

令和 6 年 6 月 12 日現在

機関番号：82401

研究種目：研究活動スタート支援

研究期間：2022～2023

課題番号：22K20588

研究課題名（和文）Functions of regulator molecules reprogramming insect gall organogenesis in plants

研究課題名（英文）Functions of regulator molecules reprogramming insect gall organogenesis in plants

研究代表者

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交付決定額（研究期間全体）：（直接経費） 2,200,000 円

研究成果の概要（和文）：この研究は、ゴールを作る昆虫とそれらの宿主植物との相互作用について、大きな進展を遂げました。3種類のゴール形成昆虫の高解像度ゲノムを取得し、遺伝学研究の重要な基盤を提供しました。さらに、エフェクタープロテインのリストを作成し、その機能を検証するための優先順位付けを行っています。これにより、ゴール形成の分子メカニズムの解明を目指しています。また、ニレの木の組織培養の試みは当初困難でしたが、培地条件を改良し、他の植物システムでの検証も検討しています。これらの成果は、植物と昆虫の相互作用に関する科学的理解を深めるだけでなく、農業やバイオテクノロジー分野への応用可能性も秘めています。

研究成果の学術的意義や社会的意義

この研究は、植物と昆虫の相互作用に焦点を当て、特に昆虫によるゴール形成を掘り下げます。ゴール形成昆虫のゲノムを解読し、重要なエフェクタープロテインを特定することで、ゴール形成を駆動する遺伝子調節ネットワークを明らかにします。科学的には、これにより発生再プログラミングの理解が深まり、比較器官形成研究への道が開かれます。社会的には、我々の研究成果が、ゴールを作る害虫から作物を保護するための革新的な農業戦略を提供し、バイオテクノロジーによる作物の耐性向上、植物と昆虫のダイナミクスを理解することで生態保全を進めます。

研究成果の概要（英文）：Our research has made significant strides in understanding gall-forming insects and their interactions with host plants. We successfully obtained high-resolution genomes of three gall-forming insects, providing a foundational resource for further genetic studies. A comprehensive list of putative effector proteins has been compiled and is undergoing prioritization for functional validation, aiming to elucidate the molecular mechanisms of gall induction. Additionally, although initial tissue culture attempts with elm trees faced challenges, ongoing modifications are improving medium conditions, with alternative plant systems being considered for validation. These achievements not only enhance our scientific understanding of plant-insect interactions but also hold potential agricultural and biotechnological applications.

研究分野：plant-insect interaction

キーワード：gall organogenesis

1 . 研究開始当初の背景

Plants display developmental plasticity to generate new organs or tissues to adapt to various stimuli coming from abiotic or biotic agents through the reprogramming development (Ichihayashi et al. 2020, Front. Plant Sci.). Many insects induce novel plant organs called galls and the insect galls are dramatic examples of extended phenotypes of plants: although assembled by host plant tissues, the development of galls is mainly controlled by insects and tend to be species-specific particularly for the insects' fitness (Stone & Schönrogge 2003, Trends Ecol. Evol.; Tong & Akimoto 2019, Funct. Ecol.; Korgaonkar et al. 2021, Curr. Biol.). Insects inject effector proteins, phytohormones, and other uncovered molecules into plants and these regulator molecules function importantly in gall organogenesis which is composed of cell division, differentiation and/or dedifferentiation (Takei et al. 2015, J. Insect Physiol.; Hirano et al. 2020, Front. Plant Sci.; Korgaonkar et al. 2021, Curr. Biol.). The insect gall organogenesis is supposed to share similar reprogramming processes with plant regeneration after wounding, the root nodule organogenesis, and the haustorial formation by parasitic plants in terms of cellular and molecular aspects of development, though the molecular mechanisms especially the gene regulatory networks of insect gall organogenesis are largely uncovered. Two key questions are asked and examined in this proposal: 1) what regulator molecules (peptide/protein effectors and RNAs) are utilized by insects to regulate gall organogenesis? 2) what are the functions of those insect regulator molecules for reprogramming plant development?

2 . 研究の目的

How insects make galls? To answer this question in molecular level, this proposal aims to first clarify the partial gene regulatory networks of insect gall organogenesis using aphid-galling-elm model. This funded project was initially to clarify the regulator molecules that can promote gall organogenesis such as peptides, proteins, and RNAs originated from gall-forming aphids on elm trees.

3 . 研究の方法

- Long-read genome sequencing: To obtain better resolution of insect genomes for annotating putative peptides, the two *Tetraneura* aphids and one *Eriosoma* aphid species galling on the same host plant, Japanese elm tree (*Ulmus davidiana*) were sequenced by Pacbio.
- Proteomic & Transcriptome analysis: The aphid generation initiating galls and non-galling generation were collected and used to perform comparative analysis for validating galling putative effectors.
- Tissue-culture trial: The immature embryonic tissues isolated from the original host plant were tested for tissue culture for later validation.

4 . 研究成果

- **Genome Information**

High-resolution genomes of three gall-forming insects have been successfully obtained.

- **List of Candidates of Putative Effectors**

A list of putative effectors has been compiled and is currently undergoing further analysis to prioritize candidates for functional validation.

- **Tissue Culture of Host Plant Elm Tree**

Initial attempts at tissue culture of the host plant elm tree have been met with limited success. The medium conditions are being modified for improvement. Additionally, validation in an alternative plant system is being considered.

Research Presentations

- Plant Hackers: Gall-forming Insects Extend Their Phenotypes on the Trees by Novel Plant Organogenesis, iTHEMS, RIKEN, Wako, Japan, February 2024
- Obligate Symbiotic Interactions in Aphid Gall Systems, PISI-net Meeting, Saint Malo, France, November 2023
- Insights into Early Gall Organogenesis by Woolly Aphids, The 8th International Plant Gall Symposium, Chico, CA, USA, July 2023

5 . 主な発表論文等

〔雑誌論文〕 計0件

〔学会発表〕 計2件（うち招待講演 1件 / うち国際学会 1件）

1 . 発表者名 Xin Tong; Shuji Shigenobu; Shin-ichi Akimoto
2 . 発表標題 Symbiotic Interactions by aphids galling on elm trees
3 . 学会等名 XI International Anniversary Symposium on Aphids (国際学会)
4 . 発表年 2022年

1 . 発表者名 Xin Tong
2 . 発表標題 Gall-forming aphids, small insects with great power: female-biased sex allocation via female competition induces novel insect gall organogenesis in plants
3 . 学会等名 Japan Eco-Evo English Seminar (招待講演)
4 . 発表年 2022年

〔図書〕 計0件

〔産業財産権〕

〔その他〕

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6 . 研究組織

	氏名 (ローマ字氏名) (研究者番号)	所属研究機関・部局・職 (機関番号)	備考
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7 . 科研費を使用して開催した国際研究集会

〔国際研究集会〕 計0件

8 . 本研究に関連して実施した国際共同研究の実施状況

共同研究相手国	相手方研究機関
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