GLOBAL INVASIVE SPECIES DATABASE

FULL ACCOUNT FOR: ***Phytophthora ramorum***

Phytophthora ramorum **System:** Terrestrial

Kingdom	Phylum	Class	Order	Family
Fungi	Oomycota	Peronosporea	Peronosporales	Peronosporaceae

Common name sudden oak death (English), SOD (English), maladie de l'encre des ch'nes rouges (French), ramorum dieback (English), ramorum leaf blight (English), ramorum blight (English), mort subite du ch'ne (French)

Synonym

Similar species *Phytophthora cinnamomi, Phytophthora lateralis, Phytophthora nemorosa*

Summary Until 2000, Phytophthora ramorum, the causal agent of Sudden Oak Death, was undiscovered and unnamed. This water mould or oomycete is the cause of much concern in North America and Europe due to three factors: (i) the high level of local destruction it causes in California, (ii) the lack of knowledge of its epidemiology (due to its recent discovery), and (iii) its high prevalence in nurseries (which increases the potential of spread to a new location and/or country). The oomycete has an extensive host range, covering many plant genera and several families and including treees and shrubs and woody and herbaceous perennials. Phytophthora ramorum causes canker development, shoot drooping and leaf blight. Spores spread to new locations mainly by the nursery trade and are spread locally by vectors: soil, water and articles associated with humans.

view this species on IUCN Red List

Species Description

Morphology: In culture hyphae are highly branched, contorted and dendritic. Chlamydospores, produced on hyphal tips, are at first hyaline, then darken to cinnamon brown, 30-90 µm. Sporangia (a particularly diagnostic characteristic) are oval-shaped, semi-papillate, 30-90 µm, and deciduous. Oospores have not been observed.
Disease symptoms: While most temperate-climate members of the Oomycota genus *Phytophthora* are root-infesting, soil and water-bourne organisms, *P. ramorum* spreads mostly aerially and generally infests trees and plants above the soil line (including leaves, shoots, woody stems and bark). Infections on the bark develop into cankers, which produce a red/brown/black sappy exudate (a symptom referred to as \"bleeding\"). Cankers can occur on the trunk at the root crown up to 20m above the ground, but do not enlarge below the soil line into the roots. Individual cankers are delimited by thin black lines in the inner bark and can be over 2m in length. Aerial seeps not connected to the root collar are a good indication that a tree is infected by *P. ramorum* (other *Phytophthora* can cause identical seeps linked to root infections). Infections on the leaves cause spotting and browning. Infections on the twigs cause branch drooping and dieback (ANR, 2003; Garbelotto, 2004; Rizzo *et al.*, 2002b).
Please see PaDIL (Pests and Diseases Image Library) Species Content Page *Fungi: Sudden oak death* \r\n for high quality diagnostic and overview images.

Notes
Publications, management guidelines and educational resources can be assessed from:
ANR, 2003. *Marin County UCCE. Sudden Oak Death: Publications*.
Pdfs on a wide range of topics including the biology, genetics and management of SOD can be assessed from:
UC Berkeley, 2004. *Sudden Oak Death Science Symposium*

Lifecycle Stages
The oomycete develops sporangia, which hold and produce zoospores and which can be airborne. The sporangium releases zoospores once it has landed on a suitable host surface. The leaves and twigs of susceptible hosts are readily colonised by zoospores. A water film and/or warm temperatures (around 18–20°C) facilitate infection. Leaves and twigs then develop black lesions (which spread to branches in some species, causing dieback). In conditions of high humidity (close to 100%) and moderate temperature, new sporangia and resting round structures (chlamydospores) will be produced on the lesions in approximately 48 hours. Infectious propagules accumulate in the soil beneath the plant in water bodies. In the final disease phase, the main stems of tanoaks and oaks may be infected. The pathogen preferentially colonises the sugar-rich phloem of the host, only marginally colonising the outer bark and xylem. As a result of phloem colonisation a canker develops under the bark, and sappy exudates will flow outside the bark. In tanoaks multiple cankers often occur on tanoaks at different heights (thought to be caused by sporangia produced on leaves of the infected host tanoak or on the leaves of adjacent infected hosts). On the less susceptible coast live oaks cankers normally only occur near the soil line (presumably caused by the accumulation of sporangia from the leaves of adjacent infected hosts). As oak leaves are rarely colonised by *P. ramorum* re-infection from the host tree is not likely. This is why infection in oaks is epidemiologiclly linked to, and depends on, the presence of adjacent infected foliar hosts (such as bay laurel). If girdling occurs the irreversible death process is started (although it may take a year or more for browning of the tree's crown to occur). Girdling leads to the establishment of secondary organisms and opportunistic pathogens (such as wood decay fungi and canker rots) (Garbello, 2004).

Habitat Description
Reports from the USA suggest the pathogen has an optimum growth temperature of 20°C, there is no mycelial growth at greater that 30°C or at less than 2°C (Sansford, Jones and Brasier, 2003). Areas with wet climates and constant mild temperatures, resembling the central California coast are optimal to disease developement. Most sporangia production occurs during the rainy season (Garbelotto, 2004).\r\n
In North America forests of three main types are affected: mixed evergreen-bay-arbutus (dry open forest with grass and dense shrub understory), Tanoak-Douglas-fir (wet forest, often has a *Vaccinium* understory), Coast Redwood (open forest, often has a tanoak understory). In Europe the pathogen is mainly a pest species of *Rhododendron* and *Viburnum*. European countries where *Rhododendron* is affected have cool to cold winters with rain throughout the year. The pathogen therefore may be capable of establishment in other northern areas or some southern coastal Atlantic/Mediterranean areas in Europe. (The pattern of *Rhododendron* distribution may, however, reflect the movement of the infected stock) (Sansford, Jones and Brasier, 2003).

P. ramorum infects: \r\ntanoak (*Lithocarpus densiflorus*), coast live oak (*Quercus agrifolia*), black oak (*Quercus kelloggii*), Pacific huckleberry / evergreen huckleberry (*Vaccinium ovatum*), rhododendron and azalea species (*Rhododendron*), maple species (*Acer*), manzanita species (*Arctostaphylos*), Pacific madrone (*Arbutus menziesii*), California buckeye (*Aesculus californica*), California bay laurel (*Umbellularia californica*), California honeysuckle (*Lonicera hispidula*), toyon / Christmasberry (*Heteromeles arbutifolia*), California coffeeberry (*Rhamnus californica*), coast redwood (*Sequoia sempervirens*), Douglas-fir (*Pseudotsuga menziesii*), Western star flower (*Trientalis latifolia*), hybrid viburnum (*Viburnum bodnantense*) (only in cultivation), *Pieris* spp. (only in cultivation), *Camellia* spp. (only in cultivation).
For an updated list of plants reported (or suspected) to be susceptible to *P. ramorum* please see: \r\nPPQ, 2004. *List of Hosts and Plants Associated with Phytophthora ramorum*

Reproduction
Phytophthora ramorum produces large amounts of asexual infectious swimming propagules (zoospores) in oval-shaped sporangia, as well as producing hard, round, resting propagules (chlamydospores). To complete its sexual cycle *P. ramorum* requires individuals bearing two mating types (A1 and A2). In nature in North America only A2 individuals have been reported, while - with a single exception - only A1 have been reported from nursery or nursery-linked infections in Europe (as of April 2004) (Garbelotto, 2004).

General Impacts
There are two categories of hosts for *Phytophthora ramorum*, each of which are susceptible to the pathogen in different organs: bark canker hosts and foliar hosts. Bark canker hosts become infected on their trunks. In highly susceptible species (tanoaks and to a lesser extent oaks) cankers eventually girdle the tree, resulting in starvation and death. Mortality may occur in as short a timespan as two years. Foliar hosts become infected on their leaves and twigs. Leaf infection is accompanied by branch infections and branch dieback in some foliar hosts (for example, rhododendrons, Pacific madrone, Pacific huckleberry and Toyon / Christmasberry); in other foliar hosts only leaves are affected (for example, bay laurel, maples and buckeye). Foliar hosts only occaasionally die from infection. (Tanoaks belong to both host categories as they may develop bark and/or foliar infections. Foliar infections are common in young tanoaks and result in leaf blight and the killing of the plant from the \"top down\") (ANR, 2003; Garbelotto, 2004).
Many plants within the host range of the oomycete are grown for economic gain or have environmental or social valued. Tanoak, coast live oak and black oak in USA hardwood forests infected with the oomycete die in a short period of time following the onset of symptoms. Oak plays an important role in European natural ecosystems, especially forest and savanna-woodland ecosystems. It can be found in parks and open countrysides. It has been estimated that there are about 200 million oak trees in the UK and their loss from could have a major impact on soil erosion, hydrology, sedimentation in rivers in certain areas. Other possible effects include loss of associated organisms (biodiversity) and a negative impact on tourism, cultural history and local woodland economies (Braisier, 2000a, unpub., in Sansford, Jones and Brasier, 2003).

Management Info
Preventative measures: Preventing the introduction of *Phytophthora ramorum* into new areas should be the first priority when managing Sudden Oak Death (SOD). This entails identifying the likely sources of infection. In order of importance these sources are live plants (especially those supporting sporulation), green waste, soil and water, debarked untreated wood, entire logs and firewood. Quarantine and sanitation measures for nursery plants, wood products and soil associated with infestation sites should be employed to prevent both long and short distance spread. \r\n
Drenth *et al*. 2006 describe the development and validation of a DNA-based diagnostic assay that can detect and identify 27 different *Phytophthora* species. Belbahri *et al* (2007) report that the \"new specific hybridization probes for a real-time PCR amplification method\" they developed for early detection of *P. ramorum* is found to be rapid, robust and labour-saving, and has proved suitable for routine use in a molecular diagnostic laboratory. Please follow this link *managing Phytophthora ramorum* for detailed management options.

Pathway
In the case of Europe interregional transport of the disease appears to have already occurred due through the trading and sales of ornamental plants (Garbelotto, 2004). Infected plants have been found in nurseries in Europe and the USA. *P. ramorum* could be spread to new countries by the nursery trade.
The combined microsatellite, sequencing and morphological analyses by Ivors *et al.* (2006) suggest the 151 isolates analysed clustered in three clades, represent distinct evolutionary lineages. All three clades were identified in some US nurseries, emphasizing the role of commercial plant trade in the movement of this pathogen. Movement of contaminated soil (or other habitat material) may spread the pathogen. The leaves of susceptible hosts may become infected when splashed with infected soil (Garbelotto, 2004). How *P. ramorum* originally entered Europe and the USA is unknown, but the seperate clades (a clade is defined as a group of species that share a common ancestor, which is not shared by another species outside of the clade) are of different mating types (A1 and A2 respectively) and appear to be from distinct genetic lineages, suggesting the pathogen is from a third location (with both mating types and representations of both lineages) (Garbelotto, 2004).

Principal source: Sansford, Jones and Brasier, 2003. *Pest Risk Analysis: Phytopthora ramorum*.
Garbelotto, 2004. *Sudden Oak Death: A Tale of Two Continents.*

Compiler: National Biological Information Infrastructure (NBII) & IUCN/SSC Invasive Species Specialist Group (ISSG)

Review: Anon

Pubblication date: 2008-05-28

ALIEN RANGE

[1] BELGIUM
[1] DENMARK
[1] FRANCE
[1] IRELAND
[1] NEW ZEALAND
[1] SLOVENIA
[1] SWEDEN
[3] UNITED STATES
[1] CANADA
[1] EUROPE
[1] GERMANY
[1] NETHERLANDS
[1] POLAND
[1] SPAIN
[2] UNITED KINGDOM

BIBLIOGRAPHY

48 references found for **Phytophthora ramorum**

Managment information
Agriculture and Natural Resources (ANR). 2003. *Marin County UCCE: Sudden oak Death Hosts and Symptoms*. University of California: California.
Summary: Available from: http://cemarin.ucdavis.edu/symptoms.html [Accessed 12 January 2005]
Animal and Plant Health Inspection Service (APHIS), 2004. Press Release: USDA takes action in three states to halt spread of plant fungus.
Summary: Press release on latest quarantine measures to prevent spread of Sudden Oak Death.
Belbahri, L., G. Calmin, S. Wagner, E. Moralejo, S. Woodward and F. Lefort., 2007. Specific hybridization real-time PCR probes for *Phytophthora ramorum* detection and diagnosis. Forest Pathology Volume 37, Issue 6, December 2007 pages 403–408
Drenth, A, G. Wagels, B. Smith, B. Sendall, C. O'Dwyer, G. Irvine and J. A. G. Irwin., 2006. Development of a DNA-based method for detection and identification of *Phytophthora* species *Australasian Plant Pathology*, 2006, 35, 147–159
Summary: Available from: http://www.publish.csiro.au/?act=view_file&file_id=AP06018.pdf [Accessed 21 March 2006]
Garbelotto, M. 2004. Sudden Oak Death: A Tale of Two Continents, *Outlooks on Pest Management*: 85 - 89.
Summary: Available from: http://cemarin.ucdavis.edu/pdf%20files/PesticideOutlook.pdf [Accessed 12 January 2005]
Ivors, K., Garbelotto, M., Vries, I. D. E., Ruyter-Spira, C., Hekkert, B. Te., Rosenzweig, N. & Bonants, P., 2006. Microsatellite markers identify three lineages of *Phytophthora ramorum* in US nurseries, yet single lineages in US forest and European nursery populations. Molecular Ecology 15 (6), 1493-1505

Liberato J.R, O'Brien J.G & Werres S 2006. Sudden oak death (*Phytophthora ramorum*) Pest and Diseases Image Library. Updated on 5/10/2006 12:24:14 PM.
Summary: Available from: http://www.padil.gov.au/pests-and-diseases/Pest/Main/136615 [Accessed 7 December 2011]
Manter, D. K., Karchesy, J. J. & Kelsey, R. G., 2006. The sporicidal activity of yellow-cedar heartwood, essential oil and wood constituents towards *Phytophthora ramorum* in culture. Forest Pathology 36 (5), 297-308.
NIDirect, 2011. Preventing the spread of tree disease
Summary: Available from: http://www.nidirect.gov.uk/index/information-and-services/leisure-home-and-community/leisure-and-recreation/outdoor-recreation/preventing-the-spread-of-tree-disease.htm [Accessed September 2 2011]
PPQ (Plant Protection and Quarantine). 2006. *Emergency and Domestic Programs: Phytophthora ramorum*. USDA (United States Department of Agriculture) APHIS (Animal and Plant Health Inspection Service).
Summary: Available from: http://www.aphis.usda.gov/ppq/ispm/pramorum/ [Accessed 26 May 2006]
Sansford, C., Jones, D. and Brasier, C. 2003. *Pest Risk Analysis: Phytopthora ramorum*. Department for Environment Food and Rural Affairs: London.
Summary: Available from: http://www.defra.gov.uk/planth/pra/sudd.pdf [Accessed 12 January 2005]
Swain, S., Harnik, T., Mejia-Chang, M., Hayden, K., Bakx, W., Creque, J. & Garbelotto, M. 2006. Composting is an effective treatment option for sanitization of *Phytophthora ramorum*-infected plant material. Journal of Applied Microbiology 101 (4), 815-827.
United States Government Accountability Office (GAO) GAO-06-353 Report, April 21, 2006. Invasive Forest Pests: Lessons Learned from Three Recent Infestations May Aid in Managing Future Efforts.
Summary: Invasive forest pests have seriously harmed our environment and imposed significant costs upon our economy. The U.S. Department of Agriculture (USDA) is the lead agency for responding to forest pests. This report evaluates the federal response to three invasive forest pests'the Asian longhorned beetle, the emerald ash borer, and the pathogen Phytophthora ramorum (P. ramorum).Specifically, GAO describes (1) the status of efforts to eradicate these species, (2) the factors affecting the success of those efforts, (3) overall forest health monitoring programs, (4) coordination and communication of the three pest response efforts, and (5) USDA's use of panels of scientific experts to aid in the response efforts.
Available from: http://www.gao.gov/new.items/d06353.pdf [Accessed 20 May 2006]

General information

Aldhous, J.R. 2004. *Phytophthora ramorum* - The current position of *Ramorum* Dieback Disease and Sudden Oak Death Disease. *Scottish Forestry*. 58(1). 3, 5-7.
Cree, L.A. 2001. Pest fact sheet: *Phytophthora ramorum*. *Canadian Food Inspection Agency*.
Summary: This fact sheet details the identification, life history, distribution, and control measures for the species in California and Oregon.
Available from: http://www.inspection.gc.ca/english/plaveg/protect/facren/sodfacte.pdf
Davidson, J. M., D. M. Rizzo, and M. Garbelotto. 2002. *Phytophthora ramorum* and Sudden Oak Death in California: II. Pathogen transmission and survival. Pp. 741-749 In: 5th Symposium on California Oak Woodlands, R. Standiford and D. McCreary, eds., *USDA Forest Service*, Gen. Tech. PSW-GTR-184
Davidson, J. M., Garbelotto, M., Koike, S. T and Rizzo, D. M. 2002. First report of *Phytophthora ramorum* on Douglas-fir in California. *Plant Disease*. 86(11). 1274.
De Merlier, D., Chandelier, A and Cavelier, M. 2003. First report of *Phytophthora ramorum* on Viburnum bodnantense in Belgium. *Plant Disease*. 87(2). 203.
Department for Environment, Food and Rural Affairs (DEFRA), United Kingdom. *Fact Sheet*.
Summary: Fact sheet with a general description of infested trees, methods of spread, and distribution.
Available from: http://www.defra.gov.uk/planth/pramorum.htm
Garbelotto, M., D. M. Rizzo, and L. Marais. 2002. *Phytophthora ramorum* and Sudden Oak Death in California: IV. chemical control. Pp. 811-818. In: 5th Symposium on California Oak Woodlands, R. Standiford and D. McCreary, eds., *USDA Forest Service*, Gen. Tech. PSW-GTR-184.
Garbelotto, M., D. M. Rizzo, K. Hayden, J. M. Davidson, and S. Tjosvold. 2002. *Phytophthora ramorum* and Sudden Oak Death in California: III. Pathogen genetics. Pp. 765-774 In: 5th Symposium on California Oak Woodlands, R. Standiford and D. McCreary, eds., *USDA Forest Service*, Gen. Tech. PSW-GTR-184.
Goheen, E. M., E. M. Hansen, A. Kanaskie, M. G. McWilliams, N. Osterbauer, and W. Sutton. 2002. Sudden oak death, caused by *Phytophthora ramorum*, in Oregon. *Plant Disease* 86:441.
Hansen, E.M., Reeser, P.W., Davidson, J.M., Garbelotto, M., Ivors, K., Douhan, L. and Rizzo, D.M. 2003a. *Phytophthora nemorosa*, a new species causing cankers and leaf blight of forest trees in California and Oregon, USA, *Mycotaxon 88*: 129 - 138.
Hansen, E. M., Reeser, P. W., Davidson, J. M., Garbelotto, M., Ivors, K., Douhan, L and Rizzo, D. M. 2003. *Phytophthora nemorosa*, a new species causing cankers and leaf blight of forest trees in California and Oregon, U.S.A. *Mycotaxon*. 2003. 129-138.
Hansen, E.M., Reeser, P.W., Sutton, W., Winton, L.M and Osterbauer, N. 2003b. First report of A1 mating type of *Phytophthora ramorum* in North America, *Plant Disease 87*(10): 1267.
Hansen, E. M., Reeser, P. W., Sutton, W., Winton, L. M and Osterbauer, N. 2003. First report of A1 mating type of *Phytophthora ramorum* in North America. *Plant Disease*. 87(10). 1267.
Huberli, D., Reuther, K. D., Smith, A., Swain, S., Tse, J. G and Garbelotto, M. 2004. First report of foliar infection of *Rosa gymnocarpa* by *Phytophthora ramorum*. *Plant Disease*. 88(4). 430.
Huberli, D., Van Sant-Glass, W., Tse, J. G and Garbelotto, M. 2003. First report of foliar infection of starflower by *Phytophthora ramorum*. *Plant Disease*. 87(5). 599.
Inman, A. J., Townend, V. C., Barnes, A. V., Lane, C. R., Hughes, K. J. D., Griffin, R. L and Eales, S. J. 2003. First report of *ramorum* dieback *(Phytophthora ramorum)* on Pieris in England. *Plant Pathology* (Oxford). 52(6). 785.
Kroon, Laurens P. N. M., Verstappen, Els C. P., Kox, Linda F. F., Flier, Wilbert G and Bonants, Peter J. M. 2004. A rapid diagnostic test to distinguish between American and European Populations of *Phytophthora ramorum*. *Phytopathology*. 94(6). 613-620.

Lane, C. R., Beales, P. A., Hughes, K. J. D., Griffin, R. L., Munro, D., Brasier, C. M and Webber, J. F. 2003. First outbreak of *Phytophthora ramorum* in England, on *Viburnum tinus*. *Plant Pathology* (Oxford). 52(3). 414.
Maloney, P. E., D. M. Rizzo, S. T. Koike, T. Y. Harnik, and M. Garbelotto. 2002. First report of *Phytophthora ramorum* on coast redwood in California. *Plant Disease* 86:1274.
Martin, Frank N., Tooley, Paul W and Blomquist, Cheryl. 2004. Molecular detection of *Phytophthora ramorum*, the causal agent of sudden oak death in california, and two additional species commonly recovered from diseased plant material. *Phytopathology*. 94(6). 621-631.
Moralejo E. and S. Werres (2002). First Report of *Phytophthora ramorum* on *Rhododendron* spp. in Spain. *Plant Dis.* 86: 9, 1052.
Murphy, S. K and Rizzo, D. M. 2003. First report of *Phytophthora ramorum* on canyon live oak in California. *Plant Disease*. 87(3). 315.
Orlikowski L.B., Szkuta G. (2002): First record of *Phytophthora ramorum* in Poland. *Phytopathologia Polonica* 25: 69-79
Orlikowski, Leszek B. 2003. Development and spread of *Phytophthora ramorum* in the presence of grapefruit extract. *Journal of Plant Protection Research*. 43(3). 213-218.
Plant Health, DEFRA/Forestry Commission. 2002 *News Release.*
Summary: News release and FAQ about the incidence of the American strain of sudden oak death in England nurseries. Available from: http://www.defra.gov.uk/news/2002/020503bquanda.htm
Rizzo, D.M., Garbelotto, M., Davidson, J.M., Slaughter, G.W. and Koike, S.T. 2002a. *Phytophthora ramorum* and Sudden Oak Death in California: I. Host Relationships. In Standiford, R. and McCreary, D. (eds.) *5th Symposium on California Oak Woodlands*: 733 - 740. USDA Forest Service.
Rizzo, D.M., Garbelotto, M., Davidson, J.M., Slaughter, G.W. and Koike, S.T. 2002b. *Phytophthora ramorum* as the cause of extensive mortality of *Quercus* spp. and *Lithocarpus densiflorus* in California, *Plant Disease 86*: 205 - 214.
Rizzo, D. M., Garbelotto, M., Davidson, J. M., Slaughter, G. W and Koike, S. T. 2002. *Phytophthora ramorum* as the cause of extensive mortality of *Quercus spp*. and *Lithocarpus densiflorus* in California. *Plant Disease*. 86(3). 205-214.
Rizzo, D. M., M. Garbelotto, J. M. Davidson, G. W. Slaughter and S. T. Koike. 2002. *Phytophthora ramorum* and Sudden Oak Death in California: I. Host Relationships. Pp. 733-740 In: 5th Symposium on California Oak Woodlands, R. Standiford and D. McCreary, eds., *USDA Forest Service*, Gen. Tech. PSW-GTR-184.
Slawson, D. 2003. *Phytophthora ramorum - Situation in the UK and EU*
Summary: Available from: http://www.defra.gov.uk/planth/phnews/ukandeu.pdf [Accessed 12 January 2005]
Themann, Karin., Werres, Sabine., Luettmann, R and Diener, H. A. 2002. Observations of *Phytophthora* spp. in water recirculation systems in commercial hardy ornamental nursery stock. *European Journal of Plant Pathology*. 108(4). 337-343
Varela, C. Pintos., Vazquez, J. P. Mansilla and Casal, O. Aguin. 2003. First report of *Phytophthora ramorum* on *Camellia japonica* in Spain. *Plant Disease*. 87(11). 1396.
Werres, Sabine and De Merlier, Daphne. 2003. First detection of *Phytophthora ramorum* mating type A2 in Europe. *Plant Disease*. 87(10). 1266.
Werres, Sabine., Marwitz, Rainer., Man in t Veld, Willem A., De Cock, Arthur W. A. M., Bonants, Peter J. M., De Weerdt, Marjanne., Themann, Karin., Ilieva, Elena and Baayen, Robert P. 2001. *Phytophthora ramorum spp*. nov., a new pathogen on *Rhododendron* and*Burnum*. *Mycological Research*. 105(10). 1155-1165.
Werres S., Marwitz R., Man in t Veld W.A., De Cock A.W.A.M., Bonants P.J.M., De Weerdt M., Themann K., Ilieva E. und R.P. Baayen (2001): *Phytophthora ramorum* sp. *nov*., a new pathogen on *Rhododendron* and *Viburnum*. *Mycological Research* 105 (10), 1155-1165.