

## Common Needle, Shoot, Branch and Stem Diseases of Conifer Trees in Bhutan

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**Extended abstract** – Bhutan is a small, landlocked, densely forested country in the South-Eastern Himalayas (FAO 1999, 2001). Forests are of immense importance for the ecology, economy and social well-being of this country and for the livelihood of its people. In mountainous areas at elevations between about 2100 and 4200 m asl., temperate conifer forests form the natural vegetation in this part of the Himalayas. These forests occupy about 24% of the total area of Bhutan and they consist mainly of Eastern Himalayan fir (*Abies densa*), Eastern Himalayan spruce (*Picea spinulosa*), Himalayan hemlock (*Tsuga dumosa*) and Himalayan Blue pine (*Pinus wallichiana*) (Grierson – Long 1983, Rosset 1999). Other conifers and various broadleaved tree species (*Rhododendron* spp., *Betula* spp., *Populus* spp., *Acer* spp., *Sorbus* spp. and *Salix* spp.) are often admixed to the aforementioned major conifer species or sometimes dominate forest stands on specific sites (Grierson – Long 1983, Rosset 1999). Another important conifer in Bhutan is Chir pine (*Pinus roxburghii*), which occurs mainly in sub-tropical and warm temperate forests (Grierson – Long 1983). This pine does, however, not form part of cold temperate conifer forests.

In the 1980's conifer forests in Bhutan were affected by two serious, large-scale forest health problems, namely decline of fir (*Abies densa*) (Donaubauer 1986, 1987, 1993, Ciesla – Donaubauer 1994) and outbreaks of the bark beetles *Ips schmutzenhoferi* on *P. spinulosa* and *P. wallichiana* and *Ips longifolia* on *P. roxburghii* (Schmutzenhofer 1987a, 1987b, 1988, Holzschuh 1988, Tshering – Chhetri 2000, Kirisits et al. 2002). Fir decline and bark beetle outbreaks have for the first time shown that diseases, insect pests and abiotic damaging factors can pose a great threat to the forests of this Himalayan country and can greatly upset the aims of forest management and conservation. These two forest health problems were also the starting point for research in forest entomology, forest pathology and forest protection in Bhutan and mark the begin of the collaboration between Bhutan and Austria in these fields. Following research and training activities in the 1980's, collaboration in forest pathology and

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forest protection between Austria and Bhutan has been continuing since 2001 as part of the Conifer Research and Training Partnership (CORET, <http://woek.boku.ac.at/coret/>) between the University of Natural Resources and Applied Life Sciences, Vienna (BOKU), Austria and Renewable Natural Resources (RNR) Forest Research of Bhutan, in which scientists from the Forestry and Agricultural Biotechnology Institute (FABI) of the University of Pretoria, South Africa also participate.

Surveys and studies, starting in the 1980's greatly increased knowledge about diseases and insect pests of conifer trees in Bhutan (e. g. Donaubaue 1986, 1987, 1993, Schmutzenhofer 1987a, 1987b, 1988, Chhetri 1990, 1995, Schieler 1992, Ciesla – Donaubaue 1994, Nedomlel 1995, Rosset 1999, Tshering – Chhetri 2000, Kirisits et al. 2002, 2007, Van Wyk et al. 2004, Coetzee et al. 2005, Konrad 2006, Dorji 2007, Barnes et al. in press). These studies helped to define potential threats of conifers and resulted in suggestions for integrated disease and pest management. Here, we provide an overview on common needle, shoot, branch and stem diseases of conifer trees in Bhutan, based on the work conducted during the past 25 years.

The most important pathogen of *Pinus wallichiana* is Himalayan dwarf mistletoe (*Arceuthobium minutissimum*) (Hawksworth – Wiens 1996). This minute parasitic plant is widespread and very damaging in dry Blue pine forests in Western Bhutan (districts Paro, Ha and Thimphu) (Donaubaue 1986, Chhetri 1990, 1995, Tshering – Chhetri 2000, Kirisits et al. 2002, Dorji 2007). *Taxillus kaempferi*, a leafy mistletoe, also commonly infects Blue pine in Western and Central Bhutan (Donaubaue 1986, Chhetri 1990, Kirisits et al. 2002, Dorji 2007). This mistletoe also occurs on *Tsuga dumosa* and *Picea spinulosa* (Grierson – Long 1983, Donaubaue 1986). Blister rust on branches and stems of Blue pine, caused by *Cronartium ribicola* or a related species occurs occasionally on young trees (Donaubaue 1987, Chhetri 1990, Kirisits et al. 2002). Needle diseases of *P. wallichiana* include Dothistroma needle blight caused by *Dothistroma septosporum* (Barnes et al. in press), needle rust caused by a *Coleosporium* sp. (Donaubaue 1987), needle cast caused by a *Rhizosphaera* sp. and infestation by sooty moulds. Hysterothecia of *Lophodermium* spp. are common on Blue pine needles (Kirisits et al. 2002), but the species have not yet been determined. *Lophodermium* spp. may be endophytes or saprophytes becoming apparent on needles affected by other needle pathogens. There are also records of a needle cast caused by cf. *Meloderma desmazierii* on *P. wallichiana* (Donaubaue 1986, Chhetri 1990). Needle rust, caused by a *Coleosporium* sp. (Chhetri 1990) and *Lophodermium* spp. have also been documented on *P. roxburghii*.

*Picea spinulosa* is affected by Sichuan dwarf mistletoe (*Arceuthobium sichuanense*), which has been recorded only from the districts Ha and Paro in Western Bhutan (Donaubaue 1987, Hawksworth – Wiens 1996, Tshering – Chhetri 2000, Dorji 2007). This dwarf mistletoe is much less prevalent than *A. minutissimum* on Blue pine and has thus far not caused economic damage (Donaubaue 1987, Dorji 2007). Sirococcus shoot blight, caused by the P type of *Sirococcus conigenus* was found for the first time on *P. spinulosa* in 2001 and this record also represented the first report of the disease and the associated pathogen from anywhere in Asia (Kirisits et al. 2002, 2007, Konrad 2006). At higher elevations, current-year spruce shoots frequently suffer from infection by a rust fungus resembling *Chrysomyxa woroninii*, which causes hypertrophy, intense yellowing and finally death of shoots (Donaubaue 1987, Kirisits et al. 2002). A second *Chrysomyxa* sp. causes needle rust, with symptoms and signs resembling those of needle rust diseases of other spruce species in the Northern hemisphere (Kirisits et al. 2002).

The most important forest health problem of *Abies densa* is a syndrome known as fir decline (Donaubaue 1986, 1987, 1993, Ciesla – Donaubaue 1994). In the 1980's numerous stands over an extensive area in Western Bhutan were affected and at many sites a large

portion, if not virtually all trees were killed. This dramatic fir decline was explained as a complex / decline disease (Ciesla – Donaubaauer 1994), with prolonged drought and probably also frost as the main inciting factors and various biotic agents (stem and root rot fungi) as predisposing and/or contributing factors (Donaubaauer 1986, 1987, 1993, Ciesla – Donaubaauer 1994). Little is known about needle, shoot, branch and stem diseases of *Abies densa*. Needle blight caused by a fungus resembling *Lirula nervisequia* was prevalent in the 1980's (Donaubaauer 1987). Trees of all age classes and especially also old trees were affected by this needle blight. Needle rust, caused by an undetermined rust fungus was observed once during the disease survey in 2001 (Kirisits et al. 2002).

Few, if any diseases have thus-far been documented on other temperate conifer trees in Bhutan. A needle cast caused by *Rhizosphaera* sp. occurs on *Tsuga dumosa* (Donaubaauer 1987), and anecdotal reports suggest the occurrence of juniper rust (caused by *Gymnosporanium* sp.) on Black juniper (*Juniperus pseudosabina*) and Weeping blue juniper (*Juniperus recurva*). The latter is supported by the occurrence of *Gymnosporangium* spermogonia and aecia on wild apple (*Malus* sp.) trees. No diseases have been recorded on Eastern Himalayan larch (*Larix griffithiana*), Sargent spruce (*Picea brachytyla*), Bhutan pine (*Pinus bhutanica*) and Yew (*Taxus baccata*).

Results of the disease surveys since the 1980's form the basis for future surveys and studies on diseases of conifer trees in Bhutan. Our ultimate goal will be to publish a guide to important and/or common diseases affecting conifers in this Himalayan country. This guide would be a useful tool in facilitating the diagnosis, prevention and management of tree disease problems. It would also be helpful for the training of students and forestry staff in Bhutan to increase their knowledge and understanding in forest pathology. As the main objective of CORET is the education of Bhutanese scholars, researchers and practitioners and thus human capacity building in various disciplines of forest science, this guide would also immensely contribute to the success of this partnership program between Austria and Bhutan.

**forest pathology / forest protection / disease survey / *Pinus wallichiana* / *Picea spinulosa* / *Abies densa***

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## REFERENCES

- BARNES, I. – KIRISITS, T. – AKULOV, A. – CHHETRI, D.B. – WINGFIELD, B.D. – BULGAKOV, T.S. – WINGFIELD, M.J. (in press): New host and country records of the Dothistroma needle blight pathogens from Europe and Asia. For. Path.
- CHHETRI, D. B. (1990): Some tree diseases and insect pests of forests of Bhutan. Tsenden 2/1 (1990): 72-79.
- CHHETRI, D. B. (1995): Observation trial on dwarf mistletoe infestation on Blue pine. Tsenden 5/1 (1995): 22-24.
- CIESLA, W. M. – DONAUBAUER, E. (1994): Decline and dieback of trees and forests. A global overview. Food and Agriculture Organization of the United Nations, Rome, Italy. FAO Forestry Paper 120. 90 p.
- COETZEE, M. P. A. – WINGFIELD, B. D. – KIRISITS, T. – CHHETRI, D. B. – BLOOMER, P. – WINGFIELD, M. J. (2005): Identification of *Armillaria* isolates from Bhutan based on DNA sequence comparisons. Plant Path. 54: 36-45.

- DONAUBAUER, E. (1986): Technical advisory services for forest development, Bhutan, Forest Pathology. Department of Forests, Ministry of Trade, Industry and Forests, Thimphu, Bhutan and Food and Agriculture Organization of the United Nations, Rome, Italy. FO/DP/BHU/83/022. Field Document 11. 37 p.
- DONAUBAUER, E. (1987): Technical advisory services for forest development, Bhutan, Forest Pathology. Department of Forests, Ministry of Trade, Industry and Forests, Thimphu, Bhutan and Food and Agriculture Organization of the United Nations, Rome, Italy. FO/DP/BHU/83/022. Field Document 12. 14 p.
- DONAUBAUER, E. (1993): On the decline of fir (*Abies densa* Griff.) in Bhutan. In: Huettl, R. F. – Mueller-Dombois, D. (eds.): Forest Decline in the Atlantic and Pacific Region. Springer-Verlag, Berlin/Heidelberg, Germany, New York, USA. 332-339.
- DORJI, S. (2007): Himalayan dwarf mistletoe (*Arceuthobium minutissimum*) and the leafy mistletoe *Taxillus kaempferi* on Blue pine – a case study in Western Bhutan. University of Natural Resources and Applied Life Sciences, Vienna (BOKU), Austria. Diploma thesis. 127 p.
- FAO (1999): Forest Resources of Bhutan – Country report. Food and Agriculture Organization of the United Nations, Rome, Italy. Forest Resources Assessment Programme (FRA). Working Paper 14. 71 p.
- FAO (2001): Global Forest Resources Assessment 2000 – Main report. Food and Agriculture Organization of the United Nations, Rome, Italy. FAO Forestry Paper 140. 479 p.
- GRIERSON, A. J. C. – LONG, D. G. (1983): Flora of Bhutan. Royal Botanic Garden, Edinburgh, UK. Volume 1, Part 1, 186 p.
- HAWKSWORTH, F. G. – WIENS, D. – GEILS, B. W. (techn. ed.) – NISLEY, R. G. (manag. ed.) (1996): Dwarf mistletoes: Biology, pathology and systematics. U. S. Department of Agriculture, Forest Service, Washington, D. C. Agriculture Handbook 709. 410 p.
- HOLZSCHUH, C. (1988): Eine neue Art der Gattung *Ips* aus Bhutan (Coleoptera, Scolytidae) [A new species in the genus *Ips* from Bhutan (Coleoptera, Scolytidae)]. Entomologica Basiliensia 12: 481-485.
- KIRISITS, T. – WINGFIELD, M. J. – CHHETRI, D. B. (2002): Studies on the association of blue-stain fungi associated with the Eastern Himalayan spruce bark beetle (*Ips schmutzenhoferi*) and with other bark beetles in Bhutan. Renewable Natural Resources Research Centre, Yusipang, Bhutan. Yusipang Report, YREP/2002/02. 88 p. (<http://woek.boku.ac.at/coret/research/YREP-2002-02.pdf>).
- KIRISITS, T. – KONRAD, H. – HALMSCHLAGER, E. – STAUFFER, C. – WINGFIELD, M. J. – CHHETRI, D. B. (2007): Sirococcus shoot blight on *Picea spinulosa* in Bhutan. For. Path. 37: 40-50.
- KONRAD, H. (2006): Molecular ecology of forest pathogens causing Dutch elm disease, blue-stain and Sirococcus shoot blight. University of Natural Resources and Applied Life Sciences, Vienna (BOKU), Austria. Dissertation. 57 p + appendix (individual papers).
- NEDOMLEL, C. (1995): Forest pathological characterisation of *Abies densa* in the integrated forest management project area. Royal Government of Bhutan, Ministry of Agriculture, Department of Forestry, Thimphu, Bhutan and ADC & FALCH Austria, Austrian Association for Development and Cooperation, Vienna, Austria. 53 p.
- ROSSET, J. (1999): Temperate conifer forests of Bhutan: A review of forestry research activities until June, 1998. Renewable Natural Resources Research Centre, Jakar, Bhutan. Special Publication No. 3. 95 p.
- SCHIELER, K. (1992): Local Forest Inventory: Bumthang, Wangtha-la – Thrumsing-la. Volume 2 – Results. ADC – EH 111/90, Integrated forest Management Project (IFMP) Wangtha-la-Thrumsing-la, Ura. 37 p. + Appendix 1, 2 and 3 (18 maps).
- SCHMUTZENHOFER, H. (1987a): Emergency assistance in controlling forest destruction by bark beetles – consultancy in forest entomology. FAO Field Document 2, TCP/BHU/6654. Food and Agriculture Organization of the United Nations, Rome, Italy. 10 p. + appendices I-III.
- SCHMUTZENHOFER, H. (1987b): Emergency assistance in controlling forest destruction by bark beetles, part II – consultancy in forest entomology. FAO Field Document 3, TCP/BHU/6654. Food and Agriculture Organization of the United Nations, Rome, Italy. 12 p. + appendices I-III.
- SCHMUTZENHOFER H. (1988) Mass outbreaks of *Ips* bark beetles in Bhutan and the revision of the genus *Ips* de Geer for the Himalayan region. In: Payne, T.L. – Saarenmaa, H. (eds.): Integrated control of Scolytid bark beetles. Proceedings of the IUFRO working party and XVII. International Congress of Entomology Symposium, “Integrated control of Scolytid bark beetles”. Vancouver, B. C., Canada. July 4, 1988. 345-355.

- TSHERING, G. – CHHETRI, D. B. (2000): Important forest insect pests and diseases of Bhutan with control measures. Renewable Natural Resources Research Centre, Yusipang, Bhutan and Natural Resources Training Institute, Lobesa, Bhutan. MoA, Field Guide 2000/1. 57 p.
- VAN WYK, M. – ROUX, J. – BARNES, I. – WINGFIELD, B. D. – CHHETRI, D. B. – KIRISITS, T. – WINGFIELD M. J. (2004): *Ceratocystis bhutanensis* sp. nov., associated with the bark beetle *Ips schmutzenhoferi* on *Picea spinulosa* in Bhutan. Stud. Mycol. 50: 365-379.