeonpea quality grain production (Chakravarty *et al*., 2016). Typically, the damage inflicted on grain yield by this bug range from 25 to 40 % (Gopali *et* al., 2013). The occurrence of the mirid bug, *Nesidiocoris cruentatus* (Hemiptera: Miridae) has recently been recorded on tender leaves and young fruits across various regions of eastern Uttar Pradesh on bottle gourd (Halder *et al*., 2017). In recent years, there has been a notable surge in the global movement of invasive exotic species from one region to another. Among economically significant arthropods, whiteflies and mealybugs play a substantial role in this invasion. In India, there are 469 species of whiteflies belonging to 71 genera known to feed on a wide range of agricultural, horticultural, and forestry crop plants, including 8 invasive species (Sundararaj *et al*, 2021). Despite various control measures available, farmers primarily rely on systemic chemical pesticides to control these insect pests. However, the unrealistic and indiscriminate use of synthetic pesticides over the years has led to outbreaks of both insect, and non-insect pests and sever environmental problems. Farmers, both in developed and underdeveloped countries, solely depend on synthetic insecticides, collectively spending an estimated 9 billion US Dollars annually (Cork *et al*., 2003).

Stink bugs (Hemiptera: Pentatomidae) are serious pests of a wide variety of agricultural crops and are often found on a succession of host plants throughout the season. Several hymenopteran egg parasitoids are known to attack Pentatomidae, including Scelionidae (*Gryon* Haliday, *Telenomus* Haliday, Trissolcus Ashmead), Eupelmid (*Anastatus* Motschulsky) and Encyrtidae (*Ooencyrtus* Ashmead). The eupelmids and encyrtids associated with pentatomids are generalists and include members that are facultative hyperparasitoids (Roversi *et al*., 2017). In contrast, scelionids in the genus *Trissolcus* and several species in the genus *Telenomus* are strictly associated with Pentatomidae, cause high levels of parasitism, and are used as biological control agents for native and invasive pentatomid species (Orr 1988). Attributes like high searching ability, high reproductive rates and lack of hyperparasitiods place them as highly potential and promising biocontrol agents (Orr 1988). Within Pentatomidae, little is known regarding the specificity and host range of scelionid species, but there has been increased interest in these host-parasitoid associations to

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determine the potential for native scelionids to utilize exotic *H. halys* as a host resource in recently invaded areas.

The superfamily Platygastroidea is the third largest group after Ichneumonoidea and Chalcidoidea in the Parasitic Hymenoptera (Austin *et al*., 2005). This superfamily comprises seven extant families with two families – Scelionidae (exclusively attacking the eggs of insects) and Platygastridae (parasitizing both insect eggs and immature stages of Cecidomyiidae and sternorrhynchous Hemiptera) are rich in species in tropical countries like India. The subfamily Telenominae (Scelionidae) is of immense importance, as agricultural pests belonging to Lepidoptera and Hemiptera are attacked by them. *Trissolcus basalis* (Wollaston) which attacks the green stink bug *Nezara virudula* (L.) eggs are being used widely in biological control programmes for its management (Powell and Shepard 1982). Scelionid parasitoids of hemipteran eggs are the subject of active study, driven by the economic damage caused by a variety of bug pests, and by recent works that accelerate further advancement (Yen *at al*., 2022). Biological control of other pentatomid pests has focussed on the use of egg parasitoids and the study of their biology (Forouzan *et al*., 2015). In the Indian subcontinent, egg parasitoids from several genera in the family Scelionidae have been reported, among them *Telenomus* Haliday, *Trissolcus* Ashmead and *Gryon* Haliday are important (Rajmohana 2006). In this review, we tried to pool some vital information regarding the Scelionid egg parasitoids of agriculturally important hemipteran pests.

Diversity of Hemipteran egg parasitoids in the superfamily Platygastroidea

The superfamily Platygastroidea (Hymenoptera: Proctotrupomorpha) is a diverse taxon of wasps that are parasitoids of nine orders of insects as well as spiders (Chen *et al*., 2021). Superfamily Platygastroidea comprises seven extant families: Geoscelionidae, Janzenellidae, Neuroscelionidae, Nixoniidae, Platygastridae, Scelionidae and Sparasionidae (Chen *et al*., 2021). Among these families, except Platygastridae and Scelionidae, the information on host range, the species composition of remaining five families are scanty. From the available information it is understand that these five families attack mainly the eggs of Orthoptera. Austin *et al*. (2005) suggested that the most likely ancestral host for Platygastroidea are the eggs of Orthoptera, however, individual groups of platygastroids have undergone subsequent changes to attack different arthropod groups. The Scelionidae and Platygastridae are the two major families of Platygastroidea, known for their diverse species composition and better understanding on their host range of which many are hemipteran insects. For instance, 26

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species of Scelioids belonging to 4 genera (*Trissolcus, Telenomus, Psix* and *Gryon*) recorded as the egg parasitoids of *Nezara viridula* (Jones 1988). The Scelionidae comprises more than 4000 species in 176 genera (Johnson 1992) with the greatest diversity of hosts in the superfamily and most biological data in general. The host taxa include: Odonata, Orthoptera, Mantodea, Embiidina, Hemiptera, Coleoptera, Neuropteran, Lepidoptera and Diptera) as well as spiders (Muesebeck 1979). The subfamily Telenominae, particularly the genera *Trissolcus* Ashmead and *Telenomus* Haliday, have been extensively studied because of their role as biological control agents of their hosts especially hemipterans. The genera *Gryon* Haliday and *Telenomus* have been reported to use several groups of hosts (e.g., *Telenomus* species are parasitoids of the eggs of Hemiptera, Lepidoptera, Diptera, and Neuroptera), but according to Taekul *et al*. (2014), the ground-plan hosts of both *Gryon* and *Telenomus* are likely to be Hemiptera. The Platygastridae comprises 69 genera (Vlug 1995). This is strikingly the most species rich family characterized by their minute size and reduction in the wing venation, number of antennomeres, number of metasomal segments and overall body sculpture. As per the available data, the most species of Platygastridae are larval or egg-larval parasitoids of Cecidomyiidae (gall midges). The subfamily Sceliotrachelinae is more biologically diverse and has been reared from the eggs of Coleoptera and auchenorrhynchous Hemiptera, the nymphs of sternorrhynchous Hemiptera.

There are six genera of scelionids recorded as the egg parasitoids of hemipteran insects. A detailed list of the documented species and the host insects they associated with is presented in the Table 1. The genus *Trissolcus* Ashmead is a cosmopolitan genus with at least 180 described species of egg-parasitoid wasps associated with stink bugs (Pentatomidae, Scutelleridae, Urostylididae), many of which are important insect pests (Chen *et al*., 2020). During the past decade, the Asian fauna of *Trissolcus* has received increased attention, driven largely by the search for biological control agents to manage two invasive stink bugs of global significance: *Halyomorpha halys* (Stål) and *Bagrada hilaris* (Burmeister) (Pentatomidae). The genus *Telenomus* Haliday is by far the largest genus in the subfamily Telenominae and includes more than 600 species reported worldwide. Species of *Telenomus* share the hosts of *Trissolcus* (Pentatomidae, Scutelleridae, Urostylididae), but also attack a wider range of Heteroptera, as well as Auchenorrhyncha, Lepidoptera, Diptera and Neuroptera. *Protelenomus* Kieffer, another genus in this subfamily, is known to parasitize coreid bugs (Veenakumari and Prashanth Mohanraj 2015; Venakumari *et al*., 2019). *Protelenomus anoplocnemidis*, *P. flavicornis* and *P. areolatus* Rajmohana are the only previously described species in this genus (Johnson 2015, Rajmohana 2013), however Venakumari *et al*. (2019) described six new species and added and revised the genus *Protelenomus*. The *Hadronotus* Förster another genus in the family Scelionidae and the species of *Hadronotus* are known to parasitize the eggs of hemipteran pests, including pentatomids such as *Piezodorus hybneri, Dolycoris baccarum*, *Nezara antennata* and *Halyomorpha halys* (Zhang et al. 2005).

Table 1. List of Scelionid parasitoids and the hemipteran insect hosts they associated.

Parasitoid species	Hosts	References
Trissolcus edessae (Fouts)	*Halyomorpha halys, Euschistus servus, Chinavia hilare*	Ogburn *et al.* (2016)
Trissolcus euschisti		
	Euschistus conspersus	Krupke and Brunner (2003)
	Edessa meditabunda	Golin *et al.* (2011)
	Chinavia hilare, Brochymena quadripustulata	Gariepy *et al.* (2018)
Trissolcus kozlovi	*Halyomorpha halys*	Moraglio *et al.* (2020)
Trissolcus semistriatus (Nees von Esenbeck)	*Eurydema* sp., Scutelleridae	Chen *et al.* (2020a)
Trissolcus podisi	*Podisus maculiventris Say*	Riley and Howard (1891)
	Halyomorpha halys (Stal) (Hemiptera: Pentatomidae) Euschistus servus (Say) Chinavia hilare (Say)	Ogburn *et al.* (2016)
Trissolcus cultratus (Mayr)	*Hippotiscus dorsalis* Stål, Pentatomidae; *Urochela luteovaria* Distant, Urostylididae	Chen *et al.* (2020a)
Trissolcus elasmuchae (Watanabe)	*Niphe elongata* (Dallas), Pentatomidae	
Trissolcus latisulcus (Crawford)	*Poecilocoris latus* Dallas, Scutelleridae	
Trissolcus yamagishii Ryu	*Niphe elongata* (Dallas), Pentatomidae	
Trissolcus japonicus (Ashmead)	*Erthesina fullo (*Thunberg), Pentatomidae; *Rhaphigaster nebulosa* (Poda), Pentatomidae	
	Halyomorpha halys	Bertoldi *et al*. (2019); Holthouse *et al*. (2020)
	Halyomorpha halys	Moraglio *et al*. (2020)
Trissolcus grandis	*Eurygaster integriceps, Eurygaster spp.*	Buleza and Mikheev (1979)
	Eurygaster integriceps	Trissi *et al*. (2006)
Trissolcus basalis (Wollaston)	*Nezara viridula*	Jones (1988); Waterhouse (1998); Colazza *et al.* (2004); Tillman (2010)
	Halyomorpha halys	Moraglio *et al*. (2020)
Trissolcus simoni	*Eurydema ventrale*	Colazza and Bin (1988);

Trissolcus simoni *Trissolcus brochymenae*	*Eurydema ventrale* *Murgantia histrionica*	Conti (2004)
Trissolcus utahensis	*Euschistus conspersus*	Krupke and Brunner (2003)
Trissolcus elimatus	*Edessa meditabunda* (F.) (Pentatomidae)	Golin *et al*. (2011)
Trissolcus urichi (Crawford)	*Euschistus heros* and *Chinavia ubica*	Sousa *et al*. (2019)
	Edessa meditabunda	Golin *et al*. (2011)
	O. poecilus *T. limbativentris*	Silva *et al*. (2021)
	Piezodorus guildinii *Nezara viridula* *Dichelops sp* *Euschistus heros* *Piezodorus guildinii*	de Almeida Paz-Neto *et al*. (2015)
Trissolcus plautiae (Watanabe)	*Plautia stali* Scott, Pentatomidae	Matsuo *et al*. (2014)
Trissolcus mitsukurii (Ashmead)	*Nezara viridula Scotinophara lurida Ensarcoris sp*.	Hokyo and Kiritani (1963);
	Nezara antennata	Hokyo and Kiritani (1963); Yasumatsu and Watanabe (1964);
	Gonopsis affinis, *Lagynotmus elongatus*, *Dolycoris baccarum* L. *Piezodorus hybneri,*	Yasumatsu and Watanabe (1964);
	Halyomorpha halys	Moraglio et al., 2020; Zapponi et al. 2020
	Pentatomidae	Chen et al. (2020a)
Trissolcus hyalinipennis	*Bagrada hilaris* (Pentatomidae)	Tofangsazi et al. (2020)
Telenomus nakagawai Watanabe	*N. viridula , S. lurida*	Hokyo and Kiritani (1963);
	N. antennata	Yasumatsu and Watanabe (1964);
Telenomus triptus	*Piezodorus hybneri*	Higuchi, 1993
	Scotinophara coarctata	Arida et et. (1988)
*Telenomus truncatus (*Nees von Esenbeck)	Pentatomidae	Tortorici *et al*. (2024)
Telenomus gifuensis Ashmead	*S. lurida, D. baccarum*,	Yasumatsu and Watanabe (1964);
	Eusarcoris parvus, Eusarcoris guttiger,	Hidaka (1958);
	N. viridula L.,	Hokyo and Kiritani (1963);
	N. antennata, *Anacanthocoris concoloratus, Riptortus clavatus Scotinophara lurida* (Pentatomidae)	Hidaka (1958);
Telenomus perplexus Girault	*Brochymena sp*	Girault, 1904
Telenomus podisi Ashmead	*Oebalus poecilus* *Euschistus heros* *Tibraca limbativentris*	Silva et al., 2021
	Murgantia histrionica	McPherson et al. 2018

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	Euschistus heros	Silva et al. (2021); Bueno et al (2020); Parra et al. (2023)
	Euschistus conspersus	Krupke and Brunner, 2003
	Euschistus servus	Ogburn *et al*. (2016)
	Halyomorpha halys	Ogburn *et al*. (2016) Cornelius *et al*. (2016)
	Piezodorus guildinii *Euschistus spp.* *Nezara viridula*	Moonga *et al*. (2018)
	Dichelops sp *Piezodorus guildinii* *Nezara viridula* *Euschistus heros*	de Almeida Paz-Neto *et al*. (2015)
	Dichelops melacanthus, Euschistus heros, Podisus nigrispinus	Queiroz *et al*. (2018)
Telenomus turesis	*Palomena prasina* L. (Hemiptera: Pentatomidae)	Ozdemir *et al*. (2023)
	Halyomorpha halys	Moraglio *et al*. (2020)
Telenomus ashmeadi	*Pentatoma ligata, P. sayi*	Morrill (1907)
	Euschistus fissilis *E. tristigmus*	Girault (1904)
	Euschistus servus	Ashmead (1893),
	Piezodorus guildinii *Euschistus spp.* *Nezara viridula* *Podisus maculiventris* (Say), *Chinavia hilaris*	Moonga *et al*. (2018)
Telenomus calvus	*Euschistus conspersus*	Krupke and Brunner (2003)
	Podisus neglectus	Aldrich (1995)
	Podisus maculiventris	Aldrich *et al*. (1984); Orr et al, 1986; Bruni *et al*. (2000)
Telenomus cuspis Rajmohana and Srikumar	*Helopeltis antonii* (Miridae)	Srikumar *et al*. (2015)
Gryon homoeoceri Nix.	*Amblypelta nianihotis* Blote *Dasynus piperis* China	Phillips (1941) Kalshoven (1981)
Gryon sp (Scelionidae)	*Amblypelta lutescens papuensis*	Greve and lsmay (1983)
	Edessa meditabunda (F.) (Hemiptera: Pentatomidae)	Golin *et al*. (2011)
	N. lugens	Manjunath *et al*. (1978)
Gryon aetherium Talamas	*Bagrada hilaris* (Burmeister) (Pentatomidae)	Rojas-Gálvez *et al*. (2021) Hogg *et al*. (2023)
Gryon ancinla Kozlov and Lê	*Acanthocoris scaber* (L.) (Coreidae)	Chen *et al*. (2020b)
Gryon clavigrallae Mineo	*Clavigralla spp.* (Coreidae)	Shanower *et al*. (1996)
Gryon gonikopalense	*Bagrada hilaris* (Pentatomidae)	Tofangsazi *et al*. (2020)
Idris elba Talamas	*Bagrada hilaris* (Burmeister), Pentatomidae	Lomeli-Flores *et al*. (2019)
Protelenomus sp	*Anoplocnemis phasiana* (Coreidae)	Kohno (2002)
Protelenomus flavicornis	*Anoplocnemis phasiana*	Veenakumari and Mohanraj

	(Coreidae)	(2015); Veenakumari *et al*. (2019)
Protelenomus gajadanta	*Pseudotheraptus devastans* (Coreidae)	Veenakumari *et al*. (2019)
Protelenomus anoplocnemidis	*Anoplocnemis curvipes* (Coreidae)	
Hadronotus pubescens (Motschoulsky)	*Riptortus pedestris* (Fab.) (Hemiptera, Alydidae)	Raju *et al*. (2022)
Hadronotus pennsylvanicus (Ashmead)	*Anasa tristis* and *Leptoglossus* sp (Coreidae)	Boyle *et al.* (2023)
Psix abnormis Kozlov and Lê, *Psix saccharicola* (Mani), *Psix sunithae, Psix lacunatus, Psix confluus* Johnson and Masner, *Psix robustus* Rajmohana, *Psix striaticeps* (Dodd), *Psix variosus* Johnson and Masner	Several pentatomids and coreids	Singh *et al*. (2012)

Gryon Haliday, 1833 is another genus within the family Scelionidae. It is the largest genera in Scelioninae with 332 species known in the world (Johnson 2019). This genus is notable for its role as an egg parasitoid, primarily targeting the eggs of various hemipteran pests, mainly Pentatomidae, Reduviidae, and Coreidae (Masner 1983). Recent studies have identified several new species within this genus, such as *Gryon ancinla* and *Gryon aetherium*, which have been reported in regions like Vietnam, China, and Pakistan, respectively (Chen at al., 2020, Hogg et al., 2023). Similarly, another genus *Idris* Förster, 1856 is also include several egg parasitoids, however majority of them are parasitic on spiders. Few species like *Idris elba* Talamas is parasitic on eggs of *Bagrada hilaris* Lomeli-Flores et al. (2019). *Hadronotus* is a genus of wasps in the Scelionidae family that includes about 217 species. Some species of *Hadronotus* include. *Hadronotus pennsylvanicus* and *Hadronotus pubescens* which are egg parasitoids of bugs belongs to the heteropteran families Coreidae and Alydidae (Raju et al. 2022; Boyle et al. 2024). The parasitoids in the genus *Psix* Kozlov, 1976 have been documented to parasitize the eggs of various hemipteran pests, contributing to the control of populations that can cause significant agricultural damage (Singh et al. 2012).

Host parasitisation potential and use of Scelionid parasitoids in biological control of hemipteran pests: few important case reports

Both Scelionidae and Platygastridae contain candidates for classical biological control programs, however Scelionidae contain most egg parasitoids of hemipteran pests, and many of them have been introduced for control of invasive pests. A clear example is *Trissolcus basalis*, which has been recorded in six zoogeographical regions. *Trissolcus basalis* is the representative example which is widely introduced into many countries for control of *Nezara viridula* (L., 1758) (Hemiptera, Pentatomidae) throughout the world (Waterhouse, 1998). The parasitoid–host association of *Trissolcus basalis* and *N. viridula* has become a favored model system in ecological, behavioral, and physiological research on insects (Austin et al. 2005). Some other species of Scelionidae including, *Trissolcus mitsukurii*, *Trissolcus colemani* (as *T. crypticus*) and *Telenomus chloropus*, have also been widely transported to control the same pest. Attempts were also made to use species of Scelionidae in the framework of classical biological control.

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The Neotropical Brown Stink Bug, *Euschistus heros* (Hemiptera: Pentatomidae), the most prevalent soybean pest, presents serious management issues due to its high frequency and abundance of occurrence (Panizzi 2013). Egg parasitoids are widely used in augmentative biological control and can be regarded the most important stink bug biocontrol agents (Laumann et al. 2010). Among the numerus species of egg parasitoids that can be used in augmentative biological control of *E. heros, Telenomus podisi* (Hymenoptera: Platygastridae) is notable for its high parasitism and control efficacy against its hosts. (Queiroz et al., 2018). Bueno et al. (2020) reported that release of *T. podisi* in the field increased *E. heros* egg parasitism to 70% and 50%, in 2017/2018 and 2018/2019, respectively. Thus, they suggested that *T. podisi* can be efficiently used to control stink bug eggs in the form of encapsulated pupa or unprotected, with similar efficacy. Gariepy *et al.* (2019) reported five species of scelionids parasitizing eleven pentatomid species. 70% of all the eggs masses examined were parasitized by parasitoids. *Telenomus podisi* Ashmead being the dominant parasitoid and was detected in all host species. *Trissolcus euschisti* Ashmead was detected in many host eggs, but was significantly more prevalent in *Chinavia hilaris* (Say) and *Brochymena quadripustulata* (Fabricius). *Trissolcus brochymenae* Ashmead and *Trissolcus thyantae* Ashmead were recorded sporadically. Parasitism of *H. halys* was 55%, and this species was significantly less likely to be parasitized than native pentatomids. The scelionid species composition of *H. halys* consisted of *Te. podisi*, *Tr. euschisti* and *Tr. thyantae*. Although these species cannot develop in fresh *H. halys* eggs, we demonstrate that parasitoids attempt to exploit this host under field conditions.

Across the United States, the squash bug, *Anasa tristis* (De Geer) (Hemiptera: Coreidae), is a serious pest of cucurbit crops. Boyle et al. (2023) reported that before the release of egg parasitoid, *Hadronotus pennsylvanicus* (Ashmead) (Hymenoptera: Scelionidae), there was very little parasitisation which was about <21% in 2020 and <8% in 2021. However, in both the years, the percentage of *A. tristis* eggs parasitized within 2 weeks of release of *H. pennsylvanicus* was significantly greater at release sites (~60%) than at no-release sites (~14%). High rates of *H. pennsylvanicus* parasitism (>72%) were further observed at release sites 4, 6, 8, and 10 weeks following parasitoid deployment. Other Scelionidae species have also been reported to have successfully released egg parasitoids. For example, *Gryon muscaeformis* released in hazel boosted parasitism rates on *Gonocerus acuteangulatus* (Heteroptera: Coreidae) eggs (Mineo and Lucido 1976). Similar results were seen when *Telenomus gifuensis* was released early in the season. This resulted in higher parasitism rates on *Scotinophara lurida* (Heteroptera: Pentatomidae) eggs than in untreated areas (Hidaka, 1958). *Gryon aetherium* has been evaluated for its effectiveness against the invasive stink bug *Bagrada hilaris*, a significant pest of crops. Research indicates that *Gryon* parasitoids can significantly reduce pest populations by targeting their eggs, thus preventing the emergence of adult pests (Hogg *et al*. 2023). In Brazil, a total of 23 species of egg parasitoids targeting stink bugs in soybean crops have been identified. Among these, *Trissolcus basalis* and *Telenomus podisi* (Ashmead) (Hymenoptera: Platygastridae) exhibit higher rates of parasitism compared to other species and are frequently utilized for the control of stink bugs (Bueno *et al*. 2012).

Clavigralla spp. (Hemiptera: Coreidae) are the serious sucking pests of pulse crops. They lay eggs in clusters. The field collections of eggs in clusters at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) by Shanower *et al*. (1996) reported 69-100% eggs parasitized by that *Gryon clavigrallae* Mineo (Hymenoptera: Scelionidae). Overall, more than 39 % of *Clavigralla* spp. eggs were parasitized by *G. clavigrallae*. The percentage of egg clusters parasitized and the percentage of eggs parasitized in a cluster were positively correlated with the size of the egg cluster. The percentage of eggs and egg clusters parasitized by *G. clavigrallae* increased through the season. A survey carried out annually from 2010 to 2013 at the Directorate of Cashew Research in Puttur, Karnataka, India, identified three species of egg parasitoids: *Telenomus* sp. (Hymenoptera: Scelionidae), *Chaetostricha* sp. (Hymenoptera: Trichogrammatidae), and *Erthymelus helopeltidis* (Hymenoptera: Mymaridae) associated with *Helopeltis* spp. *Telenomus* sp. was the most prevalent species, observed throughout the year except in March and April, with peak parasitism occurring during the monsoon months of June and July, ranging from 6.89% to 28.21% (Srikumar *et al*., 2015). Thus, the long-term benefits of a more environmentally friendly pest control technique, such as the employment of *T. podisi*, may outweigh the risk of a slight decrease in productivity. For example, the organic market typically offers higher pricing, which may compensate for minor yield losses. Biological management is required for organic crops because synthetic pesticides are not permitted. Furthermore, organic farming has showed environmental benefits at the farm level, increasing the use of biological control methods.

Conclusion

This review emphasizes the significant role of egg parasitoids, particularly those from the Scelionidae family, in controlling population of hemipteran pests. Several genera of these parasitoids are specialized in targeting the eggs of various hemipteran species, especially the stick bugs in the families Pentatomidae and Coreidae, which are major pests in the agricultural ecosystems. The ecological significance of these parasitoids as natural pest control agents is of immense importance, further, using them as biological control agents has provided viable option for safer pest management.

Future studies

Understanding the complex interactions between egg parasitoids and their hemipteran hosts will be crucial. Future studies should investigate the dynamics of host-parasitoid relationships, including factors influencing parasitism rates, host specificity, and the impact of environmental variables on these interactions. Given that the environmental conditionals greatly influence the performance of these parasitoids, future studies must focus on how climate change affect their efficiency. Studies like those examining the development of *Gryon aetherium* under varying temperature could provide insights into their adaptability and potential range expansion in response to changing climates. Further, investigating optimal release strategies and timing, as well as the impact on non-target species, will be essential for successful implementation in pest management programs.

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