学　位　論　文　内　容　の　要　旨

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学　位　論　文　題　名

Evolution of symbiotic interactions to enhance aphid transmission of plant viruses and satellite RNAs (ウイルスやそのサテライト RNA のアブラムシ伝搬を促進する共生相互作用の進化)

Natural selection within local populations is the major evolutionary process driving the form of coevolution. In the processes of evolution, all living beings, even the simplest organisms coevolve by many means for its survival in the nature. The idea of onward transmission of plant viruses and satellite RNAs is indispensable for their survival. For the movement of plant viruses from one host to another most viruses seek assistance of Homopteran insects, and aphids have become the most important plant virus vector. Aphids are responsible for transmission of nearly 40% of all known plant viruses.

One may argue that there is nothing easier for a plant virus than being carried by an insect. Yet on the contrary, here, it is reported that a plant virus or even a satellite RNA will develop sophisticated interactions wherever there is room for improving the transmission efficiency. Viruses and the satellite RNAs have found to modify the trilateral plant-virus-vector interactions at all possible scales and these modifications have often strengthened their fitness for their survival.

In this thesis, two symbiotic interactions, which coevolved targeting the upsurge of aphid transmissibility, are documented. The chapter one explains how helper component protease (HC-Pro) of leek yellow stripe virus facilitate the aphid transmission of an onion yellow dwarf virus isolate with a mutated HC-Pro gene. In the chapter two, the quadripartite symbiotic interactions among a Y-satellite RNA, cucumber mosaic virus, tabaco plant and aphid is presented; in this chapter, an extraordinary survival strategy shown by a non-coding RNA is explained in detail.

(1) Helper component protease (HC-Pro) of leek yellow stripe virus facilitates the aphid transmission of an onion yellow dwarf virus isolate with a mutated HC-Pro gene: A symbiotic association evolved among two potyviruses

It has been identified that aphid transmission of potyviruses occurs only if the virus is acquired along with or after the acquisition of a special helper protein later known as HC-Pro. We found

that the HC-Pro proteins of all onion yellow dwarf virus (OYDV) isolates infecting in garlic cultivated in Hokkaido, Japan lacked about 100 amino acids in the N-terminal region. Since this missing sequence in N-terminal of HC-Pro include the KITC motif, which is important for aphid transmission, it is assumed that those isolates have lost the ability to be transmitted through aphids. The data revealed that the mutation in HC-Pro has resulted loss of aphid transmissibility. In the nature the loss of aphid transmissibility of OYDV isolate has overcome by the symbiotic interaction with leek yellow stripe virus (LYSV). We presume that LYSV HC-Pro works *in trans* as a platform that interlinks both LYSV and OYDV with the aphid stylet.

(2) Evolution of a quadripartite symbiosis driven by a satellite RNA to promote aphid transmission

A virus is sometimes associated with a subviral non-cording RNA molecule such as a satellite RNA (satRNA) which can modify the accumulation levels and the symptoms caused by the helper virus. Since viruses are differentially transmitted by insect vectors, any change in the virus-vector interactions would affect the natural selection of virus population. Cucumber mosaic virus (CMV) is one of the most successful viral pathogens as it can infect nearly 1200 plant species. Y satellite RNA (Y-sat) is a satRNA which depends on CMV for its replication and encapsidation. The presence of Y-sat in CMV infected plants down-regulates the *ChlI* mRNA, impairing the chlorophyll biosynthesis in *Nicotiana* plants causing bright yellow symptoms. This Y-sat-mediated bright yellowing of leaves attracted our attention to decode the evolutionary standpoint of the above adaptation. Attraction of insect vectors to infected host plant and subsequent dispersal to a healthy host is vital for successful spread of Y-sat. Our data showed that the aphids are preferentially attracted to the yellow colour, and the small RNAs derived from Y-sat can then turn aphid's red to produce alate morphs. Based on these observations, we infer that via molecular crosstalk by sRNAs, Y-sat regulates both the host plant and the insect vector in order to enhance the spread of CMV +Y-sat and consequently their survival.

Finally, these two examples of symbiotic interactions driven by either a plant virus or a satellite RNA indicate how organisms have coevolved evolutionary-symbiotic-interactions to ensure their survival.