United they stand: invasive association of four-eyed fir bark beetle and ophiostomal fungus destroy fir taiga forest in Siberia

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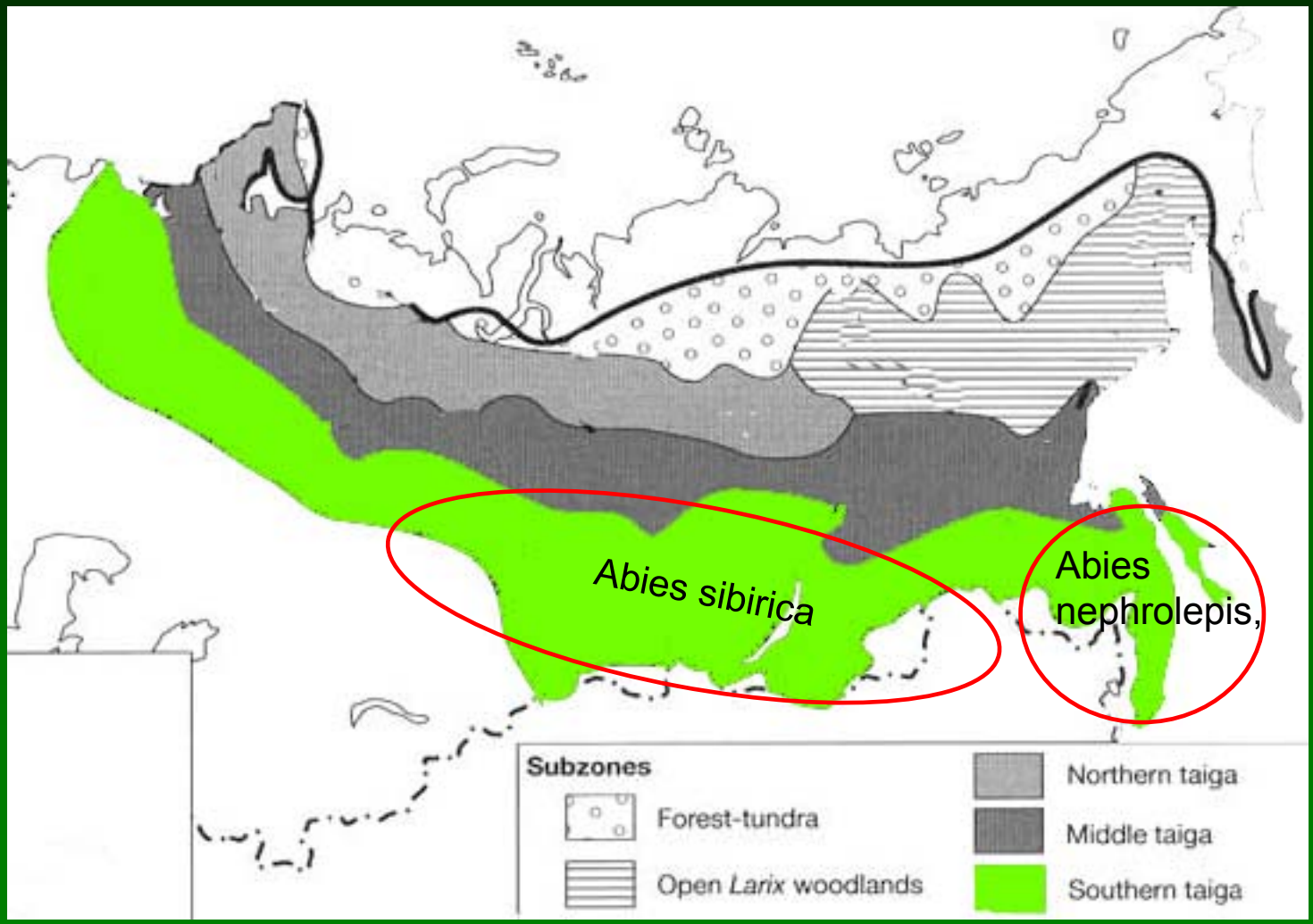
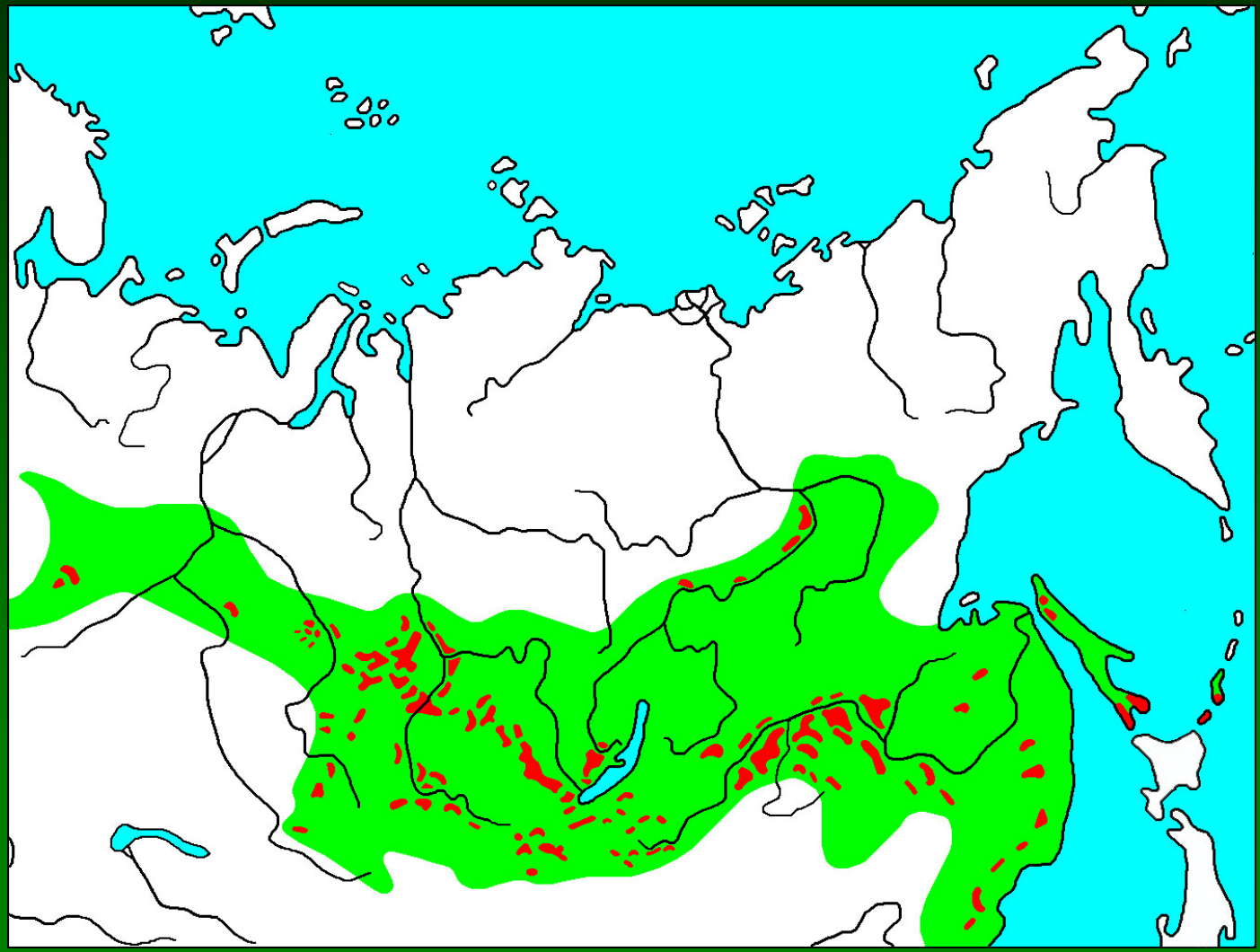
Russian Federation: geographical terminology

Southern taiga subzone

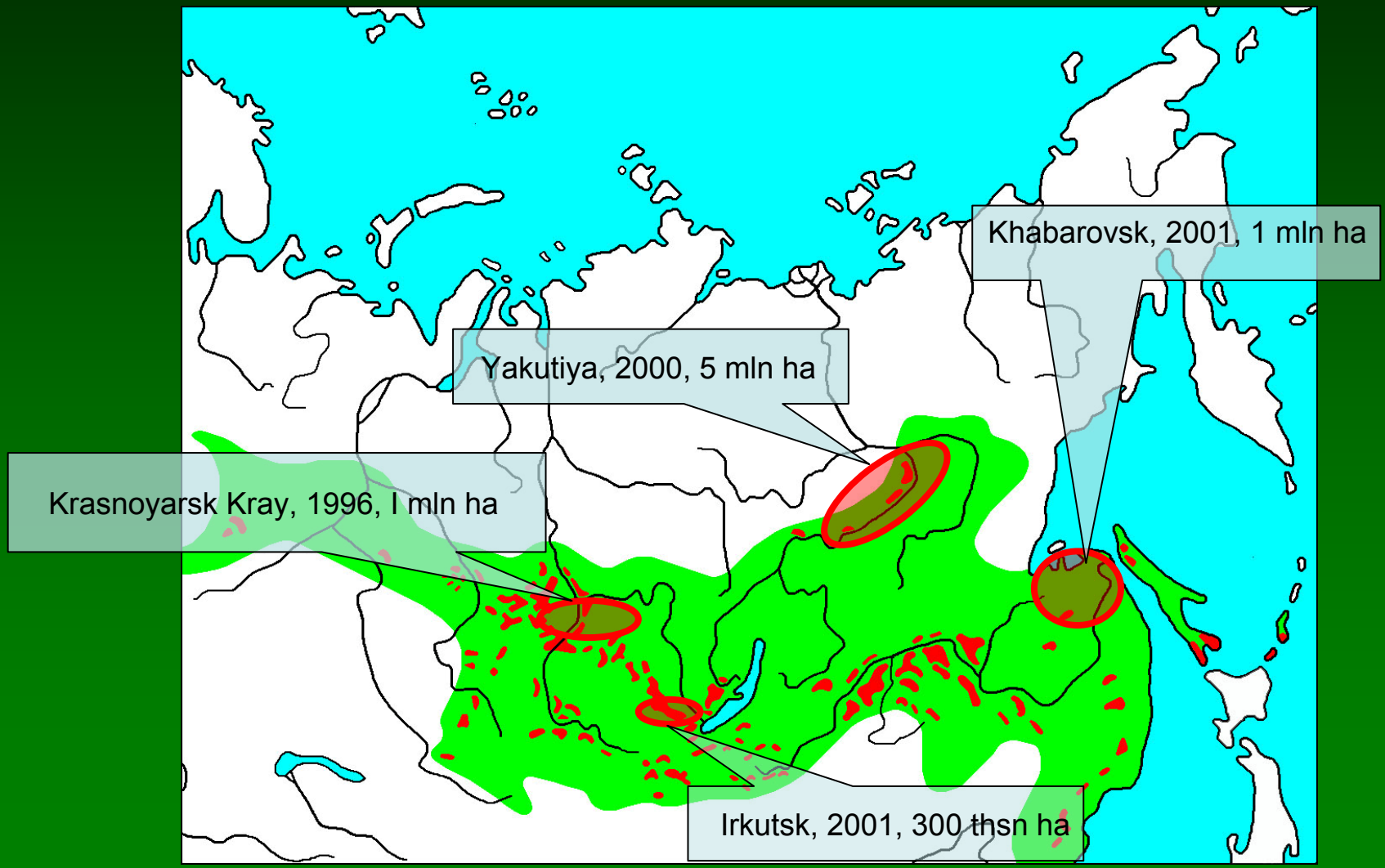


Siberian moth – a main pest of coniferous forests of Asian part of Russia

Distribution and registered outbreaks of *Dendrolimus sibiricus*



Recent outbreaks of Siberian moth



During outbreak in Krasnoyarsk Krai in 1989-1997:

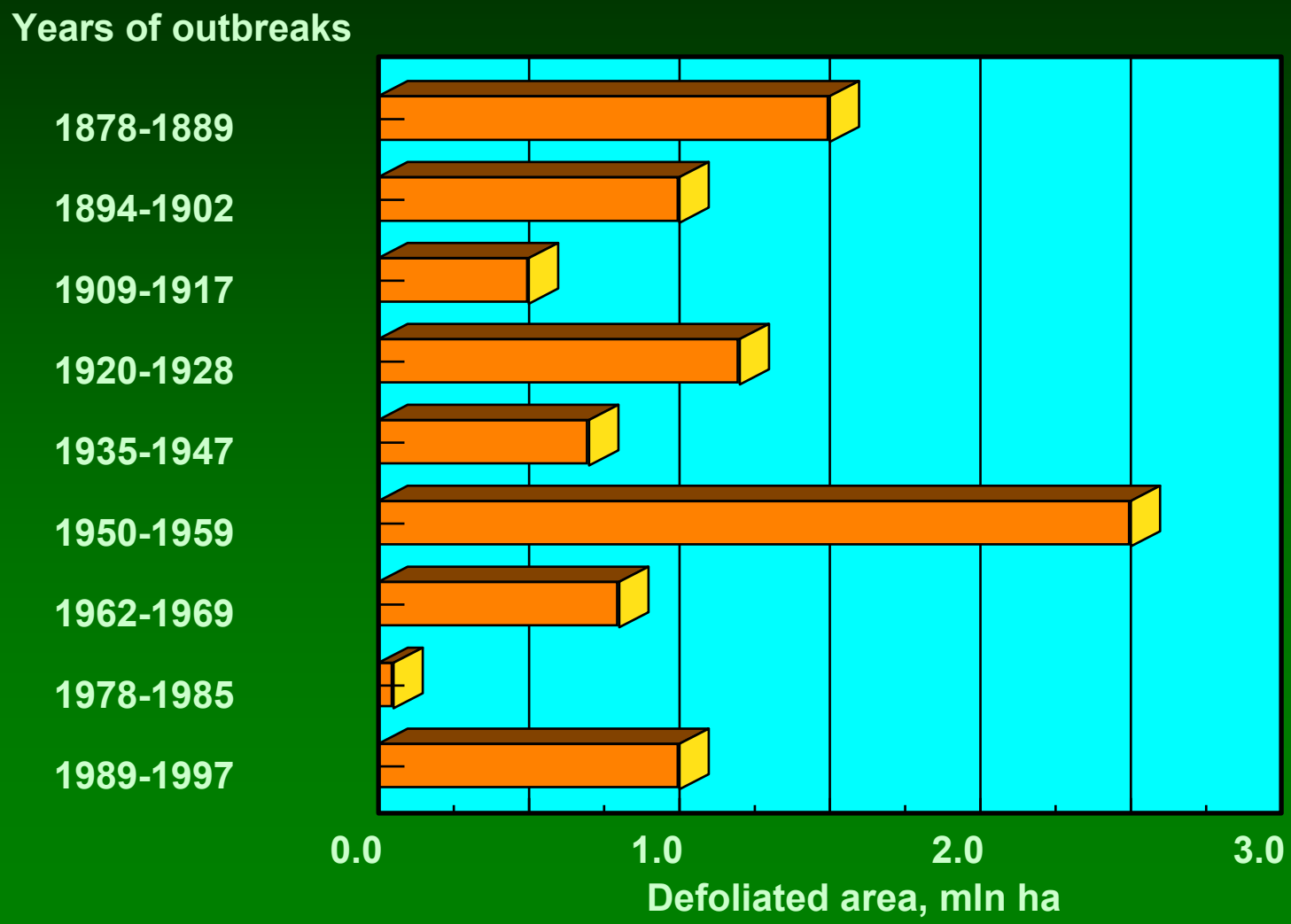
- conifers were killed on 140 000 hectares;
- 50 mln m^3 were lost;
- losses were doubled to year 2002

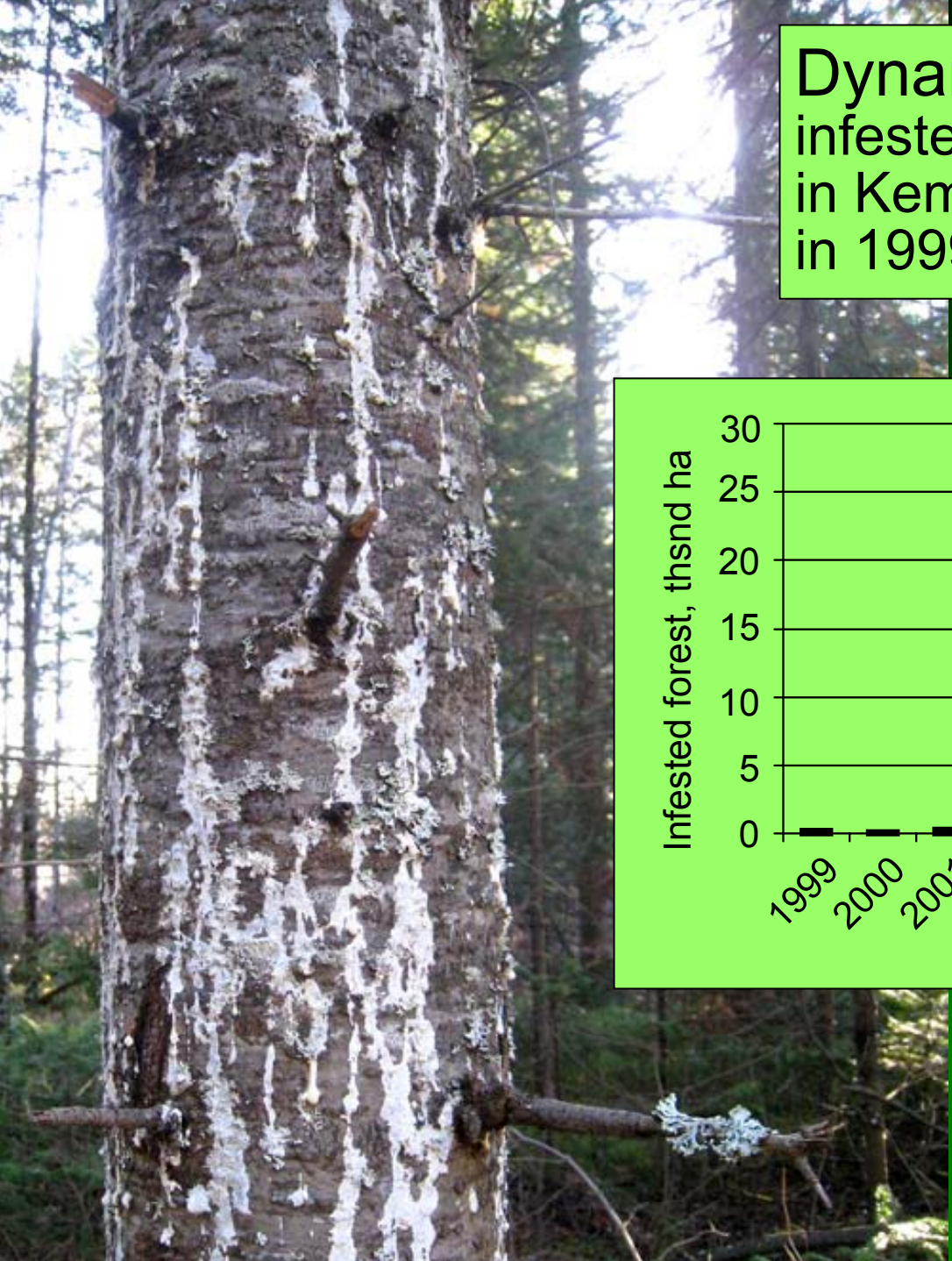
Fir sawyer beetle *Monochamus urussovi Fischer (Coleoptera: Cerambycidae)*

Leptographium sibirica Jacobs & Wingfield

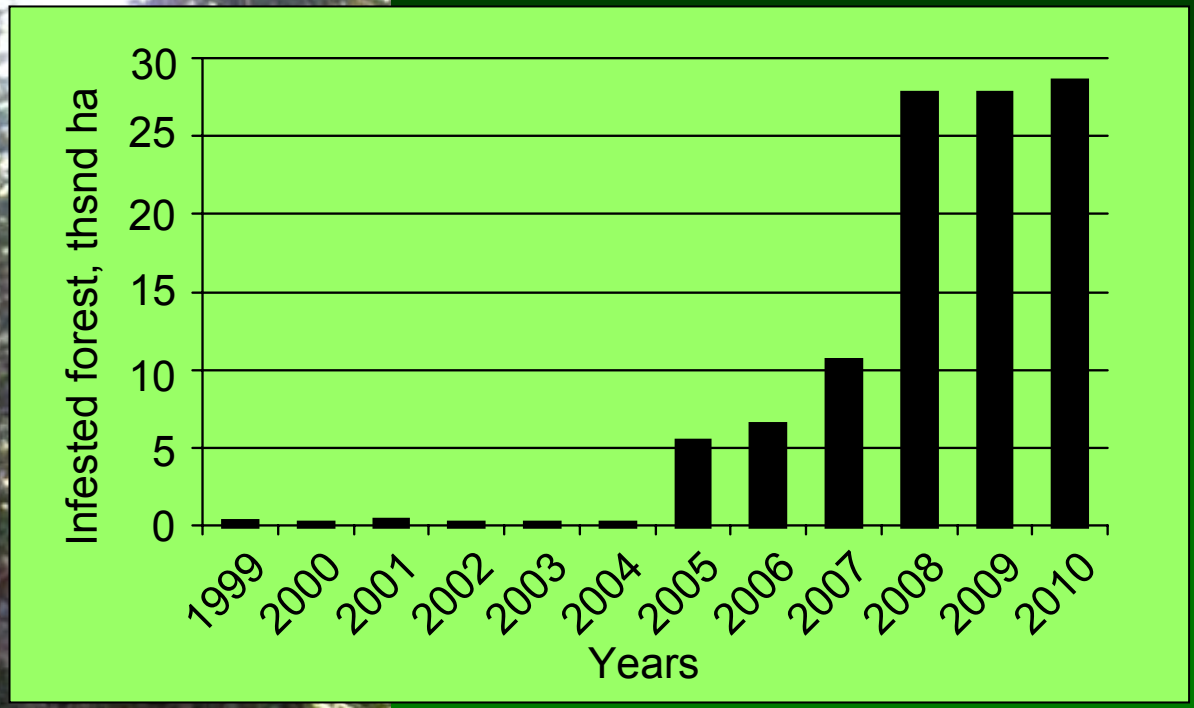
Jacobs, K., Wingfield, M.J., Pashenova, N.V. & Vetrova, V.P. (2001).
A new *Leptographium* species from Russia. Mycological Research 104, 1524-1529.

Area of forest, defoliated by Siberian moth in Krasnoyarsk Kray during the last century





Dynamics of forest area
infested by unknown wood borer in Kemerovo Oblast in 1999-2010

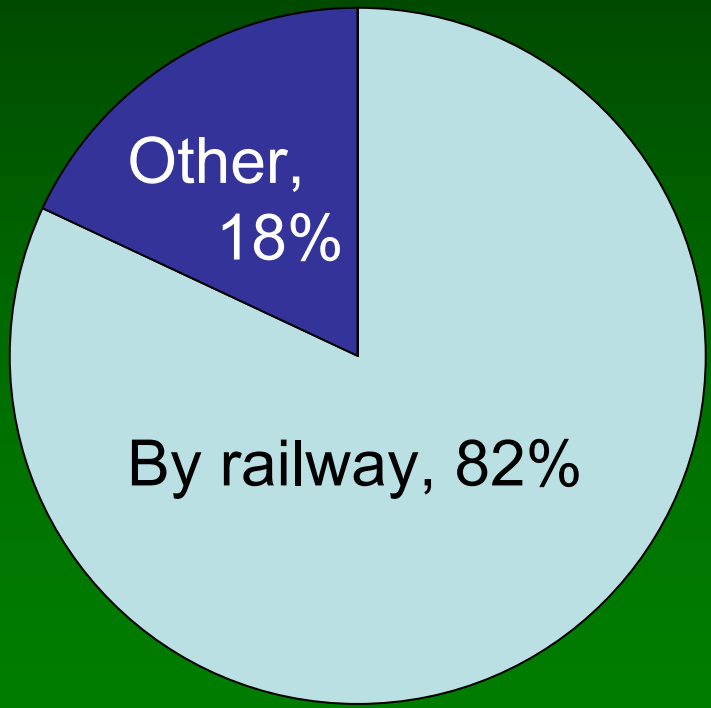


Source:
Russian Center of Forest Protection, 2004, 2010.

Bark beetle
Polygraphus proximus Blandford


Northern transasian transport corridor
0°
10°E
30°E
50°E
80°E
120°E
150°E
170°E
180°
170°W
50°N
40°N
30°N
60°E
70°E
80°E
90°E
100°E
110°E
120°E
130°E
RUSSIA
KAZAHKSTAN
MONGOLIA
CHINA
Moscow
Yekaterinburg
Krasnoyarsk
Novosibirsk
Irkutsk
Ulanbaataar
Beijing
Nakhodka
Khabarovsk
Vladivostok

Structure of internal cargo transportation in Russia (in 2007 – 2 454 bln tons)



Transsiberian railway

Was launched at 1916.

In 20th century – the world longest railroad

Vladivostok – Moscow – 9 000 km

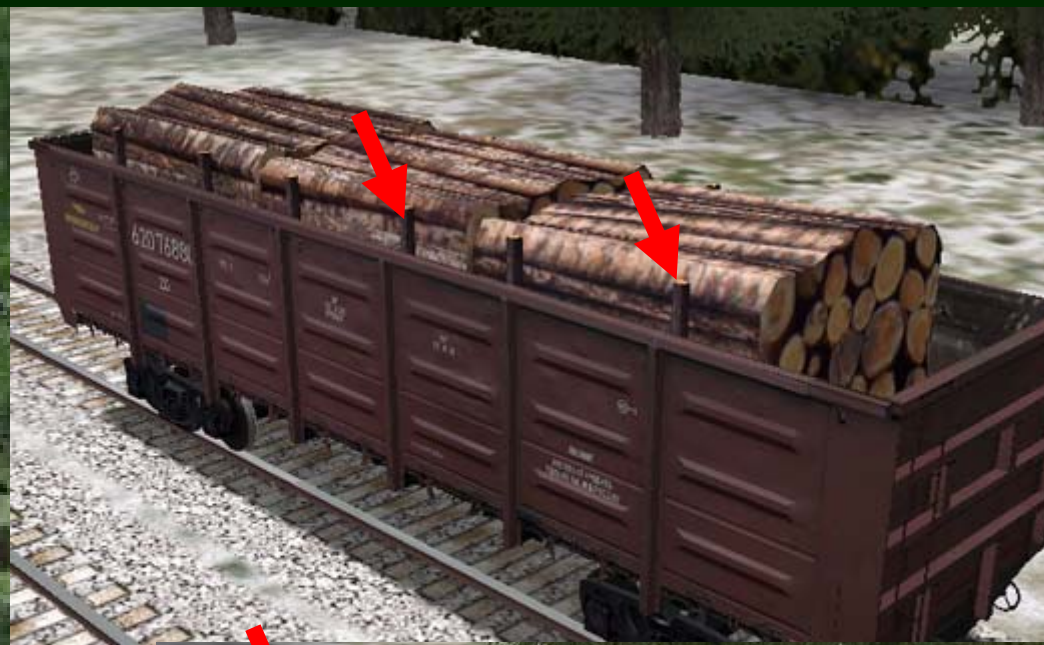
Vladivostok-Urals – 6 000 km

Maximal capacity was registered in 1988 – 1 350 bln tons

Container crosses Russia at 9 days by train.

Container reach Germany from Japan at 17 days by sea.

Fir logs with bark as poles on Transsiberian railroad



Main factors of bark beetles population dynamics

- appropriate food supply:
  - windfall;
  - **logging residue**;
  - weakened trees;
  - susceptible trees.
- parasites;
- predators;
- diseases .

«Crying firs»- first sign of massive beetle attack

Photo: Yu.Baranchikov

Increasing of necrotic area in cambium of firs

in different years of attack of Siberian fir by *Polygraphus proximus* beetles (Kozulka, Kranoayrsk Kray, October 2010)

Years of attack

First

Second-third

Third-forth

Tree crown green, without dead brunches or needles, no or very few beetle galleries

Tree crown will be red at August, a lot of galleries and beetles

Polygraphus proximus on Siberian fir

1-2 year of attack

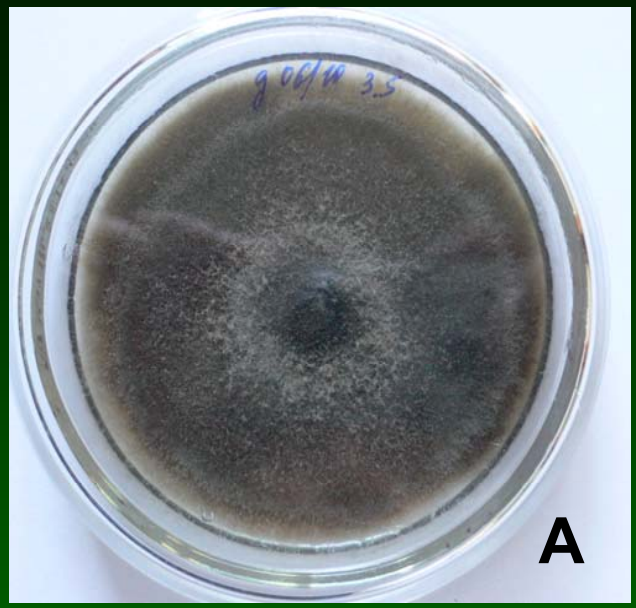
3d year of attack, August

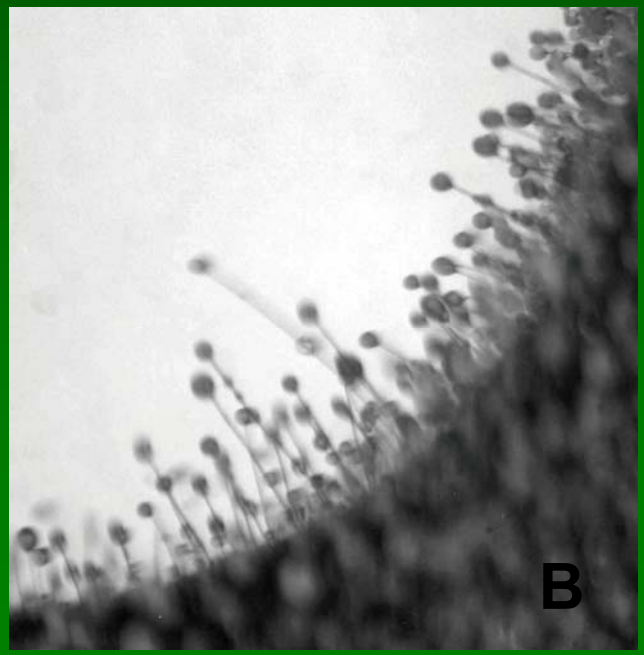
Frequency of blue stain fungi occurrence

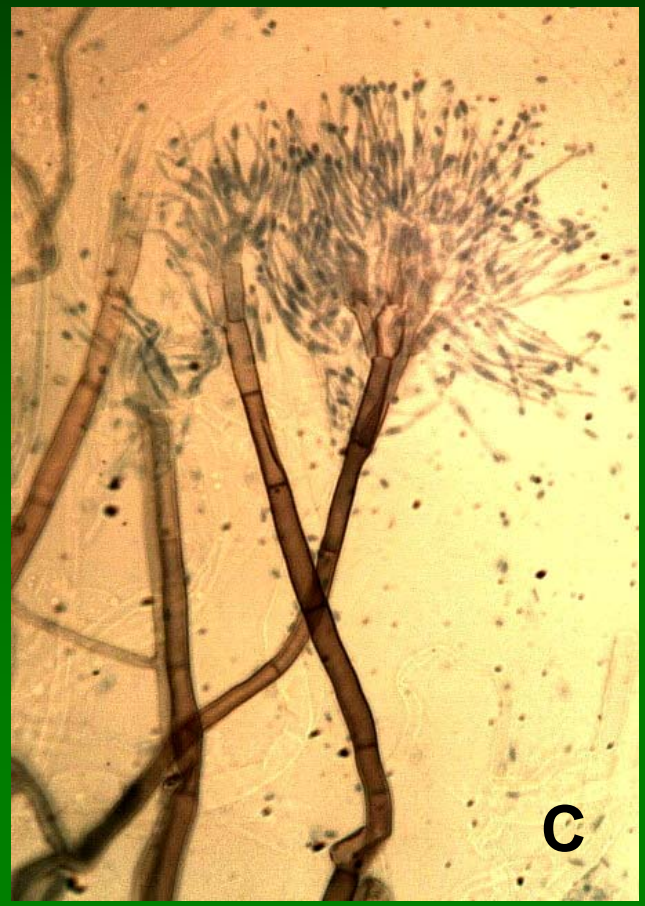
in the samples from trees of Siberian fir infested by *Polygraphus proximus* in Krasnoyarsk Kray and Tomsk Oblast'

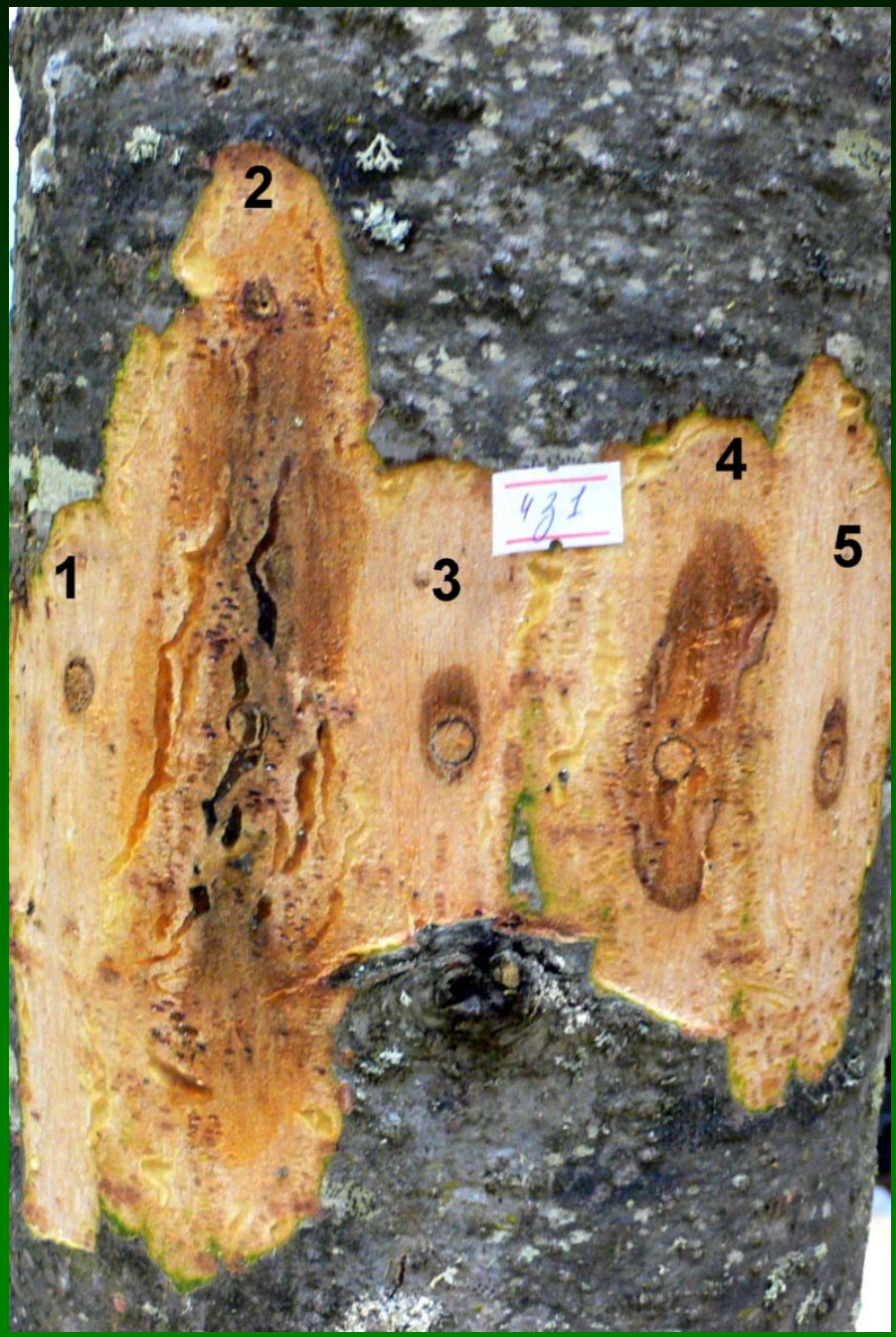
Fungus	Krasnoyarsk Kray		Tomsk Oblast'
	1st sample group	2nd sample group	
Ophiostoma sp. A	48	91	100
Ophiostoma sp. B	16	48	16
Leptographium sp.	56	52	0
Graphium sp. I	32	22	36
Graphium sp. II	0	0	16
The total frequency of fungi occurrence	76	96	100
Amount of samples, pcs.	25	23	25

Leptographium sibirica colony (A) and conidiophores (B,C) on malt extract agar









The necrotic lesions formed in the *Abies sibirica* inner bark, 4 weeks after inoculations

Inoculums:

1 – control (mechanical wounding without inoculation),
2 - *Ophiostoma sp.* A,
3 - *Ophiostoma sp.* B,
4 - *Leptographium sp.*,
5 – *Graphium sp.*

Photo by N.Pashenova

Size of necrotic lesions in the *Abies sibirica* inner bark

four weeks after artificial inoculation with the *P. proximus* associated fungi

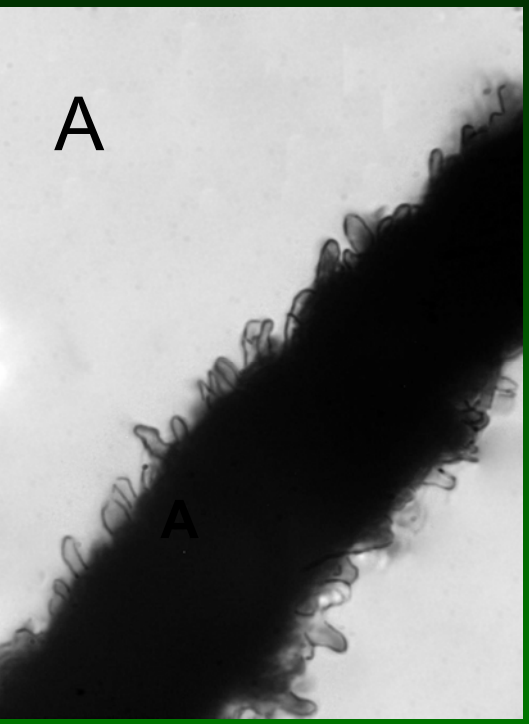
Inoculum (code of isolate)	Necrotic lesions (mm)*	
	length	width
Ophiostoma sp. A (A4)	125,6 a	28,0 a
Ophiostoma sp. A (A7)	43,8 b	16,8 b
Ophiostoma sp. B (B1)	16,6 c	12,0 c
Ophiostoma sp. B (B3)	18,8 c	10,0 c
Leptographium sp.(L1)	46,8 b	23,2 a
Leptographium sp.(L2)	41,0 b	20,0 ab
Graphiun sp. (G7)	14,2 cd	11,0 c
Graphiun sp. (G8)	17,6 c	12,8 c
Control	**11,5 d**	**11,6 c**

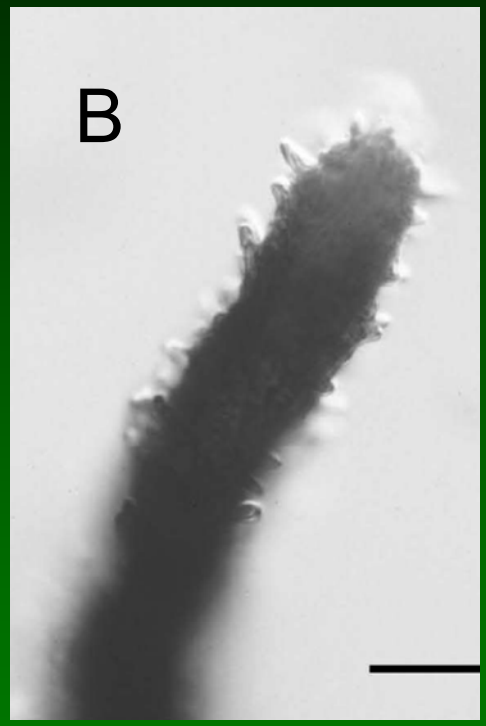
* Values in a column (mean, n=5) followed by the same letter are not significantly different (P > 0,05).

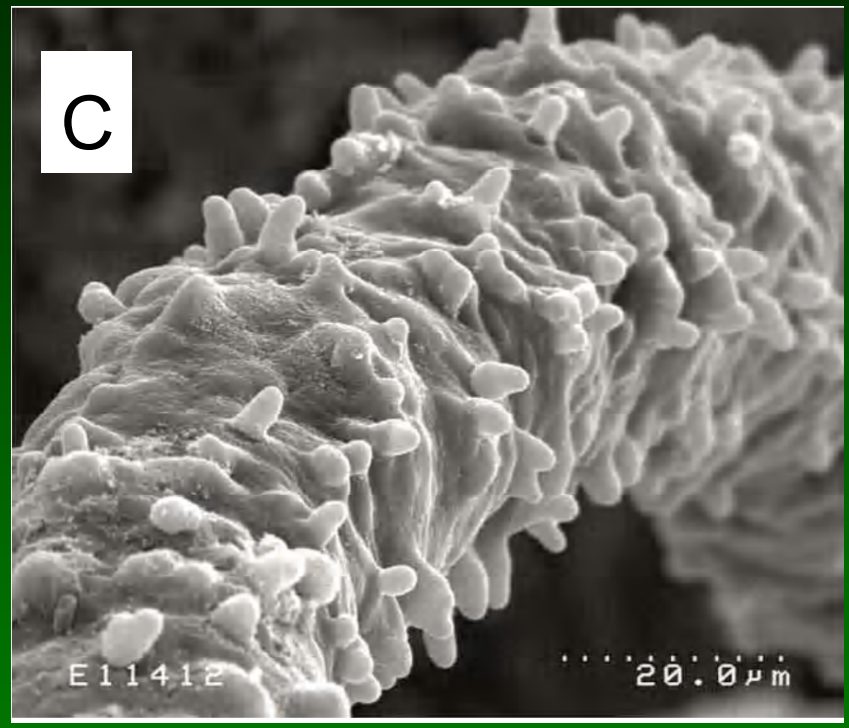
Comparison of some cultural and morphological characters of *Ophiostoma sp. A* and *Ophiostoma aoshimae*

Characters	Fungi	
	Ophiostoma sp. A	*O. aoshimae**
Perithecial base width (µm)	165 – 319	155 – 275
Perithecial neck		
length (µm)	429 – 1055	300 – 820
base width (µm)	33 – 55	45 – 80
tip width (µm)	22 – 44	20 – 50
Ostiolar hyphae	Absent	Absent
Projections on the surface of the neck	Present	Present
Ascospores		
size (µm)	2,7-4,3 x 1,2-2,0	2,5-4,5 x 1,2-2,4
shape	Oblong	Ellipsoid to oblong
Conidial state	*Leptographium*-like	Not found
Color of colony grown on MEA	Dark braun	Braun to dark olive

Ophiostoma sp. A *vs Ophiostoma aoshimae* micromorphology







Upper part of peritecium neck:

A - *Ophiostoma sp.* A;

D, C - *O.aoshimae* (from Ohtaka et al., 2006)

In May 2012 Dr. Stephen Woodward, (University of Aberdeen, UK) and his students run PCA analyses of our fungus isolates and proved it is *Ophiostoma aoshimae*.

In 2009 Lin,T.-C., Chung,W.-H., Yamaoka,Y. et al. moved *Ophiostoma aoshimae* to the genus *Grosmannia*:

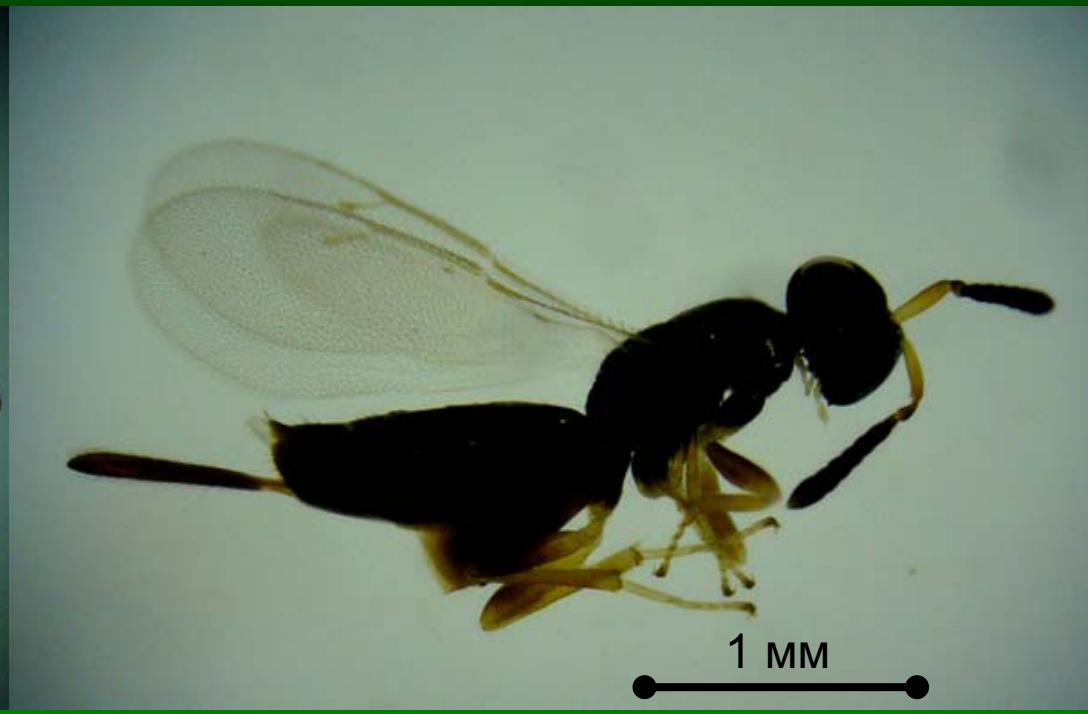
http://ftp.dna.affrc.go.jp/pub/dna_all/G/U1/34/16/GU134162/GU134162

Grosmannia aoshimae Ohtaka, Masuya et Yamaoka, 2006

Parasitic chalcids in the nests of *Polygraphus proximus* In Krasnoyarsk Kray and Tomsk Oblast'

Dinotiscus eupterus (Walker)

Roptrocerus mirus (Walker)

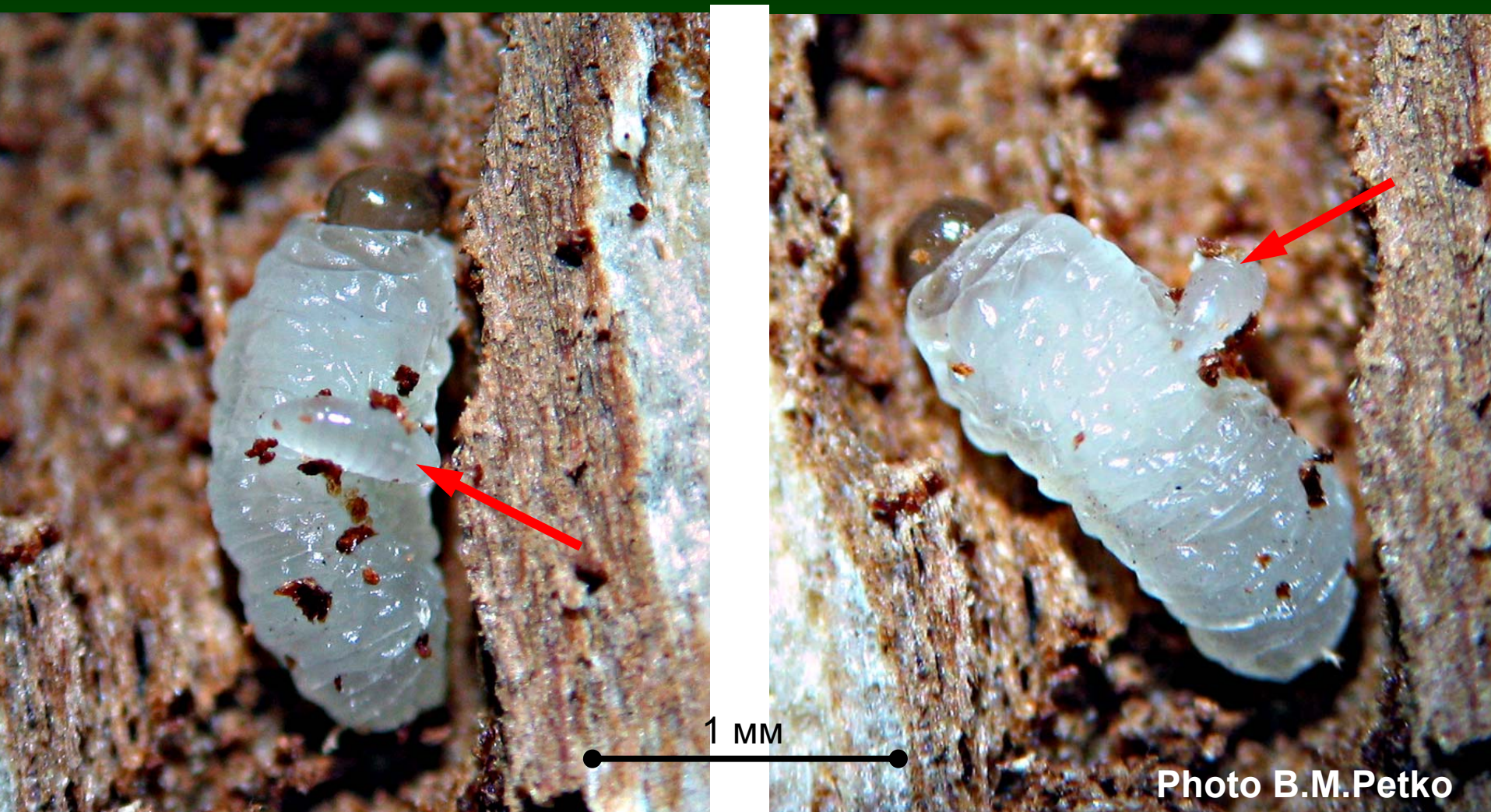


Parasitation level:

12,9 %

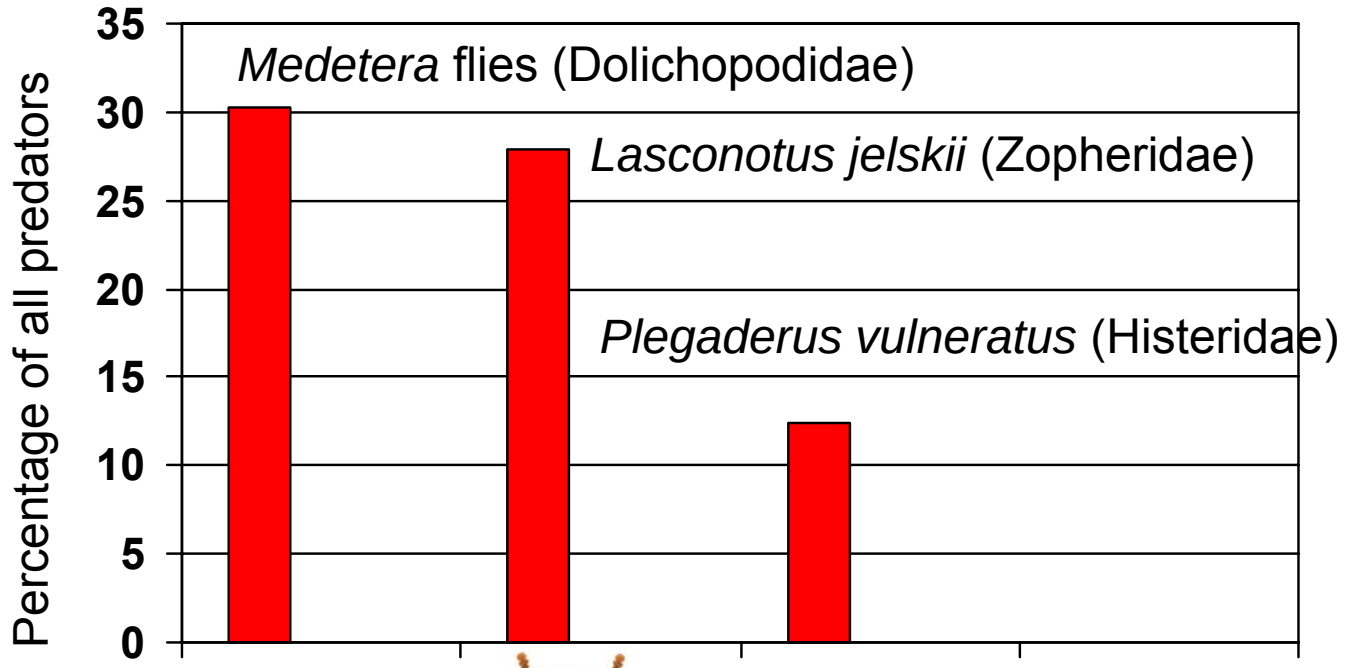
5,8 %

Both species are ectoparasites of bark beetle larvae.
They are widespread in the Boreal zone forests and are connected with many other bark beetle species.



Predators of *Polygraphus proximus* in Tomsk Oblast'

(12 species of beetles and ≥ ~ 2 species of flies)



Source: Kerchev, 2012

Summary (1 of 3)

Polygraphus proximus, a four-eyed fir bark beetle – a new aggressive pest of Siberian fir was introduced to Southern Siberia from the Russian Far East presumably in the end of 80-s. During next 20-25 years it became so adapted to the new host, that some populations formed long lasting outbreaks in the fir stands.

Summary (2 of 3)

Parasites and predators play a minor role in regulation of invader populations. Beetle's success is connected with lack of Siberian fir resistance to a blue stain fungus *Grossmannia aoshimae*, associated with the invasive bark beetle.

Summary (3 of 3)

The main problem nowadays is in the possibility of forming of some new insect-fungi associations when introduced invasive fungus will be transported by indigenous wood boring insects. This can be a real disaster for South Siberian fir stands.

Acknowledgements

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- Galina Yurchenko (Khabarovsk), Svetlana Krivets (Tomsk) and Katerina Chilahsayeva (Moscow) for beetle collections.

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Thank you for attention!