Natural Resources Management in Mountainous Areas II Forest Protection

POSTGRADUATE CURRICULUM IN MOUNTAIN FORESTRY AT BOKU IN 2012
Structure of NRM II

• Lecture with practical component
  – Forest Pathology: diseases & abiotic damages
  – Forest Entomology: forest pests
• Excursion
• Seminar presentation
Objectives

• provide a comprehensive overview about insect pests in mountain forests and afforestations at high altitudes

• students shall develop essential skills to understand specific host-insect-environment-relationships
> 50% of the species are insects

Wilson 1993 The Diversity of Life. Norton &. NY
>75% of the animals are insects

Wilson 1993 The Diversity of Life. Norton &, NY
**Tetramorium caespitum–impurum group**

- Myrmicinae
- most common ant in Paelarctics
- nests huge with up to 100 000 ants (monogyn)
- aggressive ant species
Cryptic diversity

1200bp COI

Morphologie

CHC

T. caespitum

T. impurum

T. caespitum

T. hungaricum

T. sp.A

T. sp.B

T. sp.C

T. sp.D

T. sp.E

Schlick-Steiner et al. 2006 Mol Phylo Evol
Steiner et al. 2002 J Chem Ecol
Soup of Melolontha larvae
Bombyx - wok
Chocolate Tenebrio larvae

Bon appetit
Excercise makes the Master.....
Appear as Pest

Scolytids

Cockchafer
or Natural Enemies

Ladybirds

Checkered Beetles
Polymorphism in all ontogenetic stages
Damage of a sternorrhynchan species - family adelgidae

Damage of a hymenopteran Symphyta – family Tenthredinidae

Gallery system (frass) from a bark beetle species - genus *Ips*

Insect pests
Epidemiology of forest pests

- pre-disposition of the tree
- attraction
- resistance
- stress quality intensity - dynamic
- genet. status
- climate exposition altitude
- soil
- age
- population dynamics
- aggressivity
- abundance
- antagonists competitors
- genetic status
- voltinism

Nutritional quantity and quality of the tree
**Forest entomology** concerns the study of all insect species and related arthropods that inhabit and interact in forest ecosystems and the management of insect pests that cause the degrading, defoliation, crown dieback, and death of trees.

The scope of forest entomology is wide and encompasses a large area which includes:

1) the **documentation** of all insect species and related arthropods within natural and man-made forests, and the study of the biology and ecology of these species

2) .....
2) the **description and assessment of damage** to tree structures (ie. roots, bark, cambium, sapwood, heartwood, foliage, capsules, seeds), to whole forest stands and to wood products and timber in service

3) **eradication** of recently introduced pests, or **long-term management** of established exotics and of indigenous pests, to minimise losses in wood quality and wood production, and to reduce tree mortality

4) **assessments of forest operations**, or of management impacts, on the invertebrate fauna (insects, related arthropods and other invertebrates eg. annelid worms), and the alleviation of any adverse effects on these invertebrates
Given that forest types can range from snow covered alpine to tropical rain forests, in addition to all the man-made forests of pine and eucalypts with their different climatic conditions from site to site, it is understandable that both the documentation of insect species alone and the scope of forest entomology are immense.
**Diagnosis** determination of pests & diseases – to recognise causal connection among changes (physiol. or e.g. decrease of wood growth) – is it serious or timely restricted?

**Symptoms** macro- or microscopic, chemical or physiol. effect – can be specific and less specific

**Prognosis** to foresee the occurrence and the development of a pest or disease
Some examples for internet-links

**CAB-International**
cabi.org/Corporate/Index.aspiff.boku

**IUFRO**
iufro.boku.ac.at/iufro/

**FAO**
http://www.fao.org/forestry/index.jsp

**e.g.**

**WSL**
wsl.ch/forest/wus/entomo/welcome-de.ehtml

**Insects on www**
isis.vt.edu/~fanjun/text/Links.html
faunistik.net/DETINVERT/introduction.html
Some examples for books

Pedigo & Rice 2008 Entomology and Pest Management.
Speight & Wylie 2001 Insect pests of tropical forestry. CABI Publishing.

Special publications by International Organisations

Insect body – external anatomy

caput  thorax  abdomen

ocelli  wings  tergite
pro-  meso-  meta-

antenna  legs  pleura  stigmas

sternite  cerci
Cuticula

protection
attachment for the muscles
movement – thus not all the exoskeleton is hard – series of hardened
body areas form sclerites
Cuticula
prognath

orthognath

hypognath

B

prognath

C

hypognath
Mouthparts

Labium

Labrum

Maxillen

Mandible

Labium
Antennae

- setaceous
- filiform

Geißel

Pedicellus
Scapus

A

B

JO
Types of antennae

- Filiform
- Capitulate
- Lamellate
Thorax
composed of three segments:
prothorax, mesothorax, metathorax
↓
tergum, pleurum, sternum

legs consist of 6 parts: coxa, trochanter, femur, tibia, tarsus and pretarsus
Wings

apterygot ↔ pterygot
Abdomen

contains most of the inner organs:
digestive system, circulatory system, excretory system,
tracheal system, reproductive system

tergit, sternit, pleurum
cerci
Internal organ system

- brain
- foregut
- ovarium
- heart
- anterior intestine & rectum
- ganglia
- mid gut
Reproduction

Apoderus coryli
Curculionidae

Mostly sexual

Otiorhynchus sulcatus

thelytok parthenogenetic -
Sexual dimorphism

- **primary** sex characters – gonads: ovary, testes produce eggs and sperms respectively – reproductive organs

- **secondary** sex characters (size, flightless, antennae) and **ornamental** characters (e.g. colouration)
Mitosis

- Prophase
- Metaphase
- Anaphase
- Telophase

4n → Interphase 2n → 2n
Meiosis

1. mitotic Division 4n
2. mitotic Division n

Prophase
Metaphase
Anaphase
Recombination
Parthenogenesis

• thelytoky
  from unseminated eggs arise females (cynipidae, chalcididae)

• arrhenotoky
  from unseminated eggs arise males

• amphitokoy
  from unseminated eggs arise females & males
Development

*Development + Metamorphosis:*
- ametabol
- hemimetabol
- holometabol
Larvae with three pairs of legs

Marienkäfer

Blattkäfer

Sandlaufkäfer

Bockkäfer
Puppe often free

Pupa libera

Pupa obtecta
Adults

- Pronotum
- Abdomen
- Elytre (Vorderflügel) = Flügeldecke
- Hinterflügel
hemimetabola

holometabola
Coleoptera Scarabaeidae *Melolontha spp.*
Coleoptera Curculionidae *Hylobius abietis*
Coleoptera Cerambycinae *Tetropium* sp.
*Tetropium fuscum*
Spruce

*Tetropium castaneum*
Spruce

*Tetropium gabrieli*
Larch
Coleotpera Lamiinae

Monochamus sp.
Monochamus sartor
SPRUCE

Monochamus sutor
CONIFERS
Coleoptera Bark beetles

- Scolytinae
- Hylesininae
- Ipini
• *phloophagous* species: frass in the phloem; often carving the splintwood

• *xylo-mycetophagous* species: bring ambrosia fungi into the galleries from which they live; technical damage

• *monophage* species: on one tree species

• *oligophage* species: either on conifer or deciduous trees

• *polyphage* species: on conifer and deciduous trees
Ambrosia beetles Phloem-feeding bark beetles
- entrance holes + mother galleries
- larval galleries
- maturation of young immature beetles
- frass of regeneration by adult beetles
- exit holes by adult beetles

e.g. Trypodendron

- e.g. Scolytus
- e.g. Ipinae
Female galleries
Larval galleries
Pupal chambers
Female galleries

The Eight-spined European spruce bark beetle, *Ips typographus*
"Declivity" often characteristic for species

- P. exsculptus
- P. bidentatus
- I. typographus
- I. sexdentatus
- P. curvidens
Maturation feeding of phloephagous species

During this feeding the maturation of gonads is reached
Scolytus intricatus
Tomicus piniperda
Life cycle of univoltine *Ips typographus*

- **a** adult beetles overwinter in the litter and under the bark.
- **b** they emerge and attack trees, logs or winthrows in spring.
- **c** parent beetles may re-emerge in summer and attack new trees or logs ("sister broods").
- **d** young beetles emerge in autumn and enter overwintering sites.
Primary attraction

Monoterpenes from the bark
Chemical communication of *Ips typographus*

**Figure 2.** Principle of chemical communication in *Ips typographus*.
Bark Beetle Pheromone Traps
Trap tree for Ipinae
Birth rate

Mortality

Development of one generation

Egg ↔ Adult
Tree of Life Webproject
Bsp. Coleoptera, Cucujiformia

www.tolweb.org/tree/

Lymexylidae
Cucujoida
Cleroidea
Tenebrionoidea
Chrysomeloidea
Curculionoidea

Fam: Curculionidae
U-Fam: Curculioninae
Scolytinae
Platypodinae

Marvaldi & Morrone 2000 Insect Systematics & Evolution
NEXT LECTURE DAYS

• 18.5  1315-1445
• 22.5  Excursion Meeting
      Point Tram 43 Final Station
• 23.5  1300-1800 Seminars & Exams
• 24.5  1300-1600 Seminars & Exams
• 5.6   0900-1200 Seminars
      1200-1500 Exams
Phylogeny of the genus *Ips*  
(Curculionidae, Scolytinae, Scolytitae)

36 Species (Cognato & Sperling, 2001)  
23 in N- a. Central America  
13 in Eurasia  
Frass in the phloem-cambium layer

Little is known of the asiatic diversity
Phylogeny *Ips*

23 Nearctic
12 Paläarctic

mtDNA COI 769bp
16S rDNA 525bp
EF-1a 734bp
Hemiptera - True bugs, cicadas, leafhoppers, aphids, etc.

- Sternorrhyncha (psyllids, whiteflies, aphids, coccids)
- Auchenorrhyncha (cicadas, spittlebugs, leafhoppers, treehoppers, planthoppers)
- Coleorrhyncha
- Heteroptera (true bugs)
### Sternorrhyncha - psyllids, whiteflies, aphids, and coccids

<table>
<thead>
<tr>
<th>Main host:</th>
<th>Sexuales</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Egg</td>
</tr>
<tr>
<td></td>
<td>L1 (L2)- Fundatrix (hibernation)</td>
</tr>
<tr>
<td></td>
<td>forming of galls</td>
</tr>
<tr>
<td></td>
<td><em>Migrantes alatae</em></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Side host (without galls):</th>
<th>hibernation as young larvae (<em>Hiemosistententes</em>)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the foll. year:</td>
<td>forming of more parthenogenetic generations</td>
</tr>
<tr>
<td></td>
<td>e.g. from winged sexuparae</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Main host:</th>
<th>Sexuales</th>
</tr>
</thead>
</table>
Fam. Adelgidae  
*Sacciphantes* spp.

Main host: *Picea abies*  
with gall

Side host: *Larix decidua*
Fam. Adelgidae *Dreyfusia nordmannianae*

Example of invasive aphid – side host gets the only host
Fam. Lymantriidae *Lymantria monacha*

The nun moth is the most serious defoliating insect pest of the Scots pine, Norway spruce and some other tree species. One caterpillar can damage about 300 Scots pine needles or 1000 Norway spruce needles during its development. The spruce tree defoliated more than 50% usually dies. The Scots pine is more resistant to a single defoliation than other coniferous species. Nun moth outbreaks are usually pandemic.
Fam.Lymantriidae *Lymantria dispar*

*Lymantria dispar* commonly known as the gypsy moth is one of the most destructive pests of shade, fruit, and ornamental trees throughout the northern hemisphere. It is also a major pest of hardwood forests. Gypsy moth caterpillars cause extensive defoliation, leading to reduced growth or even mortality of the host tree. Their presence can destroy the aesthetic beauty of an area by defoliating and killing the trees and covering the area with their waste products and silk. Scenic overlooks that were once beautiful have become spotted with dead standing trees where gypsy moth has invaded. Also, urticacious hairs on larvae and egg masses cause allergies in some people.
The insect is active only during the colder times of the year, spending the warm summer months as a pupa buried in the ground. The moths begin to emerge from the soil in August and shortly thereafter mate and seek out pine trees where they place their eggs. Each female produces a single egg mass which it fastens to a needle of a suitable host tree. Egg masses contain up to 300 or so eggs and the caterpillars typically eclose from them four or more weeks after they are laid. The eggs are completely covered with scales that detach from the abdomen of the female.

The caterpillars of the pine processionary are highly urticating in the third and subsequent instars. Contact with the hairs causes skin rashes and eye irritations. Susceptible individuals may also develop an allergic response to a protein associated with the hairs of the caterpillar.
Figure 3. (A) Caterpillar dermatitis (weal and flare reaction) on the body of an infant; (B) caterpillar dermatitis (persistent itchy papules) on the face of a 7-year-old child.

Hymenoptera Apocrita

Hymenoptera is one of the larger orders of insects, comprising the sawflies, wasps and ants. The name refers to the membranous wings of the insects.

Females typically have a special ovipositor for inserting eggs into hosts or otherwise inaccessible places. The ovipositor is often modified into a stinger.
Larvae of the Symphyta have legs on the thorax then the first abdominal segment is free, and the prolegs are on every segment. They have clear visible ocelli.

The larvae of butterflies are also called caterpillars have a toughened (sclerotized) head capsule and a soft body, that may have hair-like or other projections. After the 3 pairs of legs they have two abdominal segments free and then additional prolegs (up to 5 pairs). Lepidopteran larvae can be differentiated by the presence of crochets on the prolegs. They do not have clear eyes.
Fam. Tenthredinidae
*Pristiphora abietina*
Sirex woodwasp has been the most common species of exotic woodwasp detected in several ports-of-entry associated with solid wood packing materials. Awareness of the symptoms and signs of a sirex woodwasp infestation increases the chance of early detection, and thus, the rapid response needed to contain and manage this exotic forest pest.

Sirex woodwasp females drill their ovipositors into the outer sapwood to inject the symbiotic fungus (*Amylostereum areolatum*), toxic mucus, and eggs. The fungus and mucus act together to kill the tree and create a suitable environment for larval development. Females lay from 25 to 450 eggs, depending upon size of the female. Unfertilized eggs develop into males, while fertilized eggs produce females. All larval instars feed on the fungus as they tunnel through the wood. The number of instars varies from 6 to 12, and the larval stage generally takes 10-11 months. Mature larvae pupate close to the bark surface. Adults emerge about 3 weeks later.
Nematocera Cecidomyiidae

*Mikiola fagi*
Different models for gradation:
a) Aphidina *Elatobium abietinum*
b) Noctuidae, *Panolis flammea*
c) Tortricidae *Tortrix viridana*
d) Geometridae *Operophtera brumata*
Biolgoical pest control

Conservation biocontrol: The conservation of natural enemies is probably the most important and readily available biological control practice available. Natural enemies occur in all areas, from the private garden to the open forests. They are adapted to the habitat and to the target pest, and their conservation is generally simple and cost-effective. Lacewings, ladybirds or hoverfly larvae, and parasitized aphid mummies are almost always present in aphid colonies. Fungus-infected adult flies are often common following periods of high humidity. These naturally occurring biological controls are often susceptible to the same pesticides used to target their pest hosts. Preventing the accidental eradication of natural enemies is termed "simple conservation."
Classical biological control is the introduction of natural enemies to a new locale where they did not originate or do not occur naturally. This is usually done by government authorities. In many instances the complex of natural enemies associated with an insect pest may be inadequate. This is especially evident when an insect pest is accidentally introduced into a new geographic area without its associated natural enemies. Examples of introduced vegetable pests include the European corn borer *Ostrinia nubilalis*, one of the most destructive insects in the USA. To obtain the needed natural enemies, scientists turned to classical biological control. This is the practice of importing, and releasing for establishment, natural enemies to control an introduced (exotic) pest, although it is also practiced against native insect pests. The first step in the process is to determine the origin of the introduced pest and then collect appropriate natural enemies associated with the pest or closely related species. The natural enemy is then passed through a rigorous quarantine process, to ensure that no unwanted organisms (such as hyperparasitoids) are introduced, then they are mass produced, and released. Follow-up studies are conducted to determine if the natural enemy becomes successfully established at the site of release, and to assess the long-term benefit of its presence.
Biotic factors limiting outbreaks

Prokaryotes

Nematodes

Parsitoids

Predators
Insect pathogenetic fungi

- about 500 insect pathogeneic fungi
Bacteria like *Bacillus thuringiensis*
Ichneumonoidea (Apocrita, Hymenoptera)
Ichneumonidae, Braconidae....
Diptera

Brachycera Asilidae

Syrphidae

Bombylidae

Tachinidae
Monitoring and Risk Assessment of Forest Insects in Mountain Forests
Evaluating the risk of a bark beetle gradation

Monitoring
- beginn
- development

Risik

Pre disposition
- Location/forest stand

Data bank
Input

Output

Topo climate aspects
- Soil temp.
- Cambial temp.
- Air temp.
- Direction of sun
- Topography
- Structure of stand

Eco-physiol. aspects of the species
- When do they start etc.
- development
- voltinism/diapause
Lufttemperaturverteilung

Kambialtemperaturverteilung

Messstationen

Basis-Station

Air-temp.

Temp of cambium

Analysis

model
Development

> Knowledge when there is no development

- effective sums of temp of each ontogenetic stages

<table>
<thead>
<tr>
<th>Stadium</th>
<th>ENP</th>
<th>dd</th>
<th>Ifd Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eeg</td>
<td>10, 6</td>
<td>51,8</td>
<td>51,8</td>
</tr>
<tr>
<td>Larvae</td>
<td>8,2</td>
<td>204,4</td>
<td>256,2</td>
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<tr>
<td>Pupae</td>
<td>9,9</td>
<td>57,7</td>
<td>313,9</td>
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<tr>
<td>Frass of maturation</td>
<td>8,3</td>
<td>222,8</td>
<td>536,7</td>
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<tr>
<td><strong>Egg- pupae</strong></td>
<td>8,3</td>
<td>334,2</td>
<td></td>
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<tr>
<td><strong>Total development</strong></td>
<td>8,3</td>
<td>557</td>
<td></td>
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</table>

\[
T_{\text{eff}} = (T_{\text{opt}} - T_0)\left(e^{\alpha T} - e^{\alpha (T_{\max} - T_0)/\beta}\right) + \gamma
\]

\[
T \leq T_0 \text{ bzw. } T \geq T_{\Omega} \text{ gilt: } T_{\text{eff}} = 0
\]
### Thermale Kennwerte

<table>
<thead>
<tr>
<th>Entwicklungsstadium</th>
<th>dt [°C]</th>
<th>[dd]</th>
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<tbody>
<tr>
<td>Ei</td>
<td>4,51</td>
<td>81,61</td>
</tr>
<tr>
<td>Larve</td>
<td>7,00</td>
<td>234,30</td>
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<tr>
<td>Puppe</td>
<td>3,66</td>
<td>90,67</td>
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<tr>
<td>Jugendentwicklung</td>
<td>5,39</td>
<td>421,77</td>
</tr>
<tr>
<td>Reifungsfraß</td>
<td>5,75</td>
<td>275,56</td>
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<tr>
<td>Gesamtentwicklung</td>
<td>8,25</td>
<td>568,81</td>
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### Entwicklungsfortschritt 17.07.2000

<table>
<thead>
<tr>
<th>Unterabteilung</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mittelwert</th>
<th>Minimum</th>
<th>Maximum</th>
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<tr>
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<td>13088</td>
<td>11588</td>
<td>10088</td>
<td>13088</td>
</tr>
</tbody>
</table>

**Generationsentwicklung 1999**
- 1. Generation nicht vollständig entwickelt
- max. 1 Generation
- max. 2 Generationen

### Station

- Modell
  - DBMS

### Entwicklungsstadien dt [°C] [dd]

- Ei: 4,51 81,61
- Larve: 7,00 234,30
- Puppe: 3,66 90,67
- Jugendentwicklung: 5,39 421,77
- Reifungsfraß: 5,75 275,56
- Gesamtentwicklung: 8,25 568,81
1. Gen. unvollständig
max. 1 Generation
max. 2 Generationen

Development

1999

1999 (+1°C)
Entwicklungsbedingungen + Prädisposition → Risiko
Barcoding to determine cryptic species or larvae

A DNA-sequence has to be in the Genbank. Analysing genetically an unknown insect equally which ontogenetic stage the sequence will tell you which insect species you are dealing with.