Steinernematids and their natural web-spinning sawfly hosts in forest ecosystems – a historical outline

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Important historical milestones

1. Anton Krausse and his discovery of *Cephalcia abietis* outbreak in "Egge gebirge" in 1919 – parasitized sawfly larvae were found

A German forester, Anton Krausse, was in 1919 appointed by government to take charge of the web-spinning sawfly outbreak near Neuenherrsee in the Egge Mountains, Westphalen

2.Gothold Steiner and his description of *Aplectana kraussei* from this sawfly population in 1923

A batch of 5 males and 18 females which parasitized sawfly larvae was sent for a parasite identification to Gothold Steiner who described a new nematode parasite, *Aplectana kraussei* Steiner, 1923.

3.Lauro Travassos – created a new genus *Steinernema* in 1927 for this species

Reason - to separate genus *Aplectana* which contained parasites of amphibians and reptiles

4. Gothold Steiner – description of a new genus and species of *Neoaplectana glaseri*, in 1929 morphologically very close to *Steinernema krausse*

He distinguished genera *Steinernema* and *Neoaplectana* by a number of head papillae, both genera were ranked into family Oxyuridae

Difference
***Steinernema* - one ring of four papilae**
***Neoaplectana* - two rings of six papillae each**

5. Some historical changes in the classification

Filipjev created for both genera the subfamily Steinernematinae in 1934 and replaced them into family Anguillulidae

Chitwood and Chitwood promoted this taxon for family Steinernematidae in 1937

Skryabin et al. separated *S.kraussei* and replaced it into the genus *Oxysomatium* in 1951 that was illogical and generally not accepted

Sobolev created the new family Neoaplectanidae in 1953, not accepted

6. Weiser and Kohler recovered an epizootic by steinernematid nematode in larvae of Acantholyda nemoralis in 1955 and N. janickii was described

They found up to 25% parasitized eonymphs and 33% pronymphs of *Acantholda nemoralis* by *Neoaplectana janickii* (probably *S. kraussei*) during outbreak of this pest in southern Poland

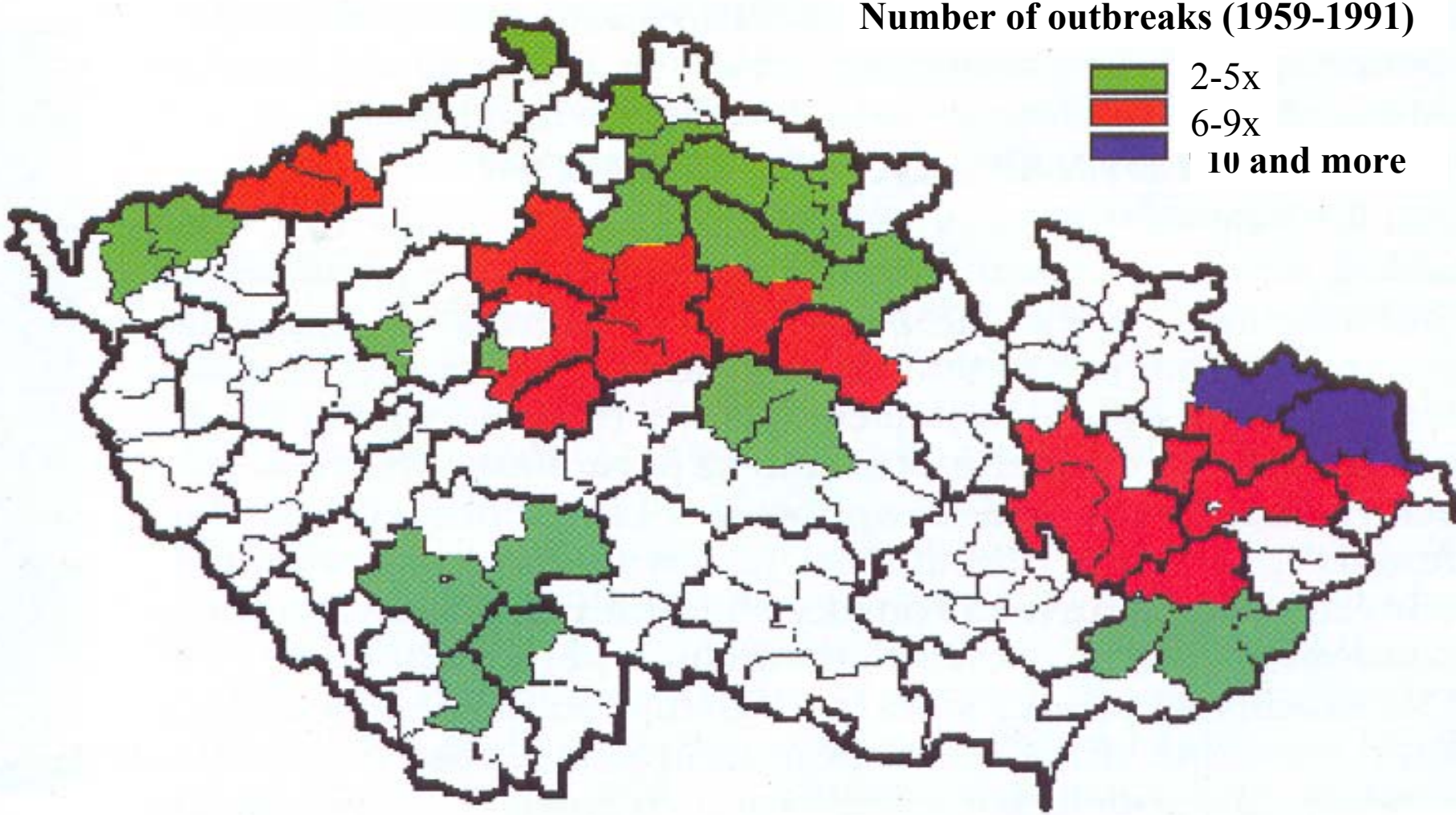
7. Jaroslav Weiser´s recovering of *S. kraussei* in southern Bohemia in mid of 70th

Severe outbraks of *C. abietis* in the Czech border mountains in this period

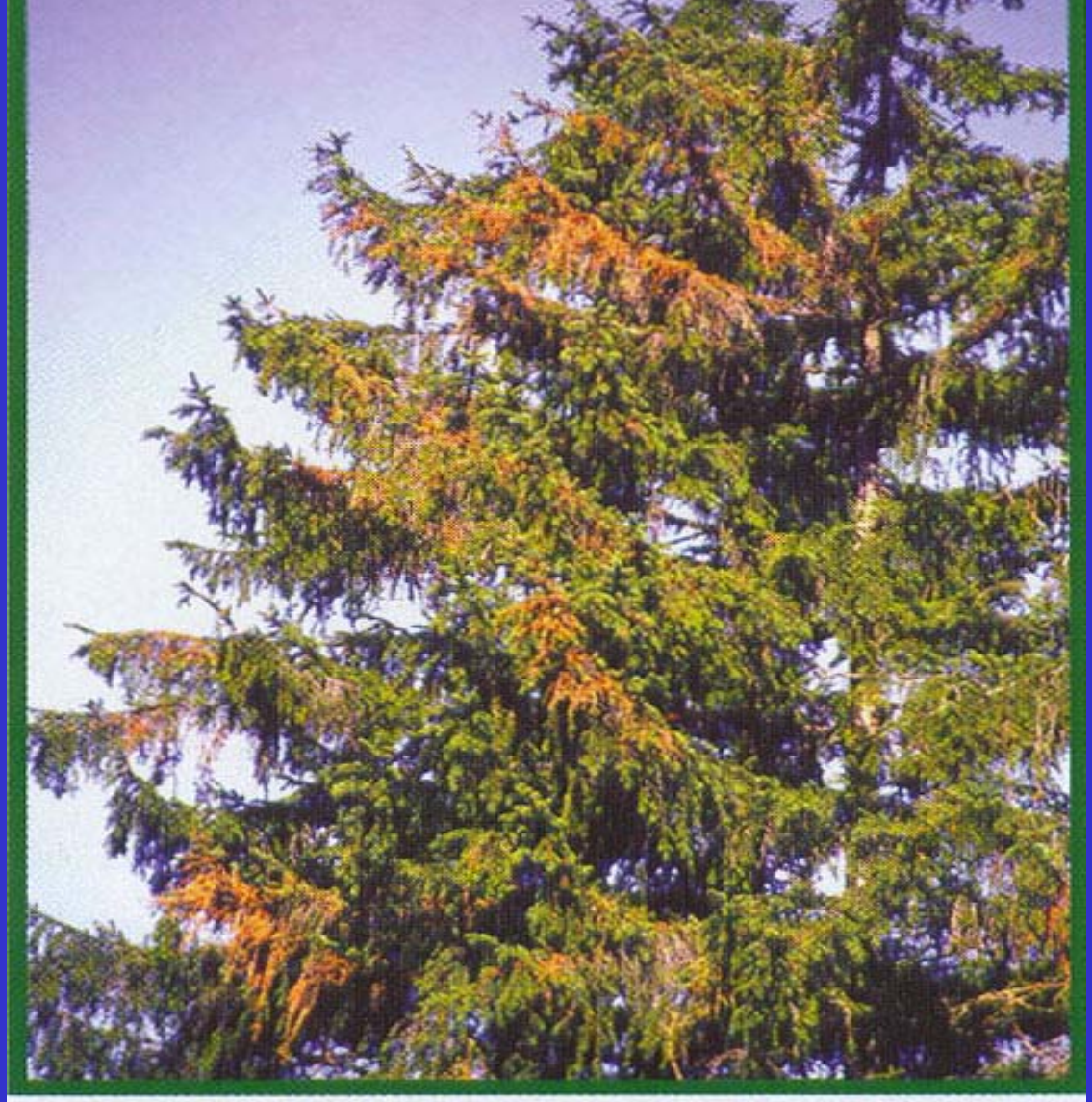
Locality Český Rudolec in S. Bohemia with its spruce monocultures had in average about 1000 dispausing larvae per m^2 and there were sites with 2000 individuals

***S. kraussei* was recovered from both, parasitized sawfly larvae and *Galleria* traps**

Sides of outbreaks of *P. abietina* in the Czech Republic



ign of sawfly feeding in a moderately damaged forest, Sumava Mts



Symptoms of *C. abietis* larvae feeding on spruce branches, August/September

C. abietis - characteristic mozaic feeding in the severely attacked spruce forest

Example of fully defoliated spruce stands by *C. abietis*

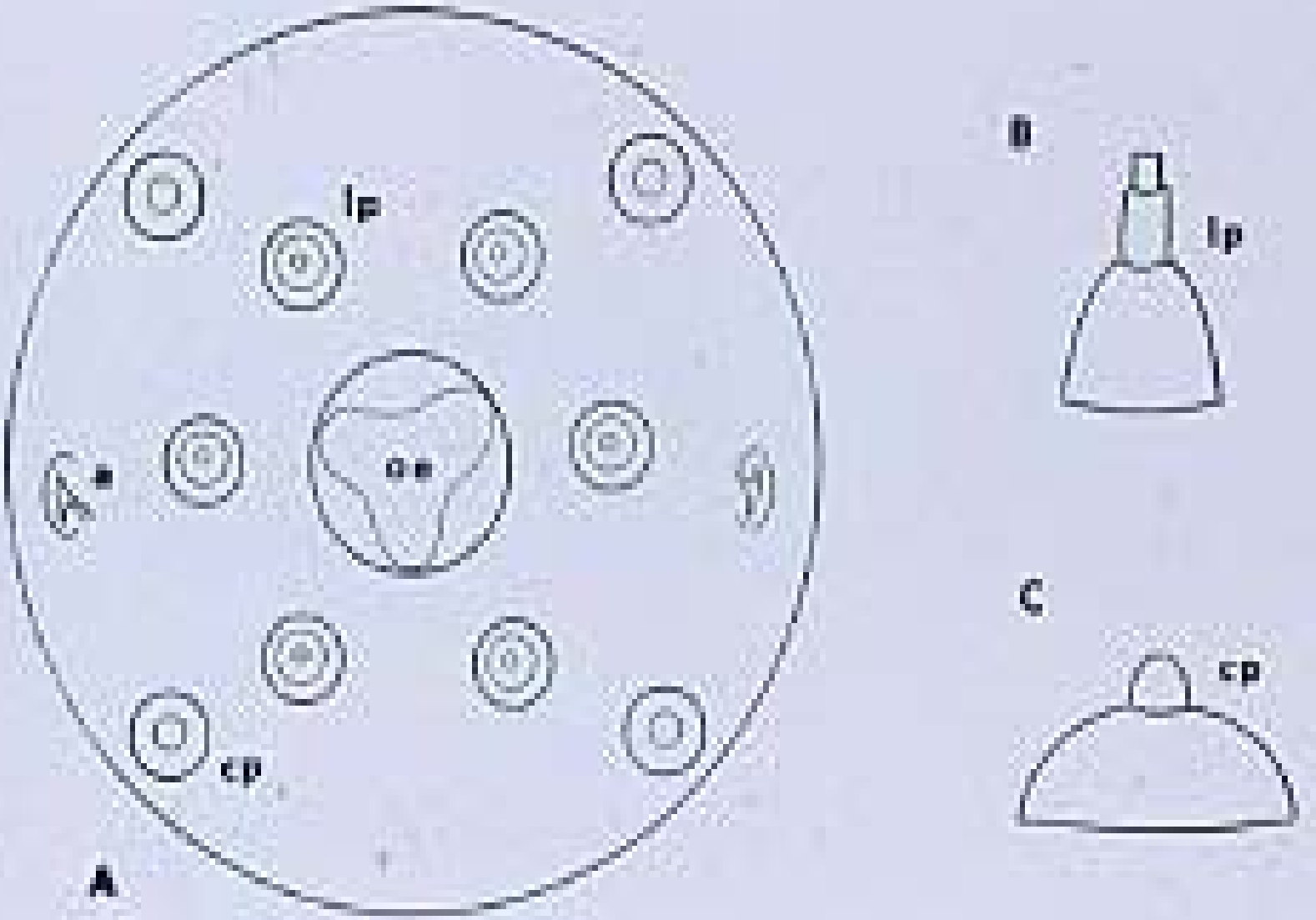
8. Re-description of *S. kraussei* based on the south Bohemian population in 1977

Established culture of the S. Bohemian isolate was compared with Steiner´s original description that, unfortunately, was very poor for any morphological characters

Type of habitat, host, and spicule shape supported the species identification

Further studies revealed that the diagram of head papillae is sam for *S. kraussei* and till this time described *Neoaplectana* species. These findings resulted in synonymization of *Neoaplectana* to old *Steinernema*

Arrangement of head papillae valid for Steinernematidae



9. Re-description of the *S. kraussei* topotype from Germany in 1994

The identity of S. Bohemia isolate was doubt by Poinar. Therefore, the main goal was revealing the type locality in Wesphalia

The historical map of forest sites (Jage 96 and 98) was found at the forest department in Neuenherrsee. No sawfly were recovered in these sites

Soil samples from a new spruce forest, about 60 years age, were taken for *Galleria* baiting which yielded an EPN morphologically identical with that from S.Bohemia

What are web-spinning sawflies

Class Insecta
Order Hymenoptera
Suborder Symphyta
Families: Pamphilidae, Diprionidae, Tenthredinidae
Other families: e.g. Siricidae

Why this name? Female is equipped with egg-laying apparatus which is a saw in appearence and use

Cephaleia abietis - male (left), female (right)

What are web-spinning sawflies -General characterization

. Sawflies are injurious in the larval stage only

. Larvae are gregarious or solitary in habit and spin a bag (webbed-nests)

. Full-grown larvae either spin cocoons or construct cells (chambers) in which they transform to pupae and adults

. Some species diapause more than one year in the soil

. Swarming usually in early spring

C. abietis - eggs attached to a spruce needle

P. abietina, last larval stage

C. abietis **-spinned bag in the late developmental stage**

C. abietis - characteristic shape of eonymphs (female up, male down)

***P. abietina,* dropping of the last larva (1x0.5 mm) and cocoons**

Simple identification of the sawfly families

Adults

Pamphilidae - body flat, antennae thread-like with 13-36 segments

Diprionidae - body robust, egg-shaped, antennae serrate (female) or pectinate (male), 18-26 segments

Tenthrenididae - abdomen oval, antennae thread-like with 9 segments

Larvae

Pamphilidae - only one pair of abdominal prolegs eonymphs form a chamber in soil

Diprionidae - 7+1 pairs of abdominal prolegs, nymphs spin a cocoon mostly in a litter or soil

Tenthrenididae - 6+1 pairs of abdominal prolegs, nymphs spin a cocoon mostly in a litter or soil

Pristiphora abietina, male and cocoon

thread-like antennae


Diprion pini - male
pectinate antenae

Diprion pini - female
serrate antenae


Diprion pini - larva
8 pairs of prolegs

List of most important sawfly pests in Europe

Spruce	feeding	diapausing
Pamphilidae		
Cephaleia abietis	old trees groups in bags	2-3 years
C. arvensis NE	gregariously	2
C. erythrogastra	gregariously with *C. abietis*	2-3

emerging is monitored by pupal eyes in *C. abietis*

Tenthredinidae		
Pristiphora abietina	young trees, soliterely	1-3

C. abietis - pupal eye of pronymph

Sawfly larvae, *P. abietina*, feeding on spruce shoots

Spruce shoots damaged by *P. abietina* feeding

C. abietis, spinned bag at the begining of feeding

***P. abietina* - characteristical feature of a damaged spruce, young (left) and old (right)**

List of most important sawfly pests in Europe
continued

Pine	feeding	diapausing
Diprionidae		
Diprion pini	mid-age trees, gregariously, 2x in year	1-2
D. sertifer	young trees, greg.or sol.,pupa on tree	
eggs		
Pamphilidae		
Acantholyda nemoralis	old trees groups in bags	2-3
A. hieroglyphica	young trees, soliterely	1
A. erythrocephala	young trees, gregariously in bags	1

List of most important sawfly pests in Europe continued

Larch	**feeding**	**diapausing**
Pamphilidae		
Cephaleia lariciphila	**young trees**	**1 year?**

Survey of natural antagonists of sawflies

Parasites
Hymenoptera - *Trichogramma* spp., ichneumonids
Diptera - tachinids

Predators
wild boar
Diptera - Therevidae, Rhagionidae
Formicidae

Pathogens
Paecilomyces farinosus
***Steinernema* spp., *Heterorhabditis* ?**

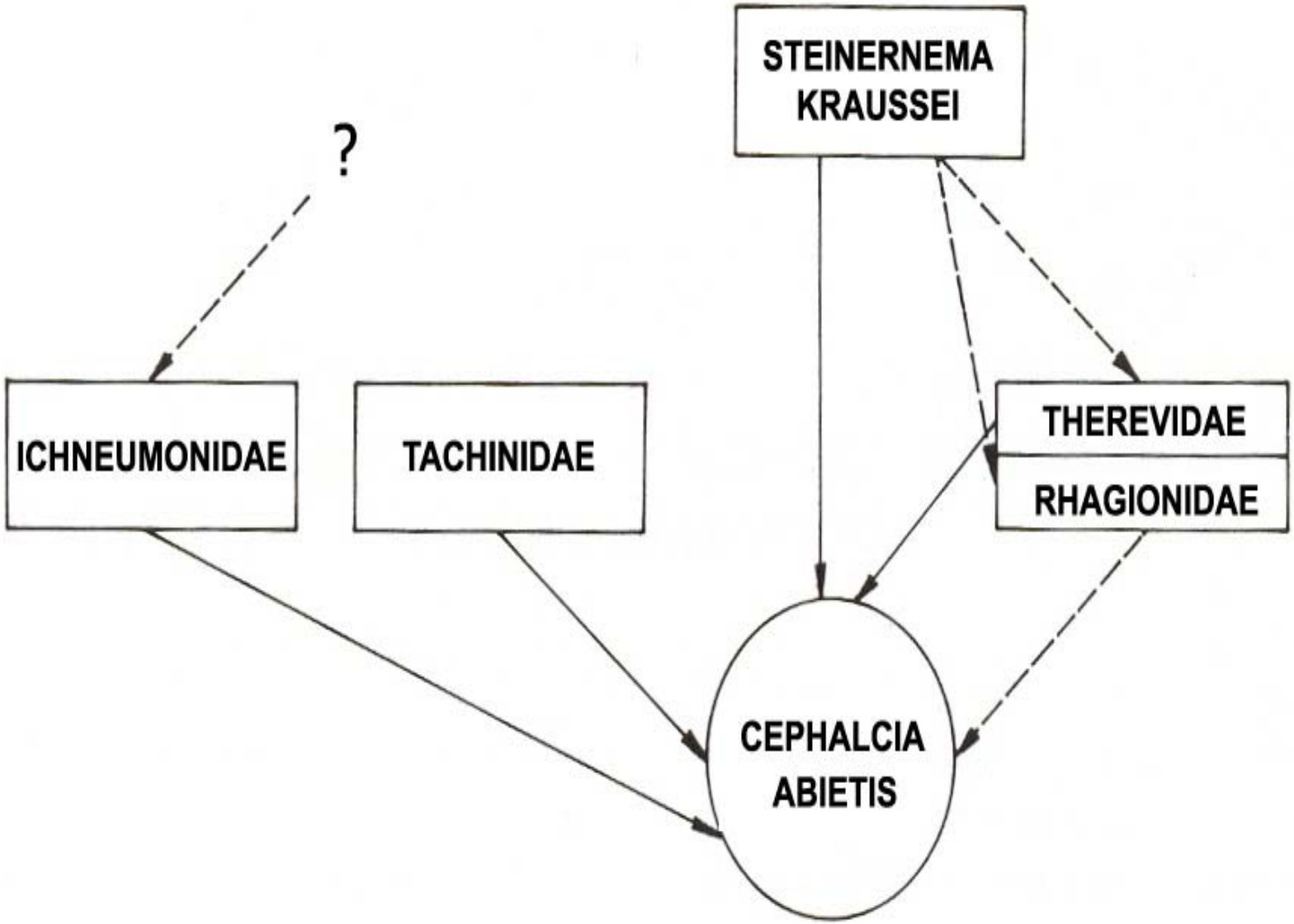
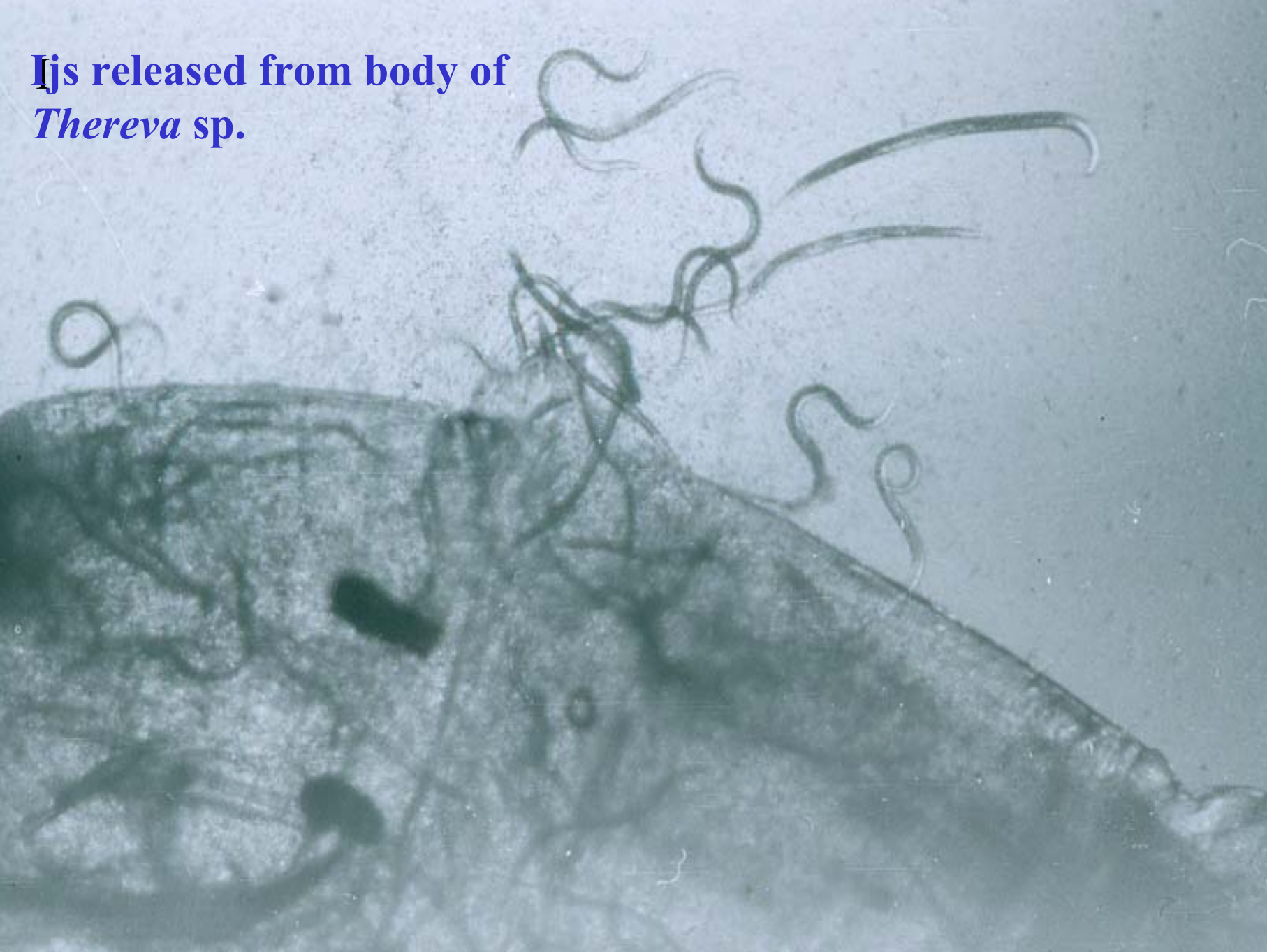


Fig. 1. Single foodweb: interaction among the sawfly Cephlalcia abietis and its predators, a parasitoid and the pathogen nematode; - - - , weak trophic connection; —, strong trophic connection

*C. abietis (*pro-) eonymphs, living (left) infected by EPNs (right)

Ijs inside body of *Thereva* sp.


Ijs released from body of
Thereva sp.

Control of sawflies by EPNs

-surprisingly very poor data-

Natural control

Czech Republic

Mráček (1986)
During outbreak in the locality Český Rudolec
Immediate parasitization ranged from 3 to 4% during vegetation season
Assessed season reduction 24 – 32% (8 generations)
Immediate parasitization at falling period reached up to 25%

Natural control (continued)

Austria

Fischer (1996) recorded a highest rate of 32% parasitization of *C. abietis* by *S. feltiae* from May till November in Muelviertel region, Oberoesterreich

USA

Asaro and Allen (1999) recovered nematode close to *S. kraussei* from pronymphs collected in pine plantations in north New York

Poland

Bednarek and Mráček (1986) studied the persistence of *S. krausse* and *S. feltiae* in the locality of *C. phalleni* in S. Poland . EPNs persisted frequently even during period past a termination of the outbreak. They were much common in damaged spruce forest tha in control sites of a virgin forest and meadow

Field control of sawflies by EPNs

Aplication of EPNs

Results in UK

Georgis and Hague (1981)
20% parasitized *C. lariciphila* larvae during falling to soil and 6% in diapausing larvae

Georgis and Hague (1986)
1. Foliar spraying with *S. feltiae* (5-20 thousand Ijs/100 cm branch resulted in 3 – 29% mortality of sawfly larvae
2. Soil aplication of 200 Ijs/cm2 of *S. feltiae* brought 61% infestation of sawfly prepupae and 17% of pupae
3. One year after the prepupal infection ranged from 5 to 15%

Field control of sawflies by EPNs (continued)

taly

Battisti (1994) - Field application of *S. kraussei* and *S. feltiae* resulte
n 36 and 56% reduction emergences when applied before dropping
nd entering sawfly larvae to soil and 32% when larvae were
lready diapausing in chambers (only *S. feltiae*)

Canada

Vincent and Beláir(1992) - Apple sawfly (*Hoplocampa testudinea)*
0 and 80 Ijs *S.carpocapsae* – more than 80% larval and 39%
repupal mortality. Next spring 22 and 25 sawfly emergency from
lots 50x50 cm, whereas 78 adults in controls

Poland

Jaworska (1992) - Apple sawfly (*Hoplocampa testudinea)*
***Heterorhabditis* sp. caused 99% mortality (prepupae) and 58%**
pupae)

Field control of sawflies by EPNs (continued)

Results in the Czech Republic

Mráček (1986)
Application of 10^5 of S. kraussei in o.25m^2 plots
Mortality ranged from 92 to 96%

Mráček and David (1986)
Application of $4x10^5$ of S. kraussei in o.25m^2 plots
Mortality ranged from 81 to 97%

Field EPN aplication against sawfly larvae in severely damaged forest, Šumava Mts.

Control perspectivity

Advantage
+ long-term soil inhabiting nymphs
+ severe outbreaks
+ easy application technology
+ easy timing for application
+ availability of native EPNs

Disadvantage
- usually a huge area of damage
- high costs of applications

Acknowledgement

1. Thanks for your patience

2. Thanks to sawflies for our job - EPNs