



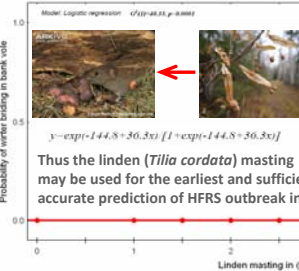
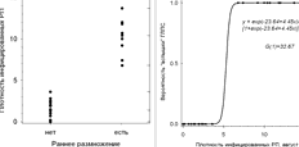
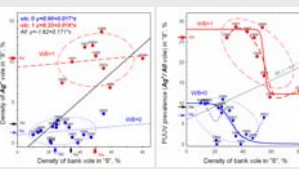
Hantavirus
C. glareolus

• The bank vole (*Clethrionomys (Myodes) glareolus* Schreb., 1780) is the main host of Puumala (PUUV) Hantavirus, which causes Hemorrhagic Fever with Renal Syndrome (HFRS) or Nephropatia Epidemica (NE) in humans.



• Epizootic monitoring of the bank vole carried out at around of Izhevsk city, UR (56°50'N 53°11'E).
• PUUV antigen in lungs of voles was detected via ELISA: 4 times a year (IV, VI, VIII, X) in 1981-1995, and once (August) up to 2005.

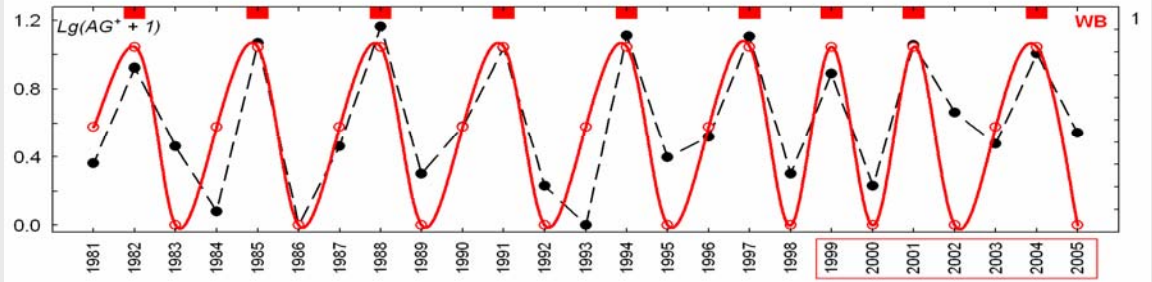
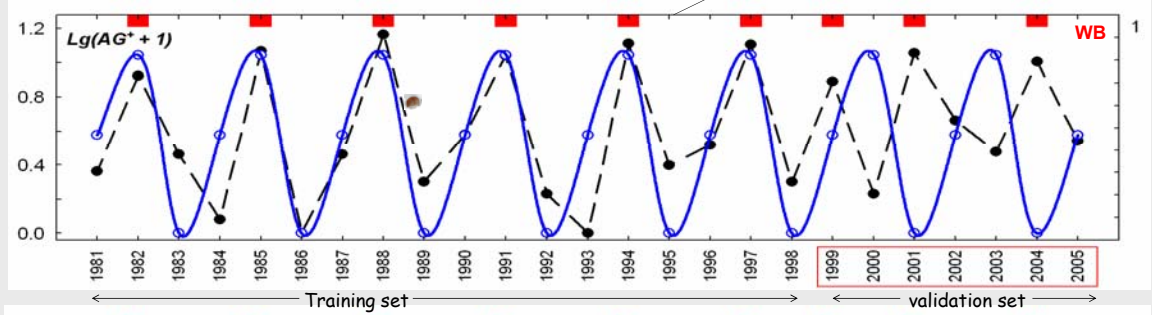
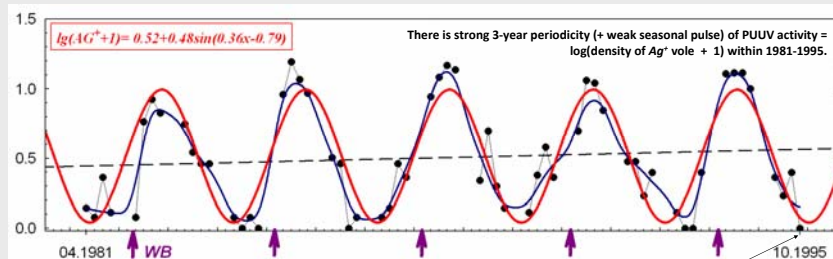
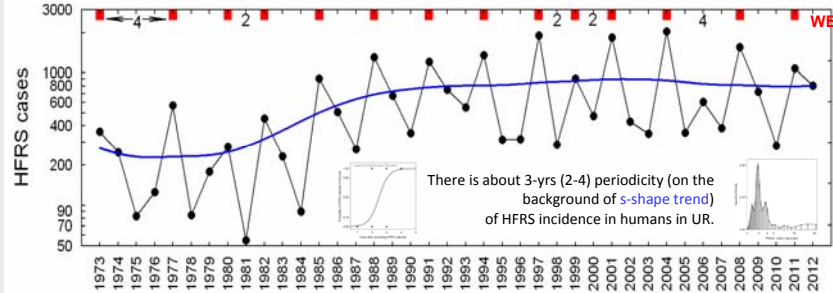
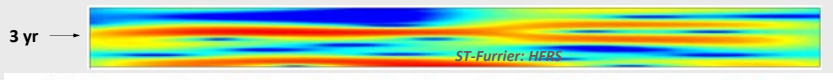
• The one time per year data can be model successfully via nonlinear difference equation similar density-dependent growth of population with non overlapping generations:
 $N_{t+1} = 1 + 2.8N_t / [1 + (N_t/4.3)^{24.9}]$
 $R(1981-1998) = 0.92, t = 9.44$
• However, the forecast of PUUV activity is losing the phase of observed fluctuation ($R(1981-2005) = 0.56, t = 3.23$) without taking into account the **interventions of quasi-periodic external force – the *Tilia cordata* mast events** in previous years, which supply voles with extra winter food for early start of breeding and thereby synchronized PUUV outbreaks via burst of infection risk in susceptible voles. $R(1981-2005) = 0.91, t = 10.83$.



PUUMALA VIRUS ACTIVITY IN THE CIS-URALS NATURAL FOCUS: AUTONOMOUS OR EXTERNALLY FORCED OSCILLATIONS?

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• Both PUUV activity and human HFRS incidence are in strong association with timing of vole breeding (WB=1). In turn the last is in strong dependence upon food supply in winter.

• The **Winter Breeding, WB (0, 1)** is the most accurate (with 1/2 year ahead) predictor both for PUUV activity and HFRS Outbreaks (HFRSO: 0, 1) in humans (1973-2012: $T_{Kendall}(HFRSO/WB) = 1.0, Z=9.1$). Linden fruits harvest (L, points 0.5) taking as only predictor, provides earlier (one year ahead) but less accurate forecast (1973-2012: $T_{Kendall}(HFRSO/L) = 0.7, Z=6.3$).

• Thus the PUUV epizootic outbreaks in the optimum of the reservoir host range (in contrast to other parts of the bank vole range) can be compared to phenomenon of **resonance or flutter**.



Tilia cordata

• Understanding mechanisms of Hantavirus activity in natural foci and predictions of HFRS epidemic outbreaks in humans are actual problems of epidemiology and medical theriology. RFBR 10-04-01657

• HFRS is widespread within temperate/boreal zone of Europe and ranked first on incidence among all zoonotic disease in Russia.
• It is highly endemic at cis-Urals with an annual incidence up to 56 per 100,000 inhabitants.

• The first part of time series of log-density of infected voles (1981-1995) is similar like (self?) oscillation with strongest 3 years periodicity and the simplest harmonic model has a surprisingly good fit ($R=0.89$).

