Genetic variation of *Pinus pinaster* Ait. seedlings in susceptibility to the pine weevil Hylobius abietis L.

Zas *et al.*, 2005

* P. pinaster is the Maritime Pine, native to Western and Southwestern Med.
* fertilisation x progeny test
* To determine genetic variation between families and the possibility to quantify resistance
* strong correlations among wounds and average seedling colour. Could use this as a proxy for quick screening for weevil damage.
* Positive correlation between diameter growth and weevil damage
* Faster growing families attacked more,
* [15,16,18,19,36]
* Changes in soil fertility, water, light regime have an effect on the phenotype
  + Affects the allocation of resources
* [10,32] examples of how genotype (not phenotype) can be affected by environment
* Adult pine weevils feed on the bark of young seedlings causing growth losses, stem deformation, increased mortality
* [2] for example of the use of genetic resistance in forestry
* Sampling
  + [51] for importance of equal damage across the area
  + 28 ‘plus' trees randomly selected in a first generation seed orchard
  + **What is a Plus Tree? A phenotypically superior specimen**
  + 8 fertilisation treatments and an unfertilised control (fertilised mean has had fertiliser applied)
  + Randomised split plot design replicated in 10 blocks
    - Split plot used when a factor that is to be studied cannot change as often as other factors over space/time due to constraints like land availibility.
    - apply your treatment to a large area then subdivide the area for each seed variety
    - accounts for lack of ability to fully randomise the factor
    - e.g. keep the oven hot for the first 8 cakes then cold for the next 8 cakes
  + Total height and ground line diameter measured one year after plantation
  + Evaluating the wounds in the stem caused by the insect
  + Stem height divided into 10 parts of equal length, each zone had its wounds evaluated on a 4-level scale
    - No damage,
    - Some wounds
    - Many wounds
    - Death due to girdling
  + expressed as the sum of the ten values expressed as a percentage
  + Leader (main stem) loss due to stem girdling was recorded as a % of the total height using a 6 level scale 0-20-40-60-80-100%
  + Wounding was reliable but hard to assess, also measured
    - Foliage colour
    - Foliage density
    - amount of resin in the stem
    - All were assessed on a scale from 1 (Yellow, low, much resin) to 4 (green, no loss of needles, no resin)
  + Analysed by a general linear model
* Found that the wounding measures were too hardy to assess properly in an operational breeding setting
* The symptom trait was easier to assess and strongly genetically correlated with the wounding measure
* Diameter growth and Weevil damage were phenotypically and genetically positively correlated.
* Colour score correlated @ r2=0.75, P<0.001

Fertilization increases Hylobius abietis L. damage in Pinus pinaster Ait. seedlings

Zas *et al.*, 2006

* Same as the above experiment but added some bits
* Geostatistics to assess whether the damage was homogenous over the study area. Is there a pattern not explained by the block design?
* Used a semivariogram
  + n=number of observational pairs
  + h=distance between pairs
  + si=value of variable at location i
  + z(si+h)=Value in an observation at *h* distance from si

Extra Food Supply Decreases Damage by the Pine Weevil *Hylobius abietis*

Orlander *et al.*, 2001

* Field experiment measured the area of bark removed on the main stem excluding the current year shoot. Done with the aid of mm squared paper
* Damage also scored on a 1-6 scale 0=undamaged, 5=dead

Predicting the extent of damage to conifer seedlings by the pine weevil (*Hylobius abietis* L.): a preliminary risk model by logistic regression

Wilson *et al.*, 1996

* 82 forest sites in Ireland
* Multiple logistic regression assessed variation in environmental factors with damage to trees
* Scale of damage to seedlings:
  + 0=no damage
  + 1=slight damage (< 5 feeding patches, altogether not exceeding 20mm2)
  + 2=moderate (5-10 feeding patches, 20-100mm2)
  + 3=heavy damage (>10 feeding patches, altogether esceeding 100 mm2)
* 41 plants assessed at 2 locations,
* Environmental variables:
  + Cover
    - veg. height
    - brashing density
  + Seedling data
    - density
    - self seededness
  + Water content of the soil
  + Stumps nearby and their quality
  + Soil type
  + Forestry management
  + Litter depth
  + Planting and felling data
  + Vegetation diversity

Site influences on *Hylobius congener* (Coleoptera: Curculionidae), a seedling Debarking Weevil of Conifer Plantations in Maine

Welty & Houseweart, 1985

* Measured the seedlings as alive or dead
* Length of the debarked area and the approximate % (25,50,75,100) of stem circumference girdled

Soil preparation Reduces Pine Weevil (*Hylobius abietis* (L.)) Damage on Both Peatland and Mineral Soil Sites One Year after Planting

Luoranen & Viiri 2012

* Systematic plot sampling
* seedlings classified as healthy, weakened or dead. Along with likely cause of damage

Effects of green tree retention, prescribed burning and soil treatment on pine weevil (*Hylobius abietis* and *Hylobius pinastri*) damage to planted Scots pine seedlings

Pitkanen *et al.*, 2005

* Severity of feeding damage classified as:
  + 0=no damage, no more than one spot-like scar
  + 1= <25%
  + 2=25-50% girth of the seedling gnawed
  + 3=feeding scar extending >50% of girth
  + 4=seedling completely girdled
* Also measured lengths of the seedlings
* 1+2 classes turned out to be of little impact on survival and so were combined in analysis

A flexible sand coating (Conniflex) for the protection of conifer seedlings against damage by the pine weevil *Hylobius abietis*

Nordlander *et al.*, 2009

* Record made of area of bark removed
* Mortality due to H. abietis and other causes
* used a logistic regression to assess likelihood of total seedling mortality in the 5 treatments,

Soil features affecting damage to conifer seedlings by the pine weevil *Hylobius abietis*

Petersson *et al.*, 2005

* Root collar diameter and height were measured upon planting
* Areas of feeding on the bark by pine weevils was assessed in 1mm2 units for all seedlings in mid-June and in the autumns of the first season and the following 2 years
* 3 point scale of damage
  + 0=undamaged or slight
  + 1=severely damaged
  + 2=killed
* Veg. cover in each patch measured on 11 point scale
  + 0=0%
  + 1=1-10%
  + etc

Abundance of Pine Weevils (*Hylobius abietis*) and damage to conifer seedlings in relation to Silvicultural practices

Sydow, 1997

* Presence of feeding damage was recorded,
* Dead seedlings were uprooted and examined closely in order to determine cause of death.‑

Managing the Pine Weevil on Lowland Pine

Wainhouse *et al.*, 2007

* Transects within which all trees sampled/ randomly selected
* Trees that have died from other causes, i.e. branch snapping or herbivory by mammals should be excluded
* Feeding is differentiated into that which penetrates down into the xylem on at least some of the feeding area and that which is superficial
  + Those that penetrate down to xylem are susceptible and are likely to be girdled in the future
* Resin at the site of attack is seen as a resistance response