agronomy

Perspective

Natural-Enemy-Based Biocontrol of Tobacco Arthropod Pests in China

Wenxin Xue †, Pengjun Xu †, Xiufang Wang, Guangwei Ren and Xinwei Wang *

Tobacco Research Institute, Chinese Academy of Agricultural Sciences, Qingdao 266101, China
* Correspondence: wangxinwei01@caas.cn
† These authors contributed equally to this work.

Abstract: The devastating impact of chemical pesticides has prompted a shift towards sustainable agricultural pest management, such as biological control with natural enemies. In recent years, commercialization advancements have enabled the suppression of pest populations through augmentative releases of biological control agents, with natural enemies being a major tactic. China has successfully implemented natural-enemy-based biocontrol strategies, particularly for controlling aphids and lepidopterans. This article provides a comprehensive overview of the state-of-the-art natural-enemy-based biocontrol against arthropod pests in tobacco in China, including practical achievements in mass-rearing methods, augmentative release strategies, and the wide-scale use of natural enemies. Current and potential future challenges for natural-enemy-based biocontrol in China are also discussed.

Keywords: pest management; natural enemy; biocontrol; mass rearing; augmentative release

Citation: Xue, W.; Xu, P.; Wang, X.; Ren, G.; Wang, X. Natural-Enemy-Based Biocontrol of Tobacco Arthropod Pests in China. *Agronomy* **2023**, *13*, 1972. https://doi.org/10.3390/agronomy13081972

Academic Editor: Dirceu Pratissoli

Received: 21 June 2023
Revised: 19 July 2023
Accepted: 25 July 2023
Published: 26 July 2023

1. Introduction

Arthropod pests, including insects and mites, pose a major challenge to agriculture worldwide, causing substantial loss to global crop production [1]. Herbivorous arthropods, in particular, can cause yield losses of up to 20%, which can have a significant impact on sustainable crop growth [2,3]. In China, tobacco (*Nicotiana tabacum* L.) is a non-food crop of great economic importance, with a cultivation area of 9.4 billion hm^2 in 2020 [4]. However, arthropod pests have a significant impact on the yield and quality of tobacco leaves, resulting in substantial economic losses (as shown in Table 1).

Table 1. Common arthropod pest species in tobacco field in China.

Species	Damage Parts	Hazardous Degree *
Lepidoptera		
Helicoverpa assulta	leaf, bud, flower, fruit	H
Heliothis armigera	leaf, bud, flower, fruit	H
Spodoptera litura	leaf, bud	H
Mamestra brassicae	leaf	L
Spodoptera exigua	leaf	L
Mythimna separata	leaf	L
Agrotis ipsilon	stem, leaf	H
Agrotis tokionis	stem, leaf	L
Agrotis segetum	stem, leaf	L
Phthorimaea operculella	leaf	M
Scrobipalpa heliopa	stem, leaf	L
Peridroma saucia	leaf	L

Table 1. *Cont.*

Species	Damage Parts	Hazardous Degree *
Hemiptera		
† *Bemisia tabaci*	leaf	H
† *Myzus persicae*	stem, leaf, bud, flower	H
Trialeurodes vaporariorum	leaf	L
Cyrtopeltis tenius	leaf	L
Nezara viridula	leaf, stem	L
Dolycoris baccarum	leaf, stem, fruit	L
Coleoptera		
Pleonomus canaliculatus	root, stem	L
Agriotes fuscicollis	root, stem	L
Opatrum subaratum	root, stem, leaf	L
Maladera formosae	leaf, root	L
Maladera orientalis	leaf, root	L
Holotrichia oblita	root, stem, leaf	L
Holotrichia parallela	root, stem, leaf	L
Anomala corpulenta	root, stem, leaf	L
Popillia quadriguttata	root, stem, leaf	L
Henosepilachua vigintioctopunctata	leaf	L
Orthoptera		
Gryllotalpa orientalis	seed, root, stem	L
Gryllotalpa unispina	seed, root, stem	L
Thysanoptera		
Thrips flavidulus	leaf, flower	L
† *Frankliniella occidentalis*	stem, leaf, flower, fruit	M
Thrips tabaci	leaf, flower	M
Mollusca		
Agriolimax agrestis	leaf	L

† vectors of virus transmission; * hazardous degree: classification of hazardous degree according to annual yield loss caused by pests. H: high, M: medium, and L: low; information was adopted from Wang et al. (2018) [5].

In the past few decades, chemical pesticides have been the primary method of controlling arthropod pests. However, this approach has led to the development of widespread pesticide resistance, as well as the contamination of agroecosystems and negative health effects [6]. Therefore, Integrated Pest Management (IPM) should focus on more sustainable approaches, such as physical, cultural, or biological controls. While physical and cultural controls that rely on engineering techniques demand more labor and time, their implementation is often limited to specific treated areas, which restricts their effectiveness in the field-crop market [7]. As such, biological control is a main contributor to sustainable agriculture, which involves using one species or biological agent to control the population size of another species [8,9]. Predators and parasitoids are among the core components of biological control agents used in agroecosystems [10–12]. China has a rich diversity of natural enemies for arthropods, with 283 natural enemy species from 71 families known to control sugarcane pests [13,14]. For example, species from the genus *Trichogramma* have been successfully used to control Lepidopteran pests [15].

Three primary methods for manipulating predator and parasitoid densities are classical, conservation, and augmentative biological control, as outlined by Van Lenteren et al. (2006) [16]. Classical biological control involves releasing natural enemies collected from the pest's area of origin into invasive areas, resulting in permanent pest population reduction. Conservation biological control seeks to protect and enhance the performance of naturally occurring natural enemies [17]. Augmentative biological control involves mass-rearing and releasing natural enemies, either in large numbers for immediate control in crops with short production cycles (inundative biological control) or over several generations in crops with long production cycles (seasonal inoculative biological control) [18]. This strategy is becoming an increasingly popular and important option for mitigating economic losses caused by pest damage worldwide [18]. The small populations of natural enemies in China have limited their ability to significantly control tobacco pests [19]. Moreover, the potential breakdown of current biological control agents and the predicted increase in pest outbreaks due to global climate change have further reduced the effectiveness of natural enemies in pest control [20–24]. In more detail, the occurrence of warmer winters or a decrease in the frequency of deep frosts is resulting in a rise in pest outbreaks [22–25]. Moreover, pests are spreading into regions that are lacking their natural enemies, while climate change, host plants, herbivores, and farmers' adaptive management strategies are altering the abundance and activity of natural enemies. These spatial and temporal mismatches between pests and their enemies may reduce the effectiveness of these biocontrol measures [21]. However, the augmentative releases of biological control agents partially compensate for these drawbacks and have proven to be a successful strategy in maintaining high densities of natural enemies, even in suboptimal conditions [18]. Currently, over 150 species of natural enemies are available for augmentative releases, allowing for the control of approximately 100 pest species [26]. Since the 1970s, China has made significant progress in exploring augmentative releases of biological control agents, including the use of the *Trichogramma* species [15].

In this article, we present a comprehensive review of the practical knowledge and achievements gained through the development of natural-enemy-based augmentative biological control programs in tobacco-growing regions of China. Furthermore, we highlight the successful implementation of natural enemies on a wide scale and identify the key traits that contribute to effective biological control. We believe that our findings will renew interest in natural-enemy-based methods both in China and in other countries.

2. Major Pests and Potential Natural Enemy Species on Tobacco

To date, over 700 species of arthropod pests have been identified in Chinese tobacco fields and storage facilities [27]. The common species are listed in Table 1, among which the major pests are *Helicoverpa assulta* (Guenée) (Lepidoptera: Noctuidae), *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae), *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae), *Agrotis ipsilon* (Hufnagel) (Lepidoptera: Noctuidae), *Myzus persicae* (Sulzer) (Hemiptera: Aphididae), and *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae).

A survey conducted in a tobacco-growing region of China revealed the presence of 743 natural enemy species belonging to 273 genera and 27 families [28]. Table 2 presents a list of arthropod species that have undergone successful mass-rearing for large-scale application in China. This list includes one parasite (*Aphidius gifuensis* (Ashmead) (Hymenoptera: Braconidae)) and three predators (*Arma chinensis* (Fallou) (Hemiptera: Pentatomidae), *Amblyseius cucumeris* (Oudemans) (Acari: Phytoseiidae), and *Harmonia axyridis* (Pallas) (Coleoptera: Coccinellidae)), as well as predators with the potential for future development in pest management, such as: *Eocanthecona furcellata* (Heteroptera: Pentatomidae) and *Habrobracon hebetor* (Say) (Hymenoptera: Braconidae). In the following section, we will delve into several biocontrol cases that utilize natural enemies to showcase China's efforts and achievements in managing tobacco arthropod pests.

Table 2. Natural enemy species against tobacco arthropod pests.

Order	Species	Target Pests
Predators		
Arachnida	*Amblyseius cucumeris* *Amblyseius mckenziei* *Neoseiulus barkeri*	mites and thrips

Table 2. *Cont.*

Order	Species	Target Pests
Coleoptera	*Coccinella septempunctata* *Harmonia axyridis* *Propylea japonica* *Adonia variegata*	aphids and whiteflies
	Pheropsophus javanus *Microcosmodes flavospilosus* *Cylindera kaleea* *Cicindela aurulenta*	lepidopterans
Diptera	*Eupeodes corollae* *Episyrphus balteatus* *Sphaerophoria scripta* *Melanostoma scalare* *Aphidoletes aphidimyza*	aphids
	Atylotus bivittateinus	lepidopterans
Hemiptera	*Arma chinensis* *Rhynocoris fuscipes* *Eocanthecona furcellata* *Orius sauteri* *Harpactor fuscipes* *Sphedanolestes impressicollis*	lepidopterans, hemipterans, homopterans, etc.
Mantodea	*Tenodera sinensis* *Hierodula patellifera*	lepidopterans
Neuropera	*Chrysopa pallens* *Chrysoperla nipponensis* *Chrysopa formosa*	aphids, stinkbugs, lepidopterans
Parasites		
Hymenoptera	*Aphidius gifuensis* *Diaeretiella rapae*	aphids
	Habrobracon hebetor	lepidopterans (Store-product pest)
	Encarsia formosa	whiteflies
	Campoletis chlorideae	lepidopterans

3. Study of Biocontrol Cases

Over the last decade, China has witnessed a steadfast commitment to natural enemies in the control of economically significant pests on tobacco. This dedication has yielded several noteworthy successes in natural-enemy-based biocontrol against tobacco's key arthropod pests. These triumphs primarily stem from two factors: mass-rearing production and release strategies. Establishing mass production systems is a crucial prerequisite for achieving effective and cost-efficient large-scale releases in the field. Additionally, the success of release strategies is closely tied to the control effect.

3.1. Case 1: Aphidius-Gifuensis-Based Biocontrol

A. gifuensis is a versatile endoparasitoid that can parasitize various species of aphids. It is the most commonly used biological control agent for managing *M. persicae* on tobacco crops in China due to its high parasitism rate, reaching over 85% in the field [29,30]. The study and application of *A. gifuensis* for aphid control in China began in the early 1970s. Since 2010, *A. gifuensis* has been widely promoted and utilized in the tobacco system of Yunnan Province [31]. Since 2019, this biological control agent has been adopted as the main technology for aphid management, leading to a decrease in pesticide usage. Through systematic research on the biological and ecological characteristics of *A. gifuensis*, China has accumulated extensive experience in breeding and applying this species. Furthermore, a national standard, "Code of Practice for *Myzus persicae* (Sulzer) Biological Control with *Aphidius gifuensis*," was released in 2019. This standard specifies the technical requirements for breeding *A. gifuensis* for the management of *M. persicae*, including *A. gifuensis* breeding, *M. persicae* release, investigation of control effects, seed conservation, and more.

3.1.1. Mass-Rearing Production

Most of the mass-rearing techniques for *A. gifuensis* have been mechanized and/or automated.

In certain tobacco planting areas in China, the mass-rearing of *A. fumigatus* is carried out in greenhouses located near the fields. This involves cultivating aphid host plants, propagating *M. persicae*, inoculating parasitoids, and selecting and collecting mummified aphids, *M. persicae*, and *A. gifuensis* for preservation [31,32]. This method offers the advantages of convenient transportation, detachable structures, intelligent controls of environmental conditions, and immediate release of parasitoids after production. However, the cost of mass-rearing on potted tobacco in greenhouses is high. To address this issue, a study on floating tobacco seedlings and the simultaneous inoculation method was conducted. This method is characterized by a short cycle, low cost, and high efficiency in feeding *M. persicae* [33–35]. In regions with specific climate characteristics such as seasonal rainfall and low temperature, the growth of tobacco and propagation of *A. gifuensis* may be greatly restricted. In such cases, the floating radish seedlings and simultaneous inoculation method can be a targeted solution [29]. Radish is a semi-cold-tolerant vegetable that supports the short growth and development period and the fast propagation of *M. persicae*. Moreover, the technique of simultaneous inoculation of *M. persicae* with *A. gifuensis* simplifies the breeding process to some extent [36].

A. gifuensis can be stored and transported in two forms: adult *A. gifuensis* or mummified parasitized aphids. Due to the strong activity and short life span of adults, storage and transportation conditions are more demanding and costly. Therefore, it is suggested to carry on packing transport in the form of mummified aphids. A high degree of mechanization and automation has been achieved in the separation, drying, impurity removal, collection, counting, and packaging of mummified aphids. Through multiple generations of iterative updates, a range of devices and machines have been introduced for application [37], namely the digital image recognition and counting system, an assembly line separating and washing device to collect the mummified aphids, an electrical device to dry the mummified aphids, an automatic selection machine to remove impurities, and an automatic quantitative divider to put the mummified aphids into the box with the specific packaging specifications [38–45]. To sum up, this equipment would greatly increase the mummified aphid efficiency; save money, time, and labor with a fully automatic operation; and keep the damage rate of mummified aphids at a low level.

Other key factors that restrict the industrial application of *A. gifuensis* are long-term storage and long-distance transportation. In the south and the north, the generation number of *A. gifuensis* is completely different, so the parameter setting up should be studied in different ways according to local conditions. A large number of targeted research also enables the natural enemy produce companies to master the rich experience of temperature and humidity preservation transportation [46–51].

3.1.2. Field Application

The release of the natural enemy is affected by the host crop, environment, and other factors. The amount and way of releasing are also different with different control objects. Additionally, to achieve a better aphid control effect, the augmentative release strategies of *A. gifuensis* are continuously explored. Several strategies have been developed: the release of an adult wasp *A. gifuensis*, hanging the card of mummy aphids, naturally scattering them field sheds, releasing them by the cage of *A. gifuensis*, etc. For example, the population of aphids can be controlled in a short time by the release of adult *A. gifuensis*. But it also has some limitations, such as the high mortality rate of *A. gifuensis* during the release process and that the control effect can be achieved only after multiple releases [52]. The auto-sustained continuous release through naturally scattering them by filed *A. gifuensis* breeding sheds and releasing them by the cage of *A. gifuensis* could perform better on the persistence control of aphids. Hence, the combination of different release methods should be considered in the application to achieve a better prevention effect [53]. Moreover, suitable release strategies (the release number and times of *A. gifuensis*) for different regions or situations have been further studied (Table 3) [53–56].

Table 3. The reference standard of the quantity of released *Aphidius gifuensis* based on the occurrence degree of *Myzus persicae*.

Number of *M. persicae* per Plant	The Quantity of Released *A. gifuensis* per Hectare	The Release Mode
1–5	3000–7500	dot scope [a]
6–20	7500–15,000	planar scope [b]
21–30	15,000–18,000	regional scale [c]

[a] *A. gifuensis* was released from the *M. persicae*-infected plants. [b] *A. gifuensis* was released to the parcel of field found with *M. persicae*. [c] *A. gifuensis* was released to the region found with *M. persicae*.

Regarding field application scales, in 2018, the national promotion area reached 890,000 hm^2, covering more than 99 percent of the total tobacco planting area [57] and obtaining an excellent control effect (82.2%). Since then, the coverage of the promoted area has been kept in full tobacco field coverage, and the effect of aphid control has been continuously improved.

3.2. Case 2: Arma-Chinensis-Based Biocontrol

A. chinensis is an polyphagous predator with a broad prey range [58]. Originating from China, it is commonly utilized for controlling Lepidopteran pests such as *H. armigera*, *S. litura*, and *S. exigua* on tobacco crops [13]. Over the past three decades, extensive research has been conducted on its geographical distribution, morphology, and biological characteristics, leading to advancements in artificial breeding and field release methods.

3.2.1. Mass-Rearing Production

One of the key issues in the efficient mass-rearing production of polyphagous predators is finding the proper food. The palatability and nutrient composition of food directly affects the feeding behavior, growth and development, and reproductive characteristics of the predators. The first part is artificial breeding based on natural preys. In China, *A. chinensis* is mainly reared on the pupae of *Antheraea pernyi* (Guérin-Méneville) (Lepidoptera: Saturniidae). During the production, it was found that the inability to completely feed on pupae and the production time and cost of *A. pernyi* pupae would restrict the mass-rearing of *A. chinensis* [59]. Therefore, a study from Xie et al. (2020) compared the fitness of three preys, the larvae and pupae of *Mythimna separate* (Walker) (Lepidoptera: Noctuidae) and larvae of *Tenebrio molitor* (Coleoptera: Tenebrionidae), by monitoring the developmental duration, egg hatchability, adult body weight, egg production, and mortality of *A. chinensis*. The results showed that *M. separate* pupae performed best on each monitoring index, followed by *T. molitor* larvae and *M. separate* larvae. A similar study comparing the performance of *T. molitor*, *M. separate*, and *Prodenia litura* larvae as preys confirmed the advantages of *T. molitor* and *M. separate* as preys for the mass-rearing of *A. chinensis* [60]. In addition, Wang et al. (2020) showed that the mixed diet of *M. separate* larvae with a small amount of *H. axyridis* pupae was beneficial to the early development and reproduction of stinkbugs [61]. Compared with *M. separate* pupae, *T. molitor* pupae could improve fecundity as food during the adult mating period [62].

In mass-rearing with prey, besides the high economic and time cost, the risk of prey shortage also exists but could be effectively solved by an artificial diet. An artificial semisynthetic feed of a micro-encapsulated *A. pernyi* pupa reduces the feeding cost by 50% while ensuring the normal production quality by feeding *A. pernyi* pupae directly [63].

Meridic diets have been developed for rearing several hemipteran predators and are a staple of the future. The main recipes studied so far include the following three: major ingredient of Recipe 1—eggs, liver, and tuna [64]; Recipe 2—beef, beef liver, and egg yolk [65]; Recipe 3—milk and egg [66]. All formulations meet the basic nutritional requirements of *A. chinensis* growth but need to be modified to achieve the same or even better performance than preys. The nutritional analysis of preferred preys is helpful to clarify the requirement and ratio of certain nutrients for predators and to provide nutritional guidance for the development of artificial diets [67]. The growth, development, and reproduction of *A. chinensis* at different stages could be significantly and positively affected by adjusting the content of saturated fatty acids and unsaturated fatty acids in the artificial diet to increase the adult acquisition rate and population growth rate of *A. chinensis* [68].

In addition to the development of food for rearing *A. chinensis*, other constraints to its mass production were explored. For example, the process of how to adjust the parameters of density and sex ratio to obtain the optimal survival rate and fecundity and to avoid intraspecific mutilation behavior was detailed [69–71].

3.2.2. Field Application

At present, research mostly stays in the laboratory stage, and there are limited cases of large-scale field release. The year of 2018 was the first year of the national pilot promotion of 2000 hm^2 for *H. assulta* and *S. litura* management. The average control efficiency was 51.48% [57]. By 2021, the promotion area reached 35,000 hm^2 with a 57.68% control efficiency.

It is worth noting that the density of *A. chinensis* decreased quickly as individuals dispersed from the release sites, and the efficiency of pest control was largely discounted. In this scenario, early population establishment on the crop was needed to use *A. chinensis* as a biological control agent [72].

3.3. Other Cases

3.3.1. Ladybeetle-Based Biocontrol (*Coccinella septempunctata* and *Harmonia axyridis*)

Predacious ladybeetles, *Coccinella septempunctata* (ladybird) (Coleoptera: Coccinellidae) and *H. axyridis*, are widely distributed in China and have a strong predation ability on aphids. They possess the characteristics of a big appetite, long life, and strong ability to adapt to the environment. Several studies have indicated that they have broad application prospects in the control of *M. persicae* in tobacco fields. At present, many studies report on bioecological characteristics, artificial diet, artificial feeding, and field application, among which there are also related studies on *M. persicae*.

The artificial rearing of *C. septempunctata* and *H. axyridis* mainly adopts aphids as a natural prey. Attempts have also been made on male honeybee pupae, the eggs of *Anagasta kuehniella* (Zeller) (Lepidoptera: Pyralidae), the eggs of *Corcyra cephalonica* (Stainton) (Lepidoptera: Pyralidae), artificial *Trichogramma* pupae, a mix of sucrose and pig liver, and meridic diets, etc. Among them, the nutritive value of male honeybee pupae was the highest, which had no adverse effect on larval growth and development and on adult *C. septempunctata*. Artificial *Trichogramma* pupae can meet the growth and development of larvae but have effects on the fertility of an adult. But, it could be served as an alternative supplement when natural prey is insufficient. Niijima et al. (1977) originally developed a synthetic diet containing 18 amino acids (60%), 6 inorganic salts (6.9%), sucrose (32.5%), cholesterol (0.5%), and 10 vitamins (0.1%) to feed adult ladybeetles, and following chemically defined diets were generally proven to influence the production of ladybeetles [73]. Moreover, factory production of *H. axyridis* can also be realized based on the industrial production of *S. exigua* larvae [74].

Ladybeetles are selected for release as eggs, larvae, and adults. The egg card release is convenient but highly affected by weather factors. The dispersal ability of larvae is small, which is conducive to the rapid establishment of population in the field. However, the resistance of the larvae is poor, and the larvae are not tolerant to long-distance transport. When the density of *M. persicae* was the same, both adults of *C. septempunctata* and *H. axyridis* had the largest predation [75]. Therefore, in view of the spread of adult beetles, one third of the hind wings of ladybeetles are subtracted and released after sunset on calm and sunny days in China. Next, whichever ratio of ladybugs is released, the control effect of *M. persicae* comes slower than pesticide, usually reaching an 80% control effect after 5 to 10 days. But, the ladybeetles have stronger persistence than pesticide [76,77].

Ladybeetles can also work with *A. gifuensis* to control aphids. Studies have shown that parasitoid and predatory natural enemies can complement each other to enhance predation efficiency and persistence. The joint release of *H. axyridis* and *A. gifuensis* demonstrated a significant synergistic effect on the control of *M. persicae* through intra-group predation [78]. A similar improved suppression of *B. tabaci* was found with the combination of *Eretmocerus eremicus* (Mercet) (Hymenoptera: Aphelinidae) and *Amblyseius swirskii* (Athias-Henriot) (Acari: Phytoseiidae) [79]. This suggests that a higher level of biodiversity among enemies could potentially result in a more effective pest suppression, especially when the natural enemies occupy diverse and complementary feeding niches [80]. However, the optimal proportion and technique for joint release require further investigation. Additionally, we should pay more attention to the observation that an overall increase in prey community richness could lead to trophic complexity, potentially influencing the overall suppression effectiveness [80].

3.3.2. Reduviid-Based Biocontrol (*Sphedanolestes impressicollis* and *Harpactor fuscipes*)

Reduviids (*Sphedanolestes impressicollis* (Stål) (Hemiptera: Reduviidae) and *Harpactor fuscipes* (Fabricius) (Hemiptera: Reduviidae)) are versatile predators that can feed on over 44 insect pests of economic significance [81,82]. Unlike other predacious hemipterans, they have a wider prey range and consume more prey to sustain their larger body size [81]. An overbroad diet may deprive it of the advantages used to hunt specific pests. However, in the presence of multiple pests, they can be very valuable predators. The biocontrol potential of predatory insects such as reduviids must be assessed under controlled conditions, which will form the baseline for their utilization in natural field conditions. The biocontrol potential of reduviids must be evaluated under controlled conditions, which will set the stage for their use in the natural field conditions [83].

Hence, multiple experiments were conducted on the predation function, search effect, self-density interference response, and dispersal ability of *S. impressicollis* and *H. fuscipes*. Field experiments revealed that both reduviids prey on *H. armigera*, *S. litura*, or *M. persicae*. The Y-tube was used to study the selectivity and selection preference of *H. fuscipes* for the aforementioned prey species. The result showed that *H. fuscipes* preferred to select the third-instar larvae of *S. litura* [84]. In addition, prey densities increased the predation capacity of *H. fuscipes* and *S. impressicollis*, while negatively interfering with their search efficiency [85]. Another study showed that the fifth-instar nymphs and adults of *H. fuscipes*, which have a strong dispersal ability, are not ideal for releasing time [86]. These findings provide important guidance for the widespread application in tobacco production in China.

4. Conclusions

The current artificial mass-rearing procedures of *A. gifuensis* are relatively cumbersome, especially in the host plant cultivation and *M. persicae* propagation steps, which significantly slow down the breeding speed. The same applies to natural predators. Therefore, the development of applicable artificial media is of particular importance. This artificial diet could extend beyond aphids and predators and could be used to provide the nutritional needs of *A. gifuensis* directly with artificial aphids while maintaining or even increasing survival, eclosion, and parasitic rates. If artificial materials were available, the entire large-scale reproduction process could be significantly optimized, and the disadvantages of traditional reproduction methods—such as complicated processes, large space occupation, and high costs—could be resolved.

Through studying biocontrol cases, it becomes apparent that there is a need to increase the abundance of available commercial natural enemies. While commercial explorations are primarily focused on controlling aphids, other pests such as lepidopterans also cause significant damage. However, the development and application of corresponding natural enemies for these pests, as well as other potential candidates, like *E. formosa* against *B. tabaci* and predatory mites against thrips, is relatively lacking. Additionally, further work is needed to quantify the advantages inherent in mechanizing mass-rearing systems.

Moreover, it remains uncertain whether the over-reliance on a few particular natural enemy species could have negative environmental impacts. Despite the lack of addressed potential risks associated with the widespread mass release of natural enemies in China, the continuous manual intervention over the years calls for increased awareness of the risks, such as the superseding of native natural enemy species [16,87]. Therefore, to enhance the quality control of commercial natural enemy releases, environmental monitoring should be incorporated into the routine supervision of mass-rearing production and field application policies.

Finally, the decision regarding the production, importation, and release of biological control agents is a national matter and involves multiple authorities. The National Plant Protection Organization, responsible for implementing the guidelines outlined in the International Plant Protection Convention, oversees this process. Through advancements in homogeneous density, enemy breeding technology, automation, storage, packaging, and release techniques, a technical system was established to stabilize the production of natural enemies. Moving forward, industry standards must be established to clarify product quality indexes, inspection methods, and classification standards in order to create a healthy and sustainable application system for the natural-enemy-based biocontrol of tobacco arthropod pests. The industry is also actively promoting the implementation of biological control, especially the natural-enemy-based biocontrol and providing extensive services to farmers.

Natural-enemy-based biocontrol offers numerous advantages, including safety for humans, animals, and plants, as well as no pollution to the environment and easy development with abundant natural resources. Although, from this study, we can also see some of the drawbacks of natural enemy control, such as its slow effect, reliance on complex artificial breeding technology, limitations imposed by natural conditions, and issues with practical application. However, these limitations can be mitigated by integrating other control measures. It is worth noting that the advancement of plant genetic engineering technology has greatly facilitated the development of efficient insect-resistant crop varieties. Insecticidal Bt endotoxins have been successfully incorporated into transgenic varieties of eggplant, maize, potato, soybean, tomato, and rice, demonstrating remarkable effectiveness in insect control [88]. Nevertheless, it is essential to emphasize the necessity for long-term and systematic scientific research, along with continuous follow-up evaluations to assess the impact of insect-resistant crops on predator insects. Such evaluations are crucial for ensuring the sustainability and effectiveness of biocontrol strategies in the context of integrated pest management.

In general, the widespread use of natural enemies as a means of augmentative application has proven to be an effective way of reducing the reliance on pesticides and meeting the growing demand for sustainable agriculture and safer food. However, in comparison to pesticides, which offer a more immediate solution, the practical application of natural enemies among farmers needs to be improved. To remain competitive with other protection methods such as pesticides, the natural-enemy-based biocontrol methods used in China's agricultural industry must continue to evolve, particularly by expanding the range of targeted pests, increasing the diversity and efficiency of native natural enemies, and combining natural enemy biocontrol agents with other pest management methods to achieve additive control effects. In the future, the key to controlling arthropod pests in

China's agricultural fields will be to integrate and optimize multiple management measures based on the local ecological environment, the types of pests present, and their occurrence patterns, while also reducing the cost of natural-enemy-based biocontrol.

Funding: This work was supported by Major Special Projects for Green Pest Control (110202001035 (LS-04), 110202201017 (LS-01)), Major Special Projects for Big Data (110202201051 (SJ-01)), and the Central Public-interest Scientific Institution Basal Research Fund (No. 1610232023027).

Data Availability Statement: Data openly available in the public repository.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Oerke, E.C.; Dehne, H.W. Safeguarding production–Losses in major crops and the role of crop protection. *Crop Prot.* **2004**, *23*, 275–285. [CrossRef]
2. Pimentel, D.; Peshin, R. *Integrated Pest Manaement: Pesticides Problems, Vol. 3*; Springer: New York, NY, USA; Berlin/Heidelberg, Germany; Dordrecht, The Netherlands; London, UK, 2014; Volume 91, ISBN 9788578110796.
3. Abrol, D.P.; Shankar, U. Integrated Pest Management. In *Breeding Oilseed Crops for Sustainable Production*; Academic Press: Cambridge, MA, USA, 2016; pp. 523–549. [CrossRef]
4. FAO Production Quantity of Tobacco (Unmanufactured) in World in 2022. *FAOSTAT*. 2022. Available online: https://www.fao.org/faostat/en/#data/LC (accessed on 20 June 2023).
5. Wang, F.; Zhou, Y.; Ren, G. *Insects on Tobacco in China*; China Agricuture Press: Beijing, China, 2018.
6. Nicolopoulou-Stamati, P.; Maipas, S.; Kotampasi, C.; Stamatis, P.; Hens, L. Chemical pesticides and human health: The urgent need for a new concept in agriculture. *Front. Public Health* **2016**, *4*, 148. [CrossRef] [PubMed]
7. Vincent, C.; Weintraub, P.; Hallman, G. Physical Control of Insect Pests. In *Encyclopedia of Insects*, 2nd ed.; Academic Press: Cambridge, MA, USA, 2009; ISBN 9780123741448.
8. Van Lenteren, J.C.; Bolckmans, K.; Köhl, J.; Ravensberg, W.J.; Urbaneja, A. Biological control using invertebrates and microorganisms: Plenty of new opportunities. *BioControl* **2018**, *63*, 39–59. [CrossRef]
9. Vila, E.; Wäckers, F.; Klapwijk, J. Shipping augmentative biocontrol agents. *OIE Rev. Sci. Tech.* **2022**, *41*, 75–81. [CrossRef] [PubMed]
10. Ballal, C.R.; Verghese, A. Role of Parasitoids and Predators in the Management of Insect Pests. In *New Horizons in Insect Science: Towards Sustainable Pest Management*; Chakravarthy, A.K., Ed.; Springer: New Delhi, India, 2015; pp. 307–326. ISBN 9788132220893.
11. Tendeng, E.; Labou, B.; Sylla, E.H.S.; Baldé, A.; Diatte, M.; Seydi, O.; Ndiaye, I.A.; Diop, P.; Sène, S.O.; Djiba, S.; et al. Natural enemies and pest control in field-grown crop in Southern Senegal. *Adv. Entomol.* **2022**, *10*, 287–299. [CrossRef]
12. Pagore, G.K.; Devi, Y.K.; Kumar, K.; Thorhate, P. Role of natural enemies parasitoids and predators in management of insect pest of cauliflower: A Review. *Pharma Innov. J.* **2021**, *10*, 305–311.
13. Shen, S.; Xu, G.; Chen, F.; Clements, D.R.; Gu, X.; Ji, S.; Zhang, L.; Yang, H.; Zhang, F.; Yin, K.; et al. Effects of *Aphidius gifuensis* release on insect communities and diversity in tobacco fields of Yunnan Province, China. *Pak. J. Biol. Sci.* **2018**, *21*, 284–291. [CrossRef]
14. Lin, S. The utilization of natural enemy–Insect in organic agriculture. *J. Guangxi Agric.* **2005**, *1*, 41–44.
15. Zang, L.S.; Wang, S.; Zhang, F.; Desneux, N. Biological control with Trichogramma in China: History, present status, and perspectives. *Annu. Rev. Entomol.* **2021**, *66*, 463–484. [CrossRef]
16. Van Lenteren, J.C.; Bale, J.; Bigler, F.; Hokkanen, H.M.T.; Loomans, A.J.M. Assessing risks of releasing exotic biological control agents of arthropod pests. *Annu. Rev. Entomol.* **2006**, *51*, 609–634. [CrossRef]
17. Cock, M.J.W.; van Lenteren, J.C.; Brodeur, J.; Barratt, B.I.P.; Bigler, F.; Bolckmans, K.; Cônsoli, F.L.; Haas, F.; Mason, P.G.; Parra, J.R.P. Do new access and benefit sharing procedures under the convention on biological diversity threaten the future of biological control? *BioControl* **2010**, *55*, 199–218. [CrossRef]
18. van Lenteren, J.C. The state of commercial augmentative biological control: Plenty of natural enemies, but a frustrating lack of uptake. *BioControl* **2012**, *57*, 1–20. [CrossRef]
19. Zeng, W.; Li, M.; Tan, L.; Zhou, G.; Li, F.; Cai, H.; He, Z. Species diversity of natural enemy insects and population dynamic of main pest insects in Changsha tobacco areas. *Chin. Tob. Sci.* **2016**, *37*, 63–67. [CrossRef]
20. Diehl, E.; Sereda, E.; Wolters, V.; Birkhofer, K. Effects of predator specialization, host plant and climate on biological control of aphids by natural enemies: A meta-analysis. *J. Appl. Ecol.* **2013**, *50*, 262–270. [CrossRef]
21. Thomson, L.J.; Macfadyen, S.; Hoffmann, A.A. Predicting the effects of climate change on natural enemies of agricultural pests. *Biol. Control* **2010**, *52*, 296–306. [CrossRef]
22. Deutsch, C.A.; Tewksbury, J.J.; Tigchelaar, M.; Battisti, D.S.; Merrill, S.C.; Huey, R.B.; Naylor, R.L. Increase in crop losses to insect pests in a warming climate. *Science* **2018**, *361*, 916–919. [CrossRef]
23. Pureswaran, D.S.; Neau, M.; Marchand, M.; De Grandpré, L.; Kneeshaw, D. Phenological synchrony between eastern spruce budworm and its host trees increases with warmer temperatures in the boreal forest. *Ecol. Evol.* **2019**, *9*, 576–586. [CrossRef]

24. Harvey, J.A.; Abarca, M.; Abram, P.K.; Kingsolver, J.G.; Ode, P.J.; Stork, N.; Terblanche, J.S.; Thomas, M.B. Scientists' warning on climate change and insects. *Ecol. Monogr.* **2022**, *93*, e1553. [CrossRef]
25. Skendži, S.; Zovko, M.; Živkovic, I.P.; Lešic, V.; Lemic, D. The Impact of Climate Change on Agricultural Insect Pests. *Insects* **2021**, *12*, 440. [CrossRef] [PubMed]
26. Leppla, N.C. Aspects of total quality control for the production of natural enemies. In *Quality Control and Production of Biological Control Agents: Theory and Testing Procedures*; CABI Publishing: Wallingford, UK, 2003; pp. 19–24.
27. Peng, S.; Shan, X.; Yao, Q.; Zhang, X.; Xiang, P.; Guo, W.; Yang, Y. Research progress on green control technology of tobacco arthropod pests. *China Agric. Inf.* **2015**, *21*, 55–56.
28. Shen, H.; Chen, H.; Zhang, C. *Study and Application of Key Technologies for Large-Scale Propagation of Tobacco Predatory Natural Enemies*; Agricultural Science: Beijing, China, 2020.
29. Zhu, J.; Wang, X.; Jiang, Z.; Yang, C.; Li, W. Using simultaneous inoculating technology to mass rear *Aphidius gifuensis*. *Chin. J. Tob.* **2012**, *6*, 74–77.
30. Agric, A. Population dynamics of *Myzus persicae* (Sulzer) and control effects of *Aphidius gifuensis* Ashmaed in the tobacco fields. *J. Anhui Agric. Sci.* **2019**, *47*, 155–157.
31. Song, Y.; Wei, J.; Yang, S.; Kuang, R. Current status and future trends of augmentative release of *Aphidius gifuensis* for control of *Myzus persicae* in China's Yunnan Province. *J. Entomol. Res. Soc.* **2011**, *13*, 87–99.
32. Deng, X.G.; Wu, W.; Yang, S. *Aphidius Gifuensis: Mass Rearing and Application*, 1st ed.; China Environmental Science Press: Beijing, China, 2010.
33. Shi, J.; Peng, S.; Luo, J.; Shan, X.; Huang, Y.; Tang, H.; Zhan, L.; Fan, C.; Yan, C.; Xiang, P.; et al. Study on the effects of different type floating seedling trays to *Myzus periscaer* Sulzer and *Aphidius gifuensis* Ashmead reproduction. *Crop Res.* **2016**, *30*, 726–728.
34. Wu, W.; Liu, C.; Liang, B.; Kan, J.; Huang, K.; Chen, H.; Wang, C.; Wu, D.; Li, H. Reproducing *Myzus periscae* and *Aphidius gifuensis* IV. Three-storey floating tobacco seedling-Using floating tobacco seedling technology to reproduce *Aphidius gifuensis*. *Southwest China J. Agric. Sci.* **2017**, *30*, 780–783.
35. Wu, W.; Liu, C.; Liang, B.; Kan, J.; Huang, K.; Wang, C.; Lv, Y.; Li, H. Using floating tobacco seedling technology to reproduce *Myzus periscae* and *Aphidius gifuensis* III: Effect of different inoculating parasites methods on rearing Aphidius gifuensis. *Southwest China J. Agric. Sci.* **2016**, *29*, 2598–2603.
36. Chen, J.; Qiu, M.; Chen, Y.; Deng, H.; Yi, L. Rapid breeding of *Aphidius gifuensis* with white radish floating seedling system and simultaneous inoculation of *Myzus persicae* and *A. gifuensis*. *Chin. Agric. Sci. Bull.* **2018**, *34*, 135–139.
37. Kan, J.; Bai, C.; Huang, K.; Chen, H.; Li, H.; Zhao, T.; Jiang, J.; Xiong, Z.; Guan, Q.; Chen, L.; et al. Products production and application technology of *Aphidius gifuensis*(II)—Collection and packaging technology for mummified aphid. *J. Southern Agric.* **2018**, *49*, 1125–1129.
38. Gao, X.; Zhao, J.; Yu, J.; Gong, J.; Zhang, G. An Automatic Quantitative Divider of Mummified Aphids. CN109850199A, 7 June 2019.
39. Zhang, L.; Gu, X.; Yang, H.; Ren, K.; Zhou, W.; Ji, S.; Ren, Y.; Li, S. An Automatic Selection Machine for Mummified Aphids. CN208976264U, 14 June 2019.
40. Lin, Z.; Ouyang, J.; Wang, Z.; Zhan, Y.; Wang, L.; Xie, Y.; Li, J.; Cao, L.; Shi, A. A Storage and Release Box for Mummified Aphids. CN209017695U, 25 June 2019.
41. Yang, Y.; Shi, A.; Lin, Z.; Ouyang, J.; Wang, Z.; Youguo, Z.; Zhang, S.; Li, D.; Li, J.; Qian, F.; et al. An Assembly Line Separating and Washing Device for Mummified Aphids. CN109225981A, 18 January 2019.
42. Huang, H. A Counting Device for Aphid Wasp in a Breeding Shed. CN209231975U, 9 August 2019.
43. Wang, Z.; Shi, A.; Lin, Z.; Ouyang, J.; Youguo, Z.; Xu, X.; Li, M.; Chen, Y.; Liu, S.; Deng, S.; et al. A Drying Device for Mummified Aphids. CN210051128U, 11 February 2020.
44. Zhang, L.; Gu, X.; Yang, H.; Pu, T.; Ren, K.; Zhou, W.; Huang, Z.; Ren, Y.; He, Y. A Continuous Automatic Selection Machine for Mummified Aphids. CN110771578A, 11 February 2020.
45. Pu, T.; Zhang, L.; Ren, K.; Li, J.; Yang, H.; Gu, X.; Ren, Y.; Zhou, W.; Zhihua, H.; Du, J. A Box for Mummified Aphid Storage and Release. CN212401984U, 26 January 2021.
46. Wu, X.; Li, T.; Wei, J.; Wang, Y.; Deng, J.; Gao, J.; Zhao, L. Effects of temperature on the development and reproduction of *Aphidius gifuensis*. *Zool. Res.* **2000**, *21*, 192–198.
47. Li, X.; Cheng, J.; Ru, B.; Chen, Y.; Tian, J.; Wang, Y.; An, D. Study on winter host and breeding conditions for mass rearing of *Aphidius gifuensis* in Shaanxi Province. *China Plant Prot.* **2017**, *37*, 50–53.
48. Yang, J.; Zou, G.; Yang, Y.; Pan, H.; Long, Q. Biological prevention and control effect of *Aphidius gifuensis* on *Myzus persicae* and aphid-transmitted virus. *Guizhou Agric. Sci.* **2017**, *45*, 47–50.
49. Yu, L.; Zheng, L.; Zhang, C.; Zhang, Z.; Wei, H. Effects of temperature and photoperiod on diapause of *Aphidius gifuensis* Ashmead. *Tob. Sci. Technol.* **2016**, *49*, 21–25. [CrossRef]
50. Meng, B.; Zhao, Z.; Li, Y.; Chen, Y.; Meng, X.; Dong, X.; Lv, F.; Yu, Y. Effects of tempreture and parasitic density of *Aphidius figuensis* on elosion rate, parasitism rate and double parasitism of mummified aphid. *Plant Dr.* **2015**, *34*, 51–55.
51. Lan, Z.; Xie, Y.; Ouyang, J.; Wu, D.; Zhan, Y. Study on low temperature storage method of *Aphidius gifuensis* mummified aphid product. *South China Agric.* **2019**, *13*, 188–191.

52. Huang, J.; Deng, J.; Gong, D.; Wang, H.; Pu, Y. The releasing times of controlling aphids by using *Apidius gifuensis* and its control effect in the field. *Chin. Agric. Sci. Bull.* **2008**, *24*, 437–441.
53. Shu, J.; Chen, W.; He, Y.; Zhong, M.; Xiao, D. Control effect on *Myzus persicae* by two different release methods of the parasitoid wasp *Aphidius gifuensis* in the field. *J. Mt. Agric. Biol.* **2018**, *37*, 25–29.
54. Li, C.; Li, J.; Guo, M.; Li, S.; Zhao, J.; Qiu, R.; Li, X.; Chen, Y.; Bai, J.; Li, S. Parameters optimization of the mummified aphid ball based on mechanization release of *Aphidius gifuensis*. *Guizhou Agric. Sci.* **2021**, *49*, 82–87.
55. Yan, F.; Zhang, R.; Yang, Q.; Chen, L.; Yang, J.; Yang, P. Effect of release times on the field control effect of *Aphidius gifuensis* on *Myzus persicae*. *J. Anhui Agric. Sci.* **2020**, *48*, 153–155.
56. An, R.; Fan, C.; Zhan, L.; Zeng, H.; Liu, Z.; Zhang, S.; He, Y.; Tang, X.; Yang, H.; Yan, X. Control effects and field application of different dispersal times of *Aphidius gifuensis* on *Myzus persicae*. *J. Anhui Agric. Sci.* **2016**, *15*, 1–23.
57. Wang, W. The Tobacco Bureau Reported the Promotion of Green Prevention and Control Technologies in Tobacco Agriculture in 2018. Available online: https://www.eastobacco.com/content/2018-12/25/content_877363.html (accessed on 25 December 2018).
58. Rider, D.A.; Zhang, L. Checklist and nomenclatural notes on the Chinese Pentatomidae (Heteroptera) I., Asopinae. *Entomotaxonomia* **2002**, *107*, 90–98.
59. Tang, Y.; Wang, M.; Li, Y.; Liu, C.; Mao, J.; Chen, H.; Zhang, L. Research progress in the control of *Spodoptera frugiperda* by predacious bugs. *Chin. J. Biol. Control* **2019**, *35*, 682.
60. Xie, X.; Huang, Y.; Xia, P.; Ren, X.; Wang, R. Explore the feasibility of breeding *Arma chinensis* with *Tenebrio molitor* as food. *Hubei Agric. Sci.* **2020**, *59*, 85–87.
61. Wang, L.; Meng, L.; Li, B. Effects of diets with *Harmonia axyridis* pupae on growth and development performance of predatory stinkbug *Arma chinensis*. *J. Nanjing Agric. Univ.* **2020**, *43*, 645–649. [CrossRef]
62. Huang, Y.; Ren, X.; Xia, P.; Xie, X.; Li, X.; Qiao, B.; Quan, L.; Wang, R. Survival rate of two pupae after cryopreservation and their influence on oviposition as the diet of *Arma chinensis* during its mating period. *Chin. Tob. Sci.* **2020**, *41*, 39–42. [CrossRef]
63. Dai, W.; Liu, M.; Cang, Y.; Wan, W.; Duan, L. Effect of *Antheraea pernyi* pupae capsule diet and different sexual ratios on artificial rearing Aram chinensis. *For. Pests China* **2019**, *38*, 17–21.
64. Zou, D.Y.; Wu, H.H.; Coudron, T.A.; Zhang, L.S.; Wang, M.Q.; Liu, C.X.; Chen, H.Y. A meridic diet for continuous rearing of *Arma chinensis* (Hemiptera: Pentatomidae: Asopinae). *Biol. Control* **2013**, *67*, 491–497. [CrossRef]
65. Zhang, J.; Zhou, Y.; Sun, S. Rearing of *Arma chinensis* (Fallou) (Hemiptera: Pentatomidae) on an artificial diet. *For. Pests China* **2017**, *36*, 37–40.
66. Liao, P.; Miao, S.; Xu, R.; Liu, C.; Chen, G.; Wang, M.; Mao, J.; Zhang, L.; Chen, H. Evaluation of a new liquid artificial diet of *Arma chinensis* Fallou (Hemiptera: Pentatomidae). *Chin. J. Biol. Control* **2019**, *35*, 9–14. [CrossRef]
67. Li, J. *Effects of Feeding on Different Preys on Arma Chinensis Development and Its Metabolomics*; Chinese Academy of Agricultural Science: Beijing, China, 2016.
68. Li, X.; Song, L.; Chen, Y.; Li, Y.; Zou, T.; Wu, S. Influence of differen fatty acids in artificial diets on growth development and fecundity of *Arma chinensis*. *Sci. Silvae Sin.* **2018**, *54*, 85–93.
69. Wu, S.; Deng, W.; Cai, H.; Yang, J.; Zeng, W.; Zhou, Z.; Li, Y. The occurrence period and effect of intraspecific cannibalism behavior of *Arma chinensis* under starvation. *Chin. J. Biol. Control* **2020**, *36*, 175–183. [CrossRef]
70. Pan, Z.; Zhang, H.; Zhang, C.; Yi, Z.; Chen, H. Effects of rearing density and sex ratio of adult *Arma chinensis* (Hemiptera: Pentatomidae) on their survival, fecundity and offspring's suitability. *Chin. J. Biol. Control* **2018**, *34*, 52–58. [CrossRef]
71. Song, L.; Tao, W.; Guan, L.; Li, X.; Chen, Y. Influence of host plant and rearing density on growth, development and fecundity of *Arma chinensis*. *Sci. Silvae Sin.* **2019**, *46*, 105–110.
72. Ren, C.; Liu, J.; Luo, M.; Nie, Z.; Huang, N.; Zhao, H.; Tang, L. A review on *Arma chinensis* Fallou(Hemiptera:Pentatomidae): A natural enemy insect. *Chin. Agric. Sci. Bull.* **2022**, *38*, 100–109.
73. Niijima, K.; Nishimura, R.; Matsuka, M. Nutritional studies of an aphidophagous coccinellid, *Harmonia axyridis*. Rearing of larvae using a chemically defined diet and fractions of drone honeybee powder. *Bull. Fac. Agric. Tamagawa Univ.* **1977**, *17*, 45–51.
74. Wang, H.; Zhang, W.; Chen, X.; Zheng, J.; Miao, L.; Qin, Q. Mass rearing the multicolored Asian lady beetle on beet armyworm larvae. *Chin. J. Appl. Entomol.* **2012**, *49*, 1726–1731.
75. Hu, J.; Lin, W.; Xu, Z.; Xu, Q.; Lin, Y. Predation function response and searching ratio of *Coccinella septempunctata* and *Harmonia axyridis* to *Myzus persicae*. *J. Anhui Agric. Sci.* **2017**, *45*, 151–153. [CrossRef]
76. Jiang, H.; Jin, J.; Xie, Z.; Tang, S.; Zhou, J.; Zhang, B. Study on the control effect of *Harmonia axyridis* against *Myzus persicae*. *Bull. Agric. Sci. Technol.* **2022**, *4*, 196–198.
77. Zhou, Y.; Cheng, Y.; Jin, J.; Li, W.; Li, F. Large scale production and release application of *Coccinella septempunctata*. *Southwest China J. Agric. Sci.* **2017**, *30*, 602–605.
78. Ke, R.; Xu, J.; Xiao, Z.; Li, L.; Chen, B.; Li, Z.; Gui, F. The predation efficiency of lady beetles on *Myzus persicae* and feeding competition of *Harmonia axyridis* with *Aphidius gifuensis*. *Chin. J. Biol. Control* **2017**, *33*, 338–344. [CrossRef]
79. Vafaie, E.K.; Pemberton, H.B.; Gu, M.; Kerns, D.; Eubanks, M.D.; Heinz, K.M. A comparison of repetitive releases of single or multiple natural enemy species on the suppression of Bemisia tabaci infesting poinsettias. *Biol. Control* **2020**, *151*, 104407. [CrossRef]
80. Snyder, W.E. Give predators a complement: Conserving natural enemy biodiversity to improve biocontrol. *Biol. Control* **2019**, *135*, 73–82. [CrossRef]

81. Sahayaraj, K. *Pest Control Mechanism of Reduviids*; Oxford Book Company: Jaipur, India, 2007; ISBN 0141259752.
82. Ambrose, D.P. *Assassin Bugs*; Science Publishers: Enfield, UK, 1999; ISBN 1-57808-030-4.
83. Tomson, M.; Sahayaraj, K.; Kumar, V.; Avery, P.B.; McKenzie, C.L.; Osborne, L.S. Mass rearing and augmentative biological control evaluation of *Rhynocoris fuscipes* (Hemiptera: Reduviidae) against multiple pests of cotton. *Pest Manag. Sci.* **2017**, *73*, 1743–1752. [CrossRef] [PubMed]
84. Su, X.; Deng, H.; Cai, Q.; Zhang, M. Predation selectivity of *Harpactor fuscipes* for important pests in tobacco. *Chin. Agric. Sci. Bull.* **2016**, *32*, 43–47.
85. Deng, H.; Wang, Z.; Chen, Y.; Wu, W.; Peng, W. Predation of *Harpactor fuscipes* on *Helicoverpa assulta* and *Spodoptera litura*. *Guangdong Agric. Sci.* **2012**, *13*, 107–109. [CrossRef]
86. Su, X.; Haibin, D.; Zhu, D.; Cai, Q.; Maoxin, Z. Studies on predatory behavior and indoor dispersal ability of *Harpactor fuscipes* to *Spodoptera litura*. *Acta Tabacaria Sin.* **2016**, *22*, 111–119.
87. Davies, A.P.; Zalucki, M.P. Collection of Trichogramma Westwood (Hymenoptera: Trichogrammatidae) from tropical northern Australia: A survey of egg parasitoids for potential pest insect biological control in regions of proposed agricultural expansion. *Aust. J. Entomol.* **2008**, *47*, 160–167. [CrossRef]
88. Li, Y.; Hallerman, E.M.; Wu, K.; Peng, Y. Insect-resistant genetically engineered crops in China: Development, application, and prospects for use. *Annu. Rev. Entomol.* **2020**, *65*, 273–292. [CrossRef]