THE RESEARCH OF PLANT-INSECT INTERACTIONS OVER THE LAST TWO DECADES

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Abstract. Ecologists have long been interested in the interactions between plants and insects. However, there are few recent reviews and syntheses on plant-insect interactions research. To explore the current state of plant-insect interactions research and promote the research progress of plant-insect interactions, we used bibliometric methodologies to analyze the annual publication volume, research strength, and research hotspots of the literature about plant-insect interactions included in the Web of Science from 2001 to 2021. The results showed that the number of publications on plant-insect interactions research increased steadily from 2001 to 2021, with the initial development stage occurring before 2004 and a steady growth stage from 2005 to 2009, as well as a steady growth trend in the number of publications. After 2010, it entered a phase of rapid development, with the highest number of articles in 2021, with 352 publications. The studies were mostly conducted in developed countries. The USA had the most publications and the greatest influence, with a total of 1,218 publications. Furthermore, China had the second-highest number of publications and the strongest growth in the last 5 years (from 2017 to 2021) in terms of recent publication output. The University of California System stands out as the research institution with the highest number of publications, followed by the United States Department of Agriculture (USDA) and the French National Center for Scientific Research (CNRS). The Chinese Academy of Agricultural Sciences (CAAS) and the Chinese Academy of Sciences (CAS) were the top two among the top 15 institutions in terms of article publication in the past five years. The author with the most publications was Dicke M, while Wei TY had been more active with 66.67% of the total number of papers published in the last five years. *Oecologia* was the journal that published the most academic articles in plant-insect interactions research, but *PNAS* had the highest impact factors. The hotspots primarily concentrated on understanding the impact of insect-plant interactions on genes, the interconnections between insects and plants, and the effects of these interactions on the diversity of ecosystems. The number of Chinese publications increased rapidly during the previous five years, indicating some strength in plant-insect interaction research. However, there is still much opportunity for improvement in terms of both the quality and number of study findings. With China's continued investment in scientific research in recent years, it is projected that plant-insect interaction research will have a significant developmental tendency in the future.
Keywords: *bibliometric, Web of Science, plants, insects, development*

Introduction

Plants and insects play crucial roles in terrestrial ecosystems. The interaction between plants and insects has long been a topic of interest in ecology. There has been a rising emphasis on researching these interactions in recent years (Schuldt et al., 2012; Zeng and Sun, 2014). The study of plant-insect interactions began over two hundred years ago, with particular attention given to the relationship between pollinators and flowers. It was recognized by Darwin that the development of angiosperms and insect pollination

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activities are closely linked, dating back to the late Cretaceous period (Gong and Huang, 2007).

Previous studies found that about a million insect species exist on Earth, roughly half of which feed on plants, and that co-evolution between plants and phytophagous insects has been going on for around 350 million years (Gatehouse, 2002). There is a pretty continuous chain of host food selection by phytophagous insects, which includes the chemical odor and visual properties of the plant itself. Phytophagous insects visually analyze the surface properties of the plant before using chemoreceptors on their antennae, mandibular whiskers, and other areas of the body to determine whether the odor evolved by the plant is suited for them or not. When a phytophagous insect comes into contact with a host plant, it uses its antennae, mouthparts, and other receptors to assess the suitability of the plant's surface morphology, structure, and chemical qualities before deciding whether to stay or leave (Wang et al., 2014). Conversely, plants have evolved several strategies to defend themselves against phytophagous insect harm, including plant avoidance (including chemotaxis), physiological poisoning, and defense against phytophagous insect harm by attracting natural enemies of phytophagous insects. It has been discovered that both physical and chemical plant characteristics influence the feeding preferences of phytophagous insects (Schuldt et al., 2012). Specifically, on the one hand, host plants release volatiles that have a strong repellant impact on phytophagous insects, affecting phytophagous insect activity (Jones and Lawton, 1991). On the other hand, Plant physical characteristics influence phytophagous insect feeding behavior (e.g., color, leaf size, and specific leaf area) (Schuldt et al., 2012). For example, Kasseney et al. (2011) discovered that plant hardness influences the feeding choice of black-winged earth termites, which choose softer wood for feeding. Furthermore, Markwick et al. (2013) found that the apple brown codling moth is more sensitive to the color of the host plant, which has a direct impact on host localization by phytophagous insects.

The interaction between plants and insects is intricate and complex, the consequence of the combined influence of several variables, and has impacted many elements of biology. Insect-host plant interactions have emerged as one of the most critical in ecosystems. Plant-insect interactions are critical for understanding forest ecosystem functions and species coexistence processes (Bagchi et al., 2014; Schuldt et al., 2015), and they may also provide an important theoretical basis for pest control that is long-term and successful. Despite the creation of a vast quantity of relevant literature and reviews on plant-insect interactions around the world, few review studies use bibliometric methods to assess the progress and trends of research on this topic.

We employed bibliometric methods to examine the annual publication volume, research strength, and research hotspots of plant-insect interactions literature published in the Web of Science from 2001 to 2021. The primary goal of this study is to provide important insights into the development history, current position, and future directions of plant-insect interactions, as well as references for future plant-insect interaction research.

Materials and methods

Data sources

The Web of Science (WoS) is a valuable database that provides access to a wide range of academic information. It includes over 13,000 reputable and influential academic journals from various disciplines, such as the natural sciences, engineering and technology, biomedicine, social sciences, arts, and humanities.

We conducted a bibliometric analysis of literature on plant-insect interactions from 2001 to 2021 through the WoS Core Collection's Science Citation Index Expanded (SCI-E) scientific citation database. We developed a subject search formula to focus specifically on the topic of plant-insect interaction by conducting an exact search in the SCI-E database for "TS=plant insect interaction OR plant-insect interaction OR communication between plant and insect OR insect-plant interaction OR insect-plant relationship OR plant-herbivore interaction OR plant herbivore interaction" and setting the type of document to the article. After excluding literature unrelated to the search topic, resulting in a total of 4140 valid documents for further statistical data analysis in this paper. Subsequently, we downloaded and exported the retrieved literature—at least 500 articles in Txt format each time—and saved them as "download" files, which were then used as data samples for categorization and data analysis.

Data analyses

To investigate the progression of plant-insect interactions in the last 20 years, we used the WoS database's literature analysis function to explore the annual number of publications, authors, institutions, countries of publication, journal distribution, and hotspots of the 4140 valid publications. The visual analysis was carried out with the VOSviewer software, and the figures were created with the software R version 4.3.0 (https://www.r-project.org).

Results

Annual number of publications

The number of publications reflects the level of attention and progress in a given topic or discipline (Chuan et al., 2016). The annual publication volume on plant-insect interactions increased steadily from 2001 to 2021, with three distinct stages of development: initial development, stable growth, and rapid development (*Figure 1*). Plant-insect interactions, in particular, were in their infancy before 2004. The annual number of publications was less than 100, and 2003 delivered the fewest number of publications over the last 20 years (83). From 2005 to 2009, the number of publications progressively grew. Following 2010, the number of articles increased rapidly. The number of publications reached a peak of 352 in 2021, which is 4.24 times more than in 2003. Particularly, the total number of publications from 2013 to 2021 was 2,568, accounting for 62.03% of the total number of publications. Similarly, despite fluctuations in publishing growth, there has been a general upward trend from 2001 to 2021, with an average annual growth rate of 6.94%. In summary, this indicates that the magnitude of plant-insect interaction studies has greatly increased and received significantly more attention in recent years.

Distribution of research strength

Main issuing countries

The number of publications from various countries can reflect their degree of activity and research (Zhou et al., 2019). Over the last 20 years, 112 countries and regions have participated in research on plant-insect interactions. Except for China, Brazil, India, and

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Mexico, all of the top 15 nations in terms of the number of publications were developed countries in Europe and North America (*Table 1*), demonstrating that research on plant-insect interactions was primarily centered in industrialized countries (*Table 1*). Specifically, the USA had the most publications, with a total of 1,218 publications, accounting for 29.42% of all publications. China, Germany, and Brazil were next, with 482, 441, and 434 publications, respectively. The volume of literature published in the USA is equivalent to that of China, Germany, and Brazil combined, demonstrating the country's position as a world leader in this discipline.

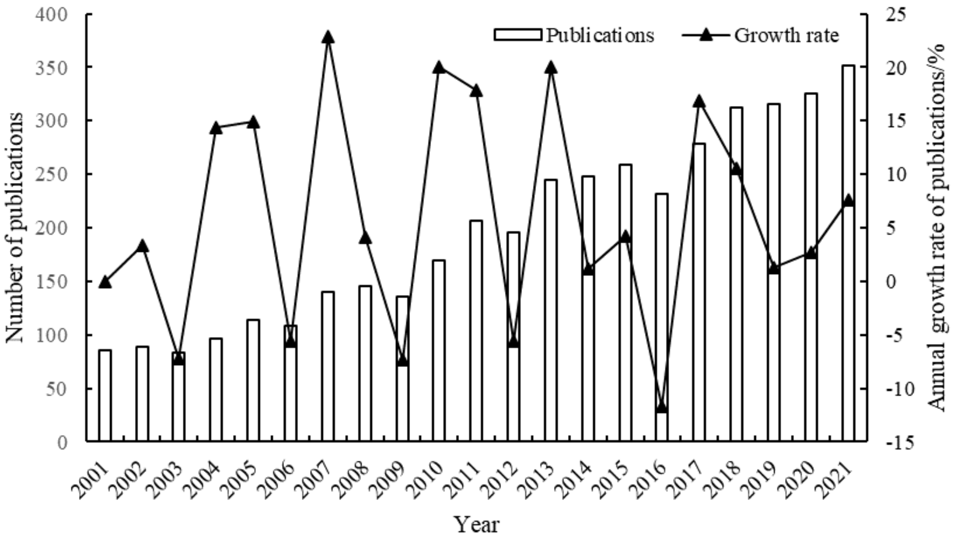

Figure 1. *Annual number of publications on the relationship between plants and insects*

Table 1. *Top 15 countries in the number of publications*

No.	Country	Number of publications	Proportion of all publications/%	Proportion of publications in recent five years/%
1	USA	1218	29.42	33.00
2	China	482	11.64	60.58
3	Germany	441	10.65	40.14
4	Brazil	434	10.48	43.55
5	England	270	6.52	29.63
6	France	237	5.72	42.19
7	Canada	215	5.19	35.81
8	Switzerland	197	4.76	35.53
9	Japan	194	4.67	34.02
11	Spain	193	4.67	45.60
10	Australia	191	4.61	25.65
12	Netherlands	182	4.40	38.46
13	Sweden	141	3.41	31.21
14	India	135	3.26	42.22
15	Mexico	114	2.75	51.75

The number of publications published in the USA in the last five years (from 2017 to 2021) is 402, accounting for 33.00% of all publications in the country and indicating a consistent growth trend. Correspondingly, China, Mexico, Spain, Brazil, India, France, and Germany accounted for more than 40% of all articles published in the previous five

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years, suggesting that these nations have been increasingly active in plant-insect interaction studies in recent years. In particular, China had produced 482 articles, placing second in the world, while the proportion of papers published in the previous five years was as high as 60.58%, placing first among all countries with the top 15 publications. While plant-insect interaction research in China lags behind that of Europe and the United States, it has recently grown more active, indicating a trend toward faster expansion.

Institutions distribution

Among the top 15 institutions (*Table 2*), the University of California System (UCS) had the highest number of publications (162), followed by the United States Department of Agriculture (USDA) and the Centre National De La recherche Scientifique (CNRS). The Chinese Academy of Agricultural Sciences (CAAS), the Chinese Academy of Sciences (CAS), and the INRAE all accounted for more than 50% of their respective publication volumes in the last 5 years, demonstrating the trend of rapid development in these institutions in recent years. Particularly, the Chinese Academy of Agricultural Sciences (CAAS) and the Chinese Academy of Sciences (CAS) have published 113 and 80 articles in plant-insect interactions research, respectively, ranking seventh and twelfth. On the other hand, the number of articles published by CAAS and CAS in the last five years accounted for 61.25% and 54.87% of their total literature, respectively, and they were the top two among the top 15 institutions in terms of article publication. These findings suggest that CAAS and CAS contribute significantly to the field of plant-insect interactions.

Table 2. *Top 15 institutions in the number of publications*

No.	Institutions	Number of publications	Proportion of all publications/%	Proportion of publications in recent five years/%
1	University of California System	162	3.91	31.48
2	United States Department of Agriculture USDA	156	3.77	28.85
3	Centre National De La recherche Scientifique CNRS	135	3.26	46.67
4	Udice French Research Universities	126	3.04	43.65
5	Max Planck Society	126	3.04	32.54
6	INRAE	115	2.78	50.43
7	Chinese Academy of Sciences	113	2.73	54.87
8	Conse jo Superior De Investigaciones Cientificas CSIC	109	2.63	44.04
9	Universidade De Sao Paulo	102	2.46	36.27
10	Wageningen University Research	94	2.27	40.43
11	Cornell University	86	2.08	37.21
12	Chinese Academy of Agricultural Sciences	80	1.93	61.25
13	Kyoto University	79	1.91	26.58
14	Conse jo Nacional De Investigaciones Cientificas y Tecnicas Connicet	77	1.86	48.05
15	Swedish University of Agricultural Sciences	72	1.74	33.33

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Authors distribution

Scholars from different countries were among the top 15 authors in terms of total publications (*Table 3*), with Dicke M from Wageningen University having the most publications (34 in total). Ohgushi T from Kyoto University and Bruelheide H from the Max Planck Institute for Chemical Ecology followed. Furthermore, in the previous five years, the top three writers accounted for more than 20% of their total publications, demonstrating a consistent growth tendency. However, Maia VC, Rassmann S, and Van Dam NM have published more than half of all papers in the last five years, showing that these three scholars have recently become more interested in plant-insect interactions. Furthermore, Chinese scholars such as Wei TY and Zhang YJ from Fujian Agriculture and Forestry University and the Institute of Botany Chinese Academy of Agricultural Sciences, respectively, had published more than 60% of the total number of publications in the last 5 years, indicating that these two scholars have recently become more active in plant-insect interactions research.

Table 3. *Top 15 authors in the number of publications*

No.	Author	Country	Number of publications	Proportion of all publications/%	Proportion of publications in recent five years/%
1	Dicke M	Netherlands	34	0.82	32.35
2	Ohgushi T	Japan	32	0.77	21.88
3	Baldwin IT	Germany	32	0.77	25.00
4	Rassmann S	Switzerland	24	0.58	54.17
5	Gershenzon J	Germany	22	0.53	31.82
6	Van Dam NM	Germany	22	0.53	50.00
7	Poelman EH	Netherlands	21	0.51	47.62
8	Del-Claro K	USA	21	0.51	38.10
9	Wei TY	China	18	0.43	66.67
10	Matthias E	Switzerland	18	0.43	44.44
11	Maia VC	Brazil	17	0.41	58.82
12	Turlings TC	Switzerland	15	0.36	26.67
13	Bento JM	Brazil	15	0.36	46.67
14	Zhang YJ	China	15	0.36	60.00
15	Oliveira PS	Brazil	15	0.36	20.00

Journals distribution

By analyzing the top 16 journals based on the number of articles published (as shown in *Table 4*), it was discovered that the majority of these journals were focused on environmental sciences and ecology, agricultural and forestry sciences, and biology. *Oecologia*, *Ecology*, *Journal of Chemical Ecology*, and *PLoS One* were the top four journals in terms of article count, with 143, 135, 109, and 105 articles, respectively. whereas the remaining journals have fewer than 100 publications. *PNAS* has the highest impact factor (12.0) of the top 16 journals. This suggests that papers published in this journal have a significant effect on plant-insect interactions. Furthermore, the average impact factor in terms of the number of publications for the top 16 journals was 4.2, which

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is rather low for journals specializing in plant-insect interactions research when compared to other disciplines (materials, etc.).

Highly cited papers

Publication citation frequency serves as a direct measure of a paper's quality, demonstrating scholars' academic proficiency and global significance (Chuan et al., 2016). Analyze the top 15 cited papers in plant-insect interactions research over the last 20 years (*Table S1*). We found that the most cited paper, authored by Dharmasiri N and published in *Nature* in 2005, had accumulated a remarkable 1428 citations. Following closely behind, Yan JB's publication in *Plant Cell* in 2009 has garnered 524 citations. Seven of the top fifteen most cited papers were from the USA; two were from China and Switzerland; and the other publications were from Germany, Spain, Italy, and Brazil. In summary, The USA is far ahead of other countries in terms of research strength and impact in plant-insect interactions research.

Table 4. *Top 16 journals in the number of publications*

No.	Journal	Number of publications	Proportion of all publications/%	Five-year impact
1	Oecologia	143	3.45	3.0
2	Ecology	135	3.26	5.3
3	Journal of Chemical Ecology	109	2.63	2.6
4	PLoS One	105	2.53	3.8
5	Entomologia Experimentalis Et Applicata	97	2.34	2.1
6	Ecological Entomology	94	2.27	2.2
7	Arthropod Plant Interactions	93	2.25	1.9
8	Journal of Ecology	78	1.88	6.3
9	Environmental Entomology	77	1.86	1.9
10	Oikos	70	1.69	3.6
11	Frontiers in Plant Science	61	1.47	6.8
12	Ecology and Evolution	55	1.33	3.0
13	Functional Ecology	54	1.30	6.0
14	PNAS	50	1.21	12.0
15	Scientific Reports	50	1.21	4.9
16	Journal of Economic Entomology	50	1.21	2.3

Analysis of research hotspots

The keywords in plant-insect interactions research were visualized using the information visualization software VOSviewer (*Figure 2*). This software enables us to identify the association between the keywords and depict them as circles with labels. The size of the circles represented the frequency with which each keyword appeared. After studying the graphic, we observed that numerous hotspots were often referenced in plant-insect interactions research from 2001 to 2021. These hotspots included genes, mechanisms, pollinators, predators, variation, abundance, diversity, community, ecosystem, etc. These high-frequency keywords indicate the current research directions and hot topics in the field of plant-insect interactions.

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We conducted a comprehensive analysis of plant-insect interactions research hotspots from 2001 to 2021 and highlighted the following three hot study themes: (1) the effects of insect-plant interactions on their genes, such as gene mutation; (2) the interactions between insects and plants, such as predation, parasitism, and mutualistic symbiosis; and (3) the effects of insect-plant interactions on ecosystem diversity. By examining the hotspots, it is possible to determine that research on pest and plant resistance, mutation, and influence on ecosystems may become a hotspot direction.

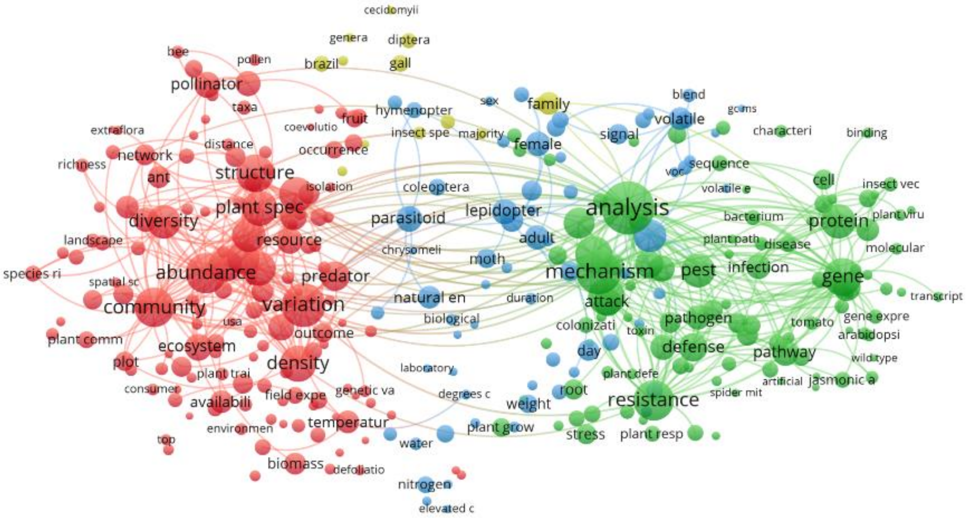

Figure 2. *Keyword hotspot analysis. The size of the circles represented the frequency with which each keyword appeared*

Discussion and conclusions

The development of plant-insect interactions in the world over the previous 20 years

Over the previous 20 years (from 2001 to 2021), the number of publications in the field has continuously expanded, with three distinct stages of development: initial development, stable growth, and rapid development. The number of papers produced annually was less than 100 during the original development stage, which lasted until 2004. From 2005 to 2009, the field experienced steady expansion, with an increase in the number of articles and increased academic interest. Plant-insect interactions have entered a rapid development phase since 2010, with a large increase in the number of publications. The number of articles peaked in 2021 at 352. Notably, between 2013 and 2021, a total of 2,568 articles were published, accounting for 62.03% of the total number of articles. This implies a major increase in interest and attention toward plant-insect interactions studies in recent years, and it suggests that plant-insect interaction research will continue to receive continuous attention from scholars in the future.

In terms of research strength distribution, all of the top 15 countries in terms of the number of publications were developed countries, except for China, Brazil, India, and Mexico. The USA has the most publications and the greatest influence, with a total of 1,218 publications, accounting for 29.42% of the total number of publications. With 482 articles, China ranks second in the world. However, 60.58% of these articles were published during the last five years, putting China among the top 15 countries in terms of recent publication output. This indicates that China has the strongest development momentum in the field of plant-insect interactions research. The University of California

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System stands out as the research institution with the highest number of publications, with 162 articles accounting for 3.91% of the total, followed by the United States Department of Agriculture (USDA) and the French National Center for Scientific Research (CNRS). Among the top 15 authors, Dicke M from Wageningen University, Netherlands, has the most publications. However, Maia VC, Rassmann S, and Van Dam NM have published more than half of all papers in the last five years, showing that these three scholars had recently developed an interest in plant-insect interactions. Furthermore, Chinese scholars such as Wei TY and Zhang YJ have published more than 60% of the total number of publications in the last 5 years, indicating that these two Chinese scholars have recently been increasingly active in plant-insect interactions research. *Oecologia* was the journal that published the most academic articles in plant-insect interactions research, but *PNAS* had the highest impact factors. This suggests that these two journals possessed strong influence and were able to attract significant attention from fellow scholars. In summary, the research outputs of select countries in Europe and the United States, as well as their institutions and scholars, have a stronger global influence, with the USA occupying an utterly dominant position in this study field.

The development of plant-insect interactions in China over the previous 20 years

Research in China on plant-insect interactions started later than in developed countries in Europe and the United States. While the number of publications in China was among the highest in the world, indicating a certain level of strength, there is still a significant gap compared to Europe and the United States. Currently, China is ranked second in the world in terms of the number of publications, with 482. The Chinese Academy of Agricultural Sciences (CAAS) and the Chinese Academy of Sciences (CAS) play a prominent role in this field and have experienced rapid development in recent years. Among the top 15 in terms of the number of publications Chinese scholars such as Wei TY and Zhang YJ from Fujian Agriculture and Forestry University and the Institute of Botany Chinese Academy of Agricultural Sciences, with 18 and 15 publications, respectively, had published more than 60% of the total number of publications in the last 5 years, indicating that these two scholars have recently become more active in plant-insect interactions research. Chinese scholars Yan et al. (2009) and Gao et al. (2011) ranked second and third in the world in terms of the number of citations in the top 15 literature for their articles published in *Plant Cell* and *PLoS Genetics*, respectively. Furthermore, the Chinese-sponsored academic journals did not make it into the top 16 journals in terms of the number of articles published. In summary, China has demonstrated some strength in plant-insect interaction research, with more active performance in the last five years indicating a stage of rapid growth. However, the average number of citations for Chinese experts remains significantly lower than for those from Europe and the United States. When compared to wealthy countries in Europe and the United States, there is plenty of room for development in both the quality and quantity of research results. With China's ongoing investment in scientific research in recent years, research on plant-insect interactions is predicted to accelerate more rapidly in the future.

Perspectives

Currently, research on the relationship between plants and insects has expanded on a large scale and has become closely connected to the development of human societies. The interactions between herbivorous insects and host plants play a crucial role in terrestrial

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food webs. For example, plant diversity, species composition, and functional traits influence herbivory insects' feeding choice and intensity (Zhang et al., 2017; Grossman et al., 2019), whereas herbivory insects influence plant survival and growth by feeding on plants, which affects the composition and dynamics of plant communities (Schuldt et al., 2015). Particularly, it is interesting to observe the co-evolution of host plants and insects, so that plants have evolved the ability to recognize insect feeding and complicated defense strategies over time (Beran and Petschenka, 2022; Abdellatef et al., 2015). The interaction between host plants and insects is similar to a long-term "game". Plants detect insect feeding signals and activate plant defenses, while insects have evolved potent counter-protections in reaction to plant defenses, particularly the saliva released by stinging insects while eating, which is vital (Liu et al., 2016; Mondal, 2017). Especially, agricultural pests are one of the most significant biological reasons for affecting economic losses in agricultural productivity, and both the rice fly and aphids are cnidarians. In the future, we will conduct additional research on the mutualistic defense mechanism between host plants and stinging insects, which will contribute to deepen the understanding of their co-evolution and provide a theoretical foundation and reference for the development of new crop pest control approaches and technologies.

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REFERENCES

[1] Abdellatef, E., Will, T., Koch, A., Imani, J., Vilcinskas, A., Kogel, K.-H. (2015): Silencing the expression of the salivary sheath protein causes transgenerational feeding suppression in the aphid Sitobion avenae. – Plant Biotechnology Journal 13(6): 849-857. https://doi.org/10.1111/pbi.12322.

[2] Bagchi, R., Gallery, R. E., Gripenberg, S., Gurr, S. J., Narayan, L., Addis, C. E., Freckleton, R. P., Lewis, O. T. (2014): Pathogens and insect herbivores drive rainforest plant diversity and composition. – Nature 506(7486): 85-88. https://doi.org/10.1038/nature12911.

[3] Beran, F., Petschenka, G. (2022): Sequestration of plant defense compounds by insects: From mechanisms to insect–plant coevolution. – Annual Reviews 67: 163-180. https://doi.org/10.1146/annurev-ento-062821-062319.

[4] Chuan, L., Zheng, H., Zhao, T., Zhao, J., Yan, Z., Zhang, X., Tan, C. (2016): Trends in research on contaminated soil remediation based on web of science database. – Journal of Agro- Environment Science 35(1): 12-20. https://doi.org/10.11654/jaes.2016.01.002.

[5] Gao, Q., Jin, K., Ying, S.-H., Zhang, Y., Xiao, G., Shang, Y., Duan, Z., Hu, X., Xie, X.-Q., Zhou, G., Peng, G., Luo, Z., Huang, W., Wang, B., Fang, W., Wang, S., Zhong, Y., Ma, L.-J., St. Leger, R. J., … Wang, C. (2011): Genome sequencing and comparative transcriptomics of the model entomopathogenic fungi Metarhizium anisopliae and *M. acridum*. - PLoS Genetics 7(1): e1001264. https://doi.org/10.1371/journal.pgen.1001264.

[6] Gatehouse, J. A. (2002): Plant resistance towards insect herbivores: A dynamic interaction. – New Phytologist 156(2): 145-169. https://doi.org/10.1046/j.1469-8137.2002.00519.x.

[7] Gong, Y., Huang, S. (2007): On methodology of foraging behavior of pollinating insects. – Biodiversity Science 15(6): 576-583. https://doi.org/10.1360/biodiv.070155.

[8] Grossman, J. J., Cavender-Bares, J., Reich, P. B., Montgomery, R. A., Hobbie, S. E. (2019): Neighborhood diversity simultaneously increased and decreased susceptibility to contrasting herbivores in an early stage forest diversity experiment. – Journal of Ecology 107(3): 1492-1505. https://doi.org/10.1111/1365-2745.13097.

[9] Jones, C. G., Lawton, J. H. (1991): Plant chemistry and insect species richness of british umbellifers. – Journal of Animal Ecology 60(3): 767-777. https://doi.org/10.2307/5413.

[10] Kasseney, B. D., Deng, T., Mo, J. (2011): Effect of wood hardness and secondary compounds on feeding preference of Odontotermes formosanus (Isoptera: Termitidae). – Journal of Economic Entomology 104(3): 862-867. https://doi.org/10.1603/EC10216.

[11] Liu, X., Zhou, H., Zhao, J., Hua, H., He, Y. (2016): Identification of the secreted watery saliva proteins of the rice brown planthopper, *Nilaparvata lugens* (Stål) by transcriptome and Shotgun LC–MS/MS approach. – Journal of Insect Physiology 89: 60-69. https://doi.org/10.1016/j.jinsphys.2016.04.002.

[12] Markwick, N. P., Poulton, J., Espley, R. V., Rowan, D. D., McGhie, T. K., Wadasinghe, G., Wohlers, M., Jia, Y., Allan, A. C. (2013): Red-foliaged apples affect the establishment, growth, and development of the light brown apple moth, *Epiphyas postvittana*. – Entomologia Experimentalis et Applicata 146(2): 261-275. https://doi.org/10.1111/eea.12024.

[13] Mondal, H. A. (2017): Shaping the understanding of saliva-derived effectors towards aphid colony proliferation in host plant. – Journal of Plant Biology 60(2): 103-115. https://doi.org/10.1007/s12374-016-0465-x.

[14] Schuldt, A., Bruelheide, H., Durka, W., Eichenberg, D., Fischer, M., Kröber, W., Härdtle, W., Ma, K., Michalski, S. G., Palm, W.-U., Schmid, B., Welk, E., Zhou, H., Assmann, T. (2012): Plant traits affecting herbivory on tree recruits in highly diverse subtropical forests. – Ecology Letters 15(7): 732-739. https://doi.org/10.1111/j.1461-0248.2012.01792.x.

[15] Schuldt, A., Bruelheide, H., Härdtle, W., Assmann, T., Li, Y., Ma, K., von Oheimb, G., Zhang, J. (2015): Early positive effects of tree species richness on herbivory in a large-scale forest biodiversity experiment influence tree growth. – Journal of Ecology 103(3): 563-571. https://doi.org/10.1111/1365-2745.12396.

[16] Wang, Z., Meng, Q., Zhong, G. (2014): Study on the feeding behavior process and mechanism of phytophagous insect. – Journal of Environmental Entomology 36(04): 612-619. https://doi.org/10. 3969/j. issn.1674 - 0858.2014.04.21.

[17] Yan, J., Zhang, C., Gu, M., Bai, Z., Zhang, W., Qi, T., Cheng, Z., Peng, W. T., Luo, H., Nan, F., Wang, Z., Xie, D. (2009): The Arabidopsis CORONATINE INSENSITIVE1 protein is a jasmonate receptor. – Plant Cell 21(8): 2220-2236. https://doi.org/10.1105/tpc.109.065730.

[18] Zeng, F., Sun, Z. (2014): Mechanism, hypothesis and evidence of herbivorous insect-host interactions in forest ecosystem. – Acta Ecologica Sinica 34(05): 1061-1071. https://doi.org/10.5846/stxb201304270830.

[19] Zhang, J., Bruelheide, H., Chen, X., Eichenberg, D., Kröber, W., Xu, X., Xu, L., Schuldt, A. (2017): Tree diversity promotes generalist herbivore community patterns in a young subtropical forest experiment. – Oecologia 183(2): 455-467. https://doi.org/10.1007/s00442-016-3769-0.

[20] Zhou, Y., Hu, G., Zhang, Z., Tao, W., Wang, J., Fu, R. (2019): Web of Science-based bibliometric evaluation of international seagrass research. – Acta Ecologica Sinica 39(11): 4200-4211. https://doi.org/10. 5846 /stxb201805271166.

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APPENDIX

Table S1. *The influence of the top 15 cited papers in the field of the relationship between plants and insects during 2001-2021*

No.	Article title	First author	Country	Total citation	Year
1	The F-box protein TIR1 is an auxin receptor	Dharmasiri N	USA	1428	2005
2	The Arabidopsis CORONATINE INSENSITIVE1 Protein Is a Jasmonate Receptor	Yan JB	China	524	2009
3	Genome Sequencing and Comparative Transcriptomics of the Model Entomopathogenic Fungi Metarhizium anisopliae and M. acridum	Gao Q	China	459	2011
4	Within-plant signaling by volatiles leads to induction and priming of an indirect plant defense in nature	Heil M	Germany	458	2007
5	Herbivores promote habitat specialization by trees in amazonian forests	Fine PVA	USA	390	2004
6	Geographic patterns in plant-pollinator mutualistic networks	Olesen JM	Spain	384	2002
7	A conserved transcript pattern in response to a specialist and a generalist herbivore	Reymond P	Switzerland	379	2004
8	Geographic structure and dynamics of coevolutionary selection	Thompson JN	USA	345	2002
9	Field crop responses to ultraviolet-B radiation: a review	Kakani VG	USA	338	2003
10	Pyric Herbivory: Rewilding Landscapes through the Recoupling of Fire and Grazing	Fuhlendorf S	USA	327	2009
11	Aldehyde suppression of copepod recruitment in blooms of a ubiquitous planktonic diatom	Ianora A	Italy	327	2004
12	Regulation and function of Arabidopsis JASMONATE ZIM-domain genes in response to wounding and herbivory	Chung HS	USA	326	2008
13	The global distribution of diet breadth in insect herbivores	Forister ML	USA	314	2015
14	Arabidopsis Basic Helix-Loop-Helix Transcription Factors MYC2, MYC3, and MYC4 Regulate Glucosinolate Biosynthesis, Insect Performance, and Feeding Behavior	Schweizer F	Switzerland	310	2013
15	Structure in plant-animal interaction assemblages	Lewinsohn TM	Brazil	301	2006

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