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Introduction

Pine wilt disease results from a multitude of complicated, biological organisms, that is, the pathogen, a host and an insect vector and climatic conditions. The general disease cycle for pine wilt disease in the Asian temperate zone is as follows. In early summer, the vector of the disease, the Japanese pine sawyer, *Monochamus alternatus*, which harbors the dispersal fourth-stage (dauer) juveniles of the pathogenic pine wood nematode, *Bursaphelenchus xylophilus* (PWN) in its tracheal system, emerge from dead pine trees and feed (maturation feeding) on the twigs of healthy pine trees. PWNs invade the healthy host tree through the feeding wounds made at this time. They then feed on the host's cells and multiply and eventually kill the host tree. After the death of the tree, the PWNs feed on fungi growing in the dead tree and maintain their population until the next year, while mature vectors lay eggs in recently killed trees, and the larvae which hatch from the eggs grow and become vectors the next year.

The above disease cycle seems uncomplicated; however, it includes many complicated factors. For example, PWNs kill their host trees, but their pathogenicity, (virulence), varies drastically among PWN isolates, and the resistance of host trees also varies among individuals and among species. As for dispersal of pine wilt disease, the vector preference of PWN is very narrow, that is, the beetles *Monochamus alternatus* as the primary vector and sometimes also *M. saltualius*, and dauer juveniles are formed in response to signals produced by the appropriate vectors. Certain issues such as how the PWN kills trees, the origin of their pathogenicity, how they choose vectors and what is the cue for dauer induction, remain unclear.

In this part, the disease cycle is explained, focusing on the "nematode". Basic information about the PWN, its taxonomic and systematic details and related nematode species and genera are described in Chap. 9. The genus *Bursaphelenchus*, to which the PWN belongs, varies morphologically and ecologically, and its generic definition is very wide. The evolutional process of the life history and morphology of the PWN and its relatives is discussed based on a comparison of the morphology, biology and molecular phylogeny of *Bursaphelenchus* spp. The difficulties and problems of morphological observation and morphological taxonomy of this genus are also described.

In Chap. 10, studies on the "genes" of PWN are introduced. Currently, an expressed sequence (EST tag) project is ongoing in Japan, and other EST project groups are working in other countries. To date, 13,000 EST of the PWN and 4,000 EST of *B. mucronatus*, the sister species of the PWN, are available on line. From these EST analyses, some interesting results have been found, for example, horizontal cellulase gene transmission from fungi to nematode. In this section, recent genetic information about the PWN and the future use of this information is discussed.

In Chap. 11, the life cycle of the PWN is described at the embryogenetic level. The cascade of PWN development, that is, developmental processes from sperm and egg cells to adults, is basically the same as that of *Caenorhabditis elegans*, a biological model organism; however, several characteristic patterns have been observed for the PWN. Some of the characteristic developmental features of PWN found during fertilization to early embryonic development are explained in detail.

The population ecology of the PWN within the host tree is described in Chap. 12. The PWN reproduces by feeding on the tissue of living trees and fungi growing in the dead wood. When the PWN invades healthy pine trees, whether or not they can obtain their first feeding resource, plant tissue, is determined by the balance between PWN pathogenicity and host resistance, while if the nematode enters a tree which is already dead, pathogenicity may not affect their fate. Also, there may be competition, for example, competition for food, among different populations of the PWN and among different nematode species. Regardless, pathogenicity can be a powerful tool to obtain the best feeding resources and habitat. Here, transition of the genetic structure of the PWN population during propagation is explained, focusing on the evolution of pathogenicity at the population level.

In Chap. 13, the biological (ecological) traits of the PWN are described, focusing on the vector of the PWN. There are two routes by which pine wilt disease spreads, that is, long-distance spread resulting from human transportation of PWN-infested logs and short-distance spread by vector beetles. In this section, the behavior of PWN when entering vector beetles, departure from such beetles and the invasion of host trees are noted as key factors in both kinds of disease spread. Several hypotheses about the controlling factors of nematode behavior, which are scientifically interesting, are also explained.