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Editorial

The simplest RNA replicons, viroids: A tribute to Ricardo Flores

Dr. Ricardo Flores, a guru of viroid science, passed away from cancer in December two years ago. The journal *Virus Research* has recently invited Francesco Di Serio, Nobuhiro Suzuki and myself to organize a special issue entitled 'The simplest RNA replicons, viroids: A tribute to (the legacy of) Ricardo Flores'. This special issue is published in memory of Dr. Flores who made tremendous contributions to the field of viroid research and served as an inspiring mentor to many students and post-doctoral fellows (see Pallas et al. in this special issue). Dr. Flores has made very significant contributions on the identification, replication, pathogenesis and evolution of viroids -minimal non-protein-coding circular RNAs (250–400 nt) able to replicate and incite diseases in plants- which are the lowest step of the biological scale (Pallas et al., 2022).

Currently, viroids are classified by the International Committee Taxonomy of Viruses into two families based on differences in their replication site and strategy and in their secondary structure: *Avsunviroidae* and *Pospiviroidae.* The family *Avsunviroidae* accommodates three genera (*Avsunviroid, Elaviroid, Pelamoviroid*), to which five species are assigned (Di Serio et al., 2018). Thirty-nine species are classified in five genera (*Apscaviroid, Cocadviroid, Coleviroid, Hostuviroid, Pospiviroid*) within the family *Pospiviroidae* (Di Serio et al., 2021). Viroids, though the smallest replicons, utilize many host factors to complete their infectious cycle, from RNA replication to cell-to-cell and in-plant systemic spread. Consequently, viroids alter host cell physiology at various levels and often cause symptoms in many crops. Plant hosts perceive viroids and exert antiviroid defense, while viroids tolerate host defense responses.

The scope of this SI covers all aspects of viroid research such as viroid identification and characterization, origin and evolution, replication, pathogenesis, adaptation, and anti-viroid defense, and control measures.

Navarro et al. (2023) summarize early experiments that in the '90 allowed the identification of four new viroids in the Ricardo Flores' laboratory and highlight how some of them became valuable experimental model systems to unveil many general features of viroids.

de la Pena and Gago-Zachert (2022) discuss the origin and the evolution of some plant-infecting viroids and human-infecting deltaviruses, both of which have commonality such as the circular nature of genomic RNAs and autocatalytic ribozyme activity, from the RNA world's viewpoint.

Balázs et al. (2022) point out why the studies on a pararetroviroid, a viroid-like RNA identified by the research team directed by Ricardo Flores and existing in both RNA and DNA forms in carnation plants, marked a new paradigm in the co-evolution of plants and pathogens.

Several chapters deal with changes induced upon viroid infection. Di Serio et al. (2023) address the role of RNA silencing in plant anti-viroid defense and viroid pathogenesis. Gomez et al. (2022) review recent revelations in the relationship between viroid infection and DNA methylation-mediated changes in host transcriptome, while the potential occurrence of RNA post-transcriptional RNA modification in both viroids and viruses are investigated by Marquez-Molins et al. (2023). Li et al. (2022) show the reprograming of metabolism in an important traditional Chinese medicinal herb by infection with an apscaviroid. Sano and Kashiwagi (2022) report the role of host selective pressure on the evolution of infecting viroid populations.

In the article by Ma et al. (2022) the most relevant questions that remain to be tackled to further understand the molecular interplay between viroids and their hosts are discussed.

Carbonell (2022) reviews RNAi strategies used to control viroid infections in plants, focusing on the advantages and perspective of artificial small RNA (art-sRNA)-based tools for controlling viroid diseases.

It should be noted that one chapter features citrus tristeza virus on which Dr. Flores also worked during his career. Moreno et al. (2022) overview the biology of citrus tristeza virus (CTV), the largest (+) RNA plant RNA virus, with a focus on a virally encoded protein p23.

Research on viroids has led to seminal discoveries in plant biology. This special issue, dedicated to the memory of Dr. Ricardo Flores, presents recent progresses on various viroid studies and we strongly believe that continued significant contributions to molecular biology in general, virology and phytopathology will be made by this fascinating research field in the near future.

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