Occurrence and Control of Main Pest Groups in *Allium tuberosum* Fields in Shijiazhuang

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Abstract [**Objectives**] This study was conducted to investigate the species and occurrence patterns of main pests in the Chinese chive (*Allium tuberosum*) fields in Shijiazhuang. [**Methods**] Our research group conducted a systematic investigation on the types and occurrence of major pests in Chinese chive fields in Shijiazhuang from April 2019 to November 2020 using the Malaise net method. [**Results**] The main pests harming Chinese chives in the region included *Thrips tabaci*, *Bradysia odoriphaga*, *Luperomorpha suturalis*, *Acrolepla alliella*, *Liriomyza chinensis*, and *Neotoxoptera formosana*. The pest populations in the region mainly experienced two peak periods, from mid June to mid July and from late August to late September. Meanwhile, corresponding green prevention and control measures were proposed based on the occurrence characteristics and biological characteristics of different pests in local chive fields. [**Conclusions**] Predicting the occurrence of pests in Chinese chive fields can provide basis for farmers to take timely prevention and control measures, reduce the damage of pests in the field to Chinese chives and realize high-quality production of Chinese chive.

Key words *Allium tuberosum*; Pests species; Occurrence regularity; Green prevention

DOI:10.19759/j.cnki.2164-4993.2024.05.008

Chinese chive (*Allium tuberosum* Rottler) is a perennial crop of *Allium* in Liliaceae, which not only has rich nutritional value and high economic value, but also has great medicinal value. According to relevant research reports, Chinese chives have the functions of antioxidation, liver protection, lipid lowering and anticoagulation, and have been widely used in medical clinical practice[1]. In recent years, Chinese chives have become more and more popular in the market, and the planting area of Chinese chive is constantly expanding, with large-scale planting everywhere. According to statistics, the planting area of Chinese chive has reached 10 million mu, but a series of problems have been found in the production process of Chinese chive. The unreasonable use of pesticides and the occurrence of pests in the cultivation process of Chinese chive directly threaten the quality and yield of Chinese chive[2]. For example, before the control of *Bradysia odoriphaga*, root irrigation is mainly used, which affects the agricultural ecological environment. Therefore, reducing the use of pesticides in Chinese chive fields and understanding the occurrence law of pests are inevitable requirements for the development of Chinese chive industry, which will help improve the quality and yield of Chinese chive, protect the economic interests of Chinese chive growers, and thus promote the sustainable development of agriculture[3]. In this study, the occurrence dynamics of pest groups in Chinese chive fields were investigated in Shijiazhuang, Hebei Province, so as to understand the main pest species and occurrence regularity, and to make clear the best control time of each pest group and formulate targeted pest control measures.

Received: July 23, 2024 Accepted: August 26, 2024

Supported by Observation and Monitoring Project of National Data Center for Insect Natural Enemies (ZX09S030101); Technology Demonstration and Service Special Project of Hebei Academy of Agriculture and Forestry Sciences (13000024P0012F410114C).

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Materials and Methods

Summary of investigation time and location

The investigation was conducted in the Chinese chive planting area of Agricultural Comprehensive Experiment Park, Hebei Academy of Agriculture and Forestry Sciences, and the occurrence of main pest groups in Chinese chive fields was investigated from April 2019 to November 2022. Chinese chive seeds were sown in mid-April every year, and the aboveground part of Chinese chive was basically dry in mid-November. During the investigation period of these two years, Chinese chive fertilizers and water were managed routinely, and cultivation management matters were recorded. The experimental field covered an area of 0.2 hm^2, surrounded by several small vegetable sheds, and the Chinese chive fields were surrounded by other crops such as Chinese onion, wheat, pepper and lotus. Chinese chives were cultivated in open field, and the variety of Chinese chive was "Dugenhong". The planting density was 15 cm between clusters and 15 cm between rows. During the investigation, the experimental field was not sprayed with any chemical agents, and the use of chemicals in surrounding plots was also recorded accordingly.

Investigation method

In this investigation, the Malaise trap method for collecting insects was used to collect insects in Chinese chive fields.

Sampling points for insect specimens were set up in the Chinese chive fields, and locations with ventilation and abundant sunshine where Chinese chives grew vigorously were chosen. The Malaise net purchased from Institute of Zoology, Chinese Academy of Agricultural Sciences was installed in the set sampling points according to the instructions. The installation of Malaise net required to tighten fixed ropes to make the net surface flat. The inclination angle of the net ridge was between 35° and 45°, and the black barrier net in the middle should partially overlap with the ground to facilitate the collection of crawling insects on the ground. The insect collecting bottle was connected with the insect channel of the Malaise net by an iron ring and fixed on the top of the Malaise net. The alcohol concentration in the collecting bottle was 95%, and the alcohol capacity in the bottle was more than 2/3. From mid-April 2019 to the end of November 2020, the collection bottle was changed every 15 d or so (no investigation was conducted in winter) until the investigation was over. Finally, each collected bottle was labeled with the date and location of collection, and the insect specimens collected from each bottle were classified and identified. Quantitative statistics and analysis were conducted.

Results and Analysis

Main pest species

The Malaise net method was used to investigate the pest groups in Chinese chive fields in Shijiazhuang. It was found that the pest groups that harmed Chinese chives in Agricultural Comprehensive Experiment Park, Hebei Academy of Agriculture and Forestry Sciences were *Luperomorpha suturalis*, *B. odoriphaga*, *Acrolepla alliella*, *Thrips tabaci*, *Liriomyza chinensis* and *Neotoxoptera formosana*. The two-year investigation also gave a general understanding of the occurrence and changes of various pest groups.

Temporal dynamic changes of main pest groups

During the whole investigation period, a total of 2 876 *L. suturalis* individuals were captured, including 2 537 in 2019 and 339 in 2020. The occurrence quantity of *L. suturalis* in 2019 was much higher than that in 2020. From the dynamic performance of the occurrence time of *L. suturalis* in 2019 (Fig. 1), the number in the peak period exceeded 1 000, and two peak periods were observed throughout the year. From mid May to the end of May, there was an upward trend, and then, it was gentle and slightly decreased. Until the end of June, with the warming of the weather, the population of the pest rose sharply, and the first peak appeared in mid July. After that, the number of adults of *L. suturalis* gradually decreased. In August, the population of the pest was at a low point, and in September, the population of the pest increased again, and the second peak appeared at the end of September. However, the peak value of the second peak was lower than that of the first peak, and then, it sharply declined and even disappeared until the end of November or early November. In 2020, the occurrence dynamics of *L. suturalis* were basically the same as that in 2019, and the two peak times were the same, both in mid July and late September, with the occurrence quantities of 181 and 31, respectively.

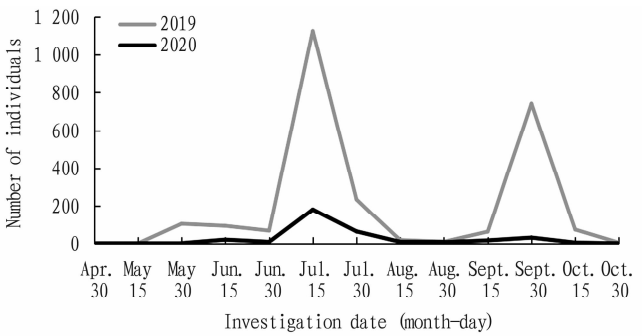

Fig. 1 Dynamics of *L. suturalis* in 2019 and 2020

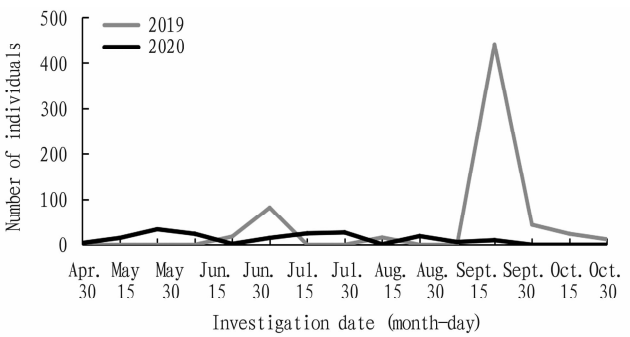

Fig. 2 Dynamics of *B. odoriphaga* in 2019 and 2020

During the whole investigation period, a total of 819 *B. odoriphaga* were collected, including 637 in 2019 and 182 in 2020. The number of *B. odoriphaga* in 2019 was much larger than that in 2020. According to the two-year dynamic performance of the occurrence time of *B. odoriphaga* (Fig. 2), the occurrence dynamics of this pest was more obvious in 2019. In 2019, *B. odoriphaga* began to occur in April, and the number increased significantly in June, reaching a small peak in mid July, with the number of 82. After that, it happened sporadically, and the population of the pest increased sharply in September, and the second peak appeared in mid October, with the number of 441, which was much higher than the first peak period. Afterwards, the population of *B. odoriphaga* decreased, and a turning point appeared at the end of October with fewer occurrences, until it disappeared by the end of November.

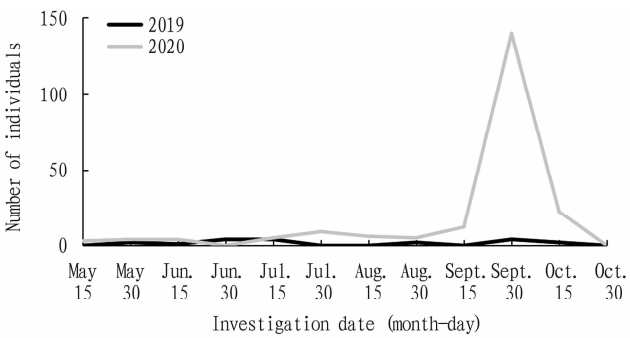

Fig. 3 Dynamics of *A. alliella* in 2019 and 2020

During the two-year investigation from 2019 to 2020, a total

of 229 *A. alliella* individuals were captured. Among them, 210 were captured in 2020 and only 19 in 2019, indicating that the occurrence of *A. alliella* in the Chinese chive fields was more serious in 2020. According to the dynamic performance of the occurrence of *A. alliella* in the past two years (Fig. 3), the occurrence in 2020 was more significant, with a small peak in late July 2020, and the population of this pest rose sharply after mid September, reaching the peak of the whole year in late September, with the occurrence quantity of 140. Afterwards, the number of population decreased and became extinct in late October.

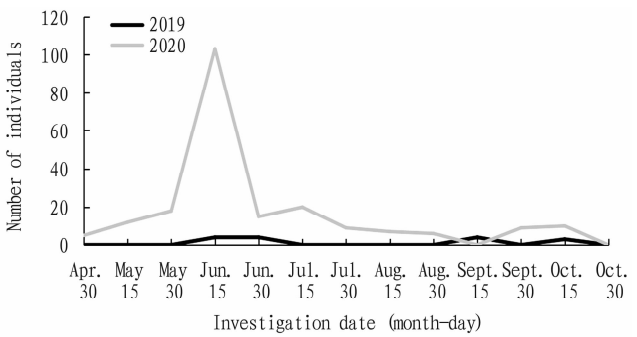

Fig. 4 Dynamics of *T. tabaci* in 2019 and 2020

In the two years, the number of *T. tabaci* individuals captured was 229, including 214 in 2020 and only 15 in 2019, which indicated that *T. tabaci* occurred in a large amount in 2020 and was more harmful to Chinese chives in the field. According to the dynamic performance of *T. tabaci* in 2020 (Fig. 4), a small number of *T. tabaci* occurred in the field in late April, and the population of this pest increased slowly until the inflection point appeared at the end of May, after which the population rose sharply. In mid June, the population of this pest was at most 103. After that, the population density decreased sharply, but a small peak appeared in mid July, and then, the population of pests decreased slowly. The population increased again in mid September, followed by a small peak in late September and extinction by the end of October.

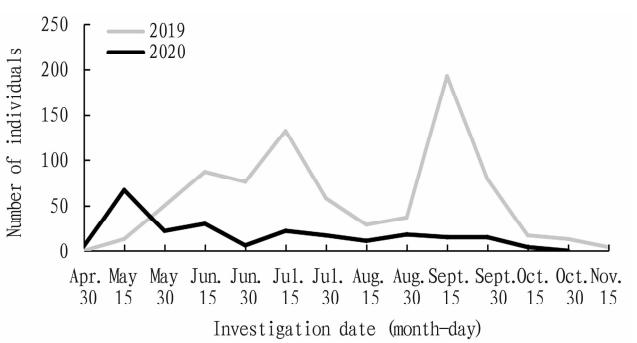

Fig. 5 Dynamics of *L. chinensis* occurrence in 2019 and 2020

In the past two years, the number of captured *L. chinensis* individuals was 1 020, including 788 in 2019 and 232 in 2020, and the occurrence quantity in 2019 was greater than that in 2020. It could be seen from the investigation data and dynamic changes of *L. chinensis* for two years (Fig. 5) that there were three peak periods of *L. chinensis* in 2019, which were mid June, mid July and mid September respectively, with the largest occurrence quantity of 193 in mid September. The peak periods in 2020 were mid May, mid June and mid September, respectively, and the peak values of the peak periods were generally lower than those in 2019, indicating that *L. chinensis* was more serious in the Chinese chive fields in 2019.

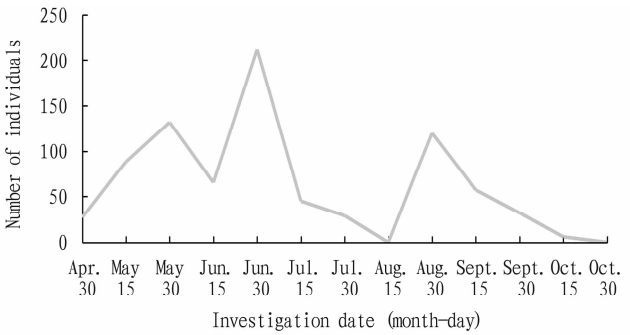

Fig. 6 Dynamics of *N. formosana* in 2020

The number of captured *N. formosana* in 2020 was 813, and the occurrence dynamics were significant. From the dynamic performance of occurrence in 2020 (Fig. 6), the pest experienced three peak periods throughout the year, with the first peak occurring in late May and an occurrence quantity of 132 aphids; the second peak appeared in late June, with the number of 212, which was also the peak of the whole year, when the population of *N. formosana* in the Chinese chive fields was the largest; and the third peak appeared in late August, and the number of pests was 120. Afterwards, the population of the pest continued to decline until it became extinct by the end of October.

Generally speaking, during the planting period of Chinese chive in this area, there were mainly two peak periods of each pest population. The first peak period occurred from mid June to mid July, and the second peak period occurred from late August to late September. After that, the number of individuals in most pest groups decreased, showing an obvious downward trend. It was closely related to the growth and development period of Chinese chive and surrounding crops. June was the beginning of summer and the aging period of Chinese chive, as well as the maturity period of surrounding crops, and the incidence of pests in Chinese chives was relatively high. In September, Chinese chives bloomed, and the population of pests reached a peak once again. From the dynamic performance of various pest groups in the Chinese chive fields, it could be seen that the occurrence of the same pest varied in different years, with significant differences in the occurrence time, number in the peak periods and occurrence quantity. By year, in 2019, the dominant species of pest group was *Lepidoptera olivaceus*, which caused the most serious damage to Chinese chives, while in 2020, the dominant species of pest group was *N. formosana*, which caused the most damage to Chinese chives. The difference of the occurrence regularity of pest groups and the difference of dominant species in different years may be closely related to the factors such as precipitation, temperature, wind speed and natural enemies in each year. When the climate conditions are suitable, the number of pest populations

will increase greatly, and the peak time will be earlier. When the temperature is too high or the humidity is high, the number of some pest populations will decrease greatly.

Control of Main Pest Groups

L. suturalis

L. suturalis mainly occurs in Shijiazhuang from April to October, and reaches its peak in mid July and the end of September. The adults feed on the leaves of Chinese chive, and larvae harm the roots of Chinese chive. For the control of *L. suturalis*, from the perspective of agricultural control, we should strengthen field management, reasonably rotate crops and clean up weeds and waste rocks in the field in time to reduce the hiding places of *L. suturalis* in Chinese chive fields[4]. Before planting Chinese chives in spring, the land can be deeply ploughed and dried, and some larvae hiding in the soil for the winter can also be killed. In addition, the roots of Chinese chive can be peeled before germination, which can reduce the damage of larvae to Chinese chives. In summer, making good use of high temperature and sunny weather and laying plastic film in Chinese chive fields can effectively reduce the insect population in the fields. Moreover, sticky insect plates can also be used to lure *L. suturalis*. Experimental results have shown that yellow and green sticky insect plates have the best trapping effect on this insect. The use of yellow and green sticky insect plates not only effectively monitors and controls *L. suturalis*, but also reduces the damage caused to Chinese chives by human activities when killing larvae to a certain extent[5]. From the point of view of biological control, the control effect of OTIU, an insect pathogenic nematode, on *L. suturalis*, is better. Zhang *et al.*[6] studied its control effect, and made it clear that the best dosage was 300 000/m^2. When using it to control pests, pesticides should not be used in the field to avoid killing the nematode.

B. odoriphaga

The distribution of *B. odoriphaga* in Chinese chive fields is mostly clustered. The adults like to eat the leaves of Chinese chive, and larvae will affect the roots of Chinese chive mostly. *B. odoriphaga* is a thermophilic pest and sensitive to humidity. Starting from the perspective of agricultural prevention and control, the temperature and humidity of the environment can be controlled, and continuous watering of the land during the occurrence of larvae in spring and autumn can kill some larvae. Because of the odor tendency of *B. odoriphaga*, it is necessary to apply mature farmyard manure in Chinese chive fields to avoid a large number of pests. Hu *et al.*[7] conducted research on the prevent and control of *B. odoriphaga* larvae using ozone water. The results showed that scientific and reasonable irrigation of ozone water in Chinese chive fields not only had the best control effect, but also promoted the growth of Chinese chive. In addition, biological control is also a very important means for *B. odoriphaga*, and the use of pathogenic nematodes to control its larvae can play a significant control role[8]. Zhu *et al.*[9] reported that *Mucor hiemalis* strain BO-1 had pathogenicity to *B. odoriphaga* larvae, and the control effect was good. Han *et al.*[10] found that *Stratiolaelaps scimitus* could prey on *B. odoriphaga* larvae, and it can be used to control *B. odoriphaga*.

A. alliella

A. alliella harms Chinese chive growth by feeding on the leaves of Chinese chive with its larvae. The control of *A. alliella* mainly relies on prediction and forecasting, and corresponding control measures are taken at the same time, mainly starting from agricultural and physical control. Currently, there are few reports on the use of natural enemies of this pest for control[11]. From the point of view of agricultural control, weeds in the field and residual Chinese chive leaves left after harvesting should be removed, and scientific fertilization and reasonable rotation should be conducted. Physical prevention and control is also an important means of prevention and control, such as trapping and killing by light and arranging insect nets in the field, which can reduce the base number of larvae[12]. In addition, sex attractants are an important green measure for preventing and controlling *A. alliella* harming Chinese chives, which not only has a good trapping effect, but also reduces the use of chemical pesticides and improves the quality and safety of Chinese chive[13].

T. tabaci

T. tabaci mainly harms Chinese chives by sucking the juice from Chinese chive leaves by adults or nymphs. For the control of *T. tabaci* in Chinese chive fields, from the perspective of agricultural control, weeds and fallen leaves of residual plants in the fields should be removed in early spring, and burned or buried intensively to reduce insect sources; and weeds in the field and surrounding areas should be removed to reduce the habitat of *T. tabaci*[14]. According to relevant research, blue sticky insect boards have a better trapping and killing effect on it. Some predatory mites can also be used to control *T. tabaci*. For example, Yang *et al.*[15] reported that Amblyseius swinskii significantly controlled the population size of *T. tabaci*.

L. chinensis

L. chinensis harms Chinese chives with larvae, which eat the mesophyll tissue of Chinese chive leaves, thus affecting Chinese chive growth and quality. For the prevention and control of *L. chinensis*, from the perspective of agricultural control, after Chinese chives are harvested by stages, it is necessary to clean residual plants and weeds in the field in time to reduce the habitat of adults in Chinese chive fields, which can play a certain role in controlling the number of adults. It is understood that *L. chinensis* only harms crops such as Chinese chive and onion, and the activity ability and migration ability of adults are weak, so crop rotation should be carried out. He *et al.*[16] investigated the parasitic wasps of *L. chinensis* in Baiyin, Gansu Province, mainly in the family Eulophidae, including *Diglyphus wani* and *Diglyphus crassinervis*. These natural enemies have a strong control effect on the occurrence of *L. chinensis*, so parasitic wasps and other natural enemies should be protected and utilized when killing pests in Chinese chive fields.

N. formosana

N. formosana has the characteristics of clustering. When the insect population is large, it often gathers on Chinese chive leaves to absorb Chinese chive juice, which makes Chinese chive leaves dry up and harms Chinese chive growth. For the prevention and

control of *N. formosana*, we should start with agricultural control. Reasonable farming system, scientific and reasonable crop layout, and timely cleaning of residual plants and Chinese chive leaves after harvesting in the field all help to reduce the opportunity for *N. formosana* to feed in the field. Its natural enemies can be used to kill *N. formosana*, and ladybugs in the field have a strong killing effect on it. In addition, Wang *et al.*[17] reported that the 3rd-instar larvae of *Aphidoletes abietis* also had strong predation ability on *N. formosana*, and the released quantity can be determined according to the severity of aphids in the field.

Discussion

The results of this experimental investigation showed that in the Chinese chive planting area of Shijiazhuang Dahe Experimental Zone, main pest groups that harm Chinese chives were *L. suturalis*, *A. alliella*, *B. odoriphaga*, *T. tabaci*, *L. chinensis* and *N. formosana*. According to the two-year investigation, *L. suturalis* and *B. odoriphaga* were the most serious pests, which directly led to the rot and yellow death of Chinese chive. The occurrence of each pest population in Chinese chive fields is closely related to crops in the surrounding environment, farming system in the field, climate, drug use and natural enemy dynamics[18]. Previously, our research group conducted an investigation on the insect community structure in this region, but specific pests harming Chinese chives were not mentioned in detail. This study found out specific pest species harming Chinese chives and the changes of pest groups in this region, so as to grasp the opportunity of prevention and control[19]. The species, occurrence quantity and occurrence period of main pests in Chinese chive fields are different in different places and in different years. For example, the main pests in Chinese chive fields in Yuncheng City, Shanxi Province[20] are *Delia antiqua* Meigen, *B. odoriphaga*, *A. alliella*, snails, *etc.*, and the main pests in Chinese chive fields in Sichuan[21] are thrips, aphids, *B. odoriphaga*, *etc.* Therefore, we should prevent and control pests in Chinese chive fields according to local actual situation. In addition, while controlling pests in Chinese chive fields, we should also consider the influence on natural enemy insect groups. When the pest population is at its peak, corresponding natural enemy insect groups are also relatively large. In this period, chemical chemicals should be used less to avoid killing a large number of natural enemy insects. In the face of different pest populations in Chinese chive fields in the same region, under the general control policy, different control measures should be taken. Corresponding control measures should be added according to the occurrence regularity and biological characteristics of different pests to achieve the best control effect. In this paper, the prevention and control measures of various pest populations in this region were put forward, mainly from agricultural control, physical control and biological control, which is in line with the concept of green prevention and control, in order to realize the unity of Chinese chive production quality and ecological benefits[22].

Based on the systematic investigation of main pest species and population dynamic changes in the Chinese chive fields in Shijiazhuang, the occurrence law of main pest groups was preliminarily grasped, which facilitates defining the control time and formulating reasonable control measures on the premise of ensuring the yield and quality of Chinese chive. Forecasting the occurrence of pests in Chinese chive fields can provide basis for farmers to take timely prevention and control measures, thus reducing the harm of pests in the field to Chinese chives and realizing high-quality production of Chinese chive.

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Comprehensive epidemic prevention measures for diarrhea symptoms

There are many factors affecting diarrhea in suckling piglets, including environmental sanitation, temperature fluctuation, heat preservation and ventilation conditions in the house[8-9]. Even piglets with anti-diarrhea genotype GG may have diarrhea. Therefore, it is necessary to establish and implement complete comprehensive epidemic prevention measures in pig farms, such as vaccine immunization and drug treatment for susceptible sows, so as to effectively prevent piglet diarrhea and improve the survival rate[10].

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Editor: Yingzhi GUANG Proofreader: Xinxiu ZHU

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Editor: Yingzhi GUANG Proofreader: Xinxiu ZHU