AARHUS
UNIVERSITY

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BED BUGS

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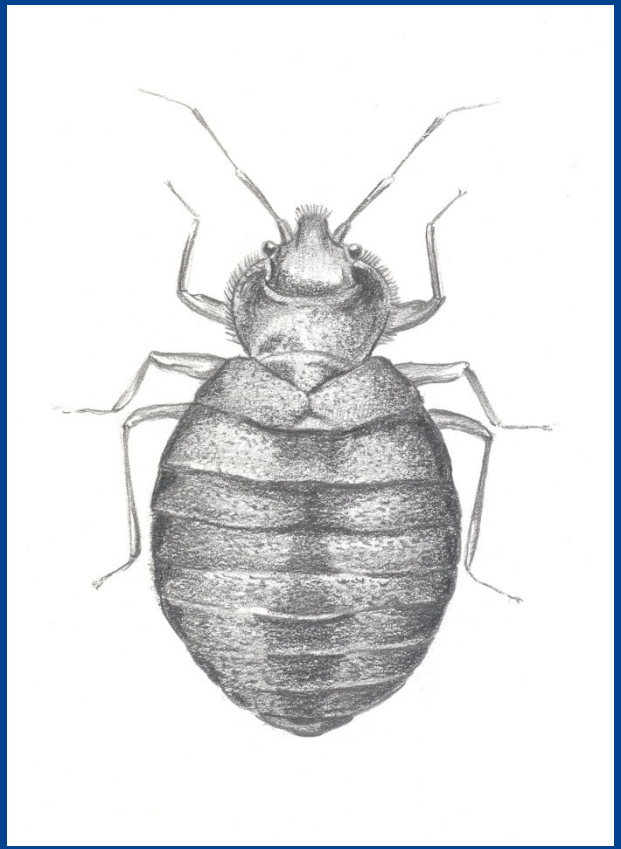
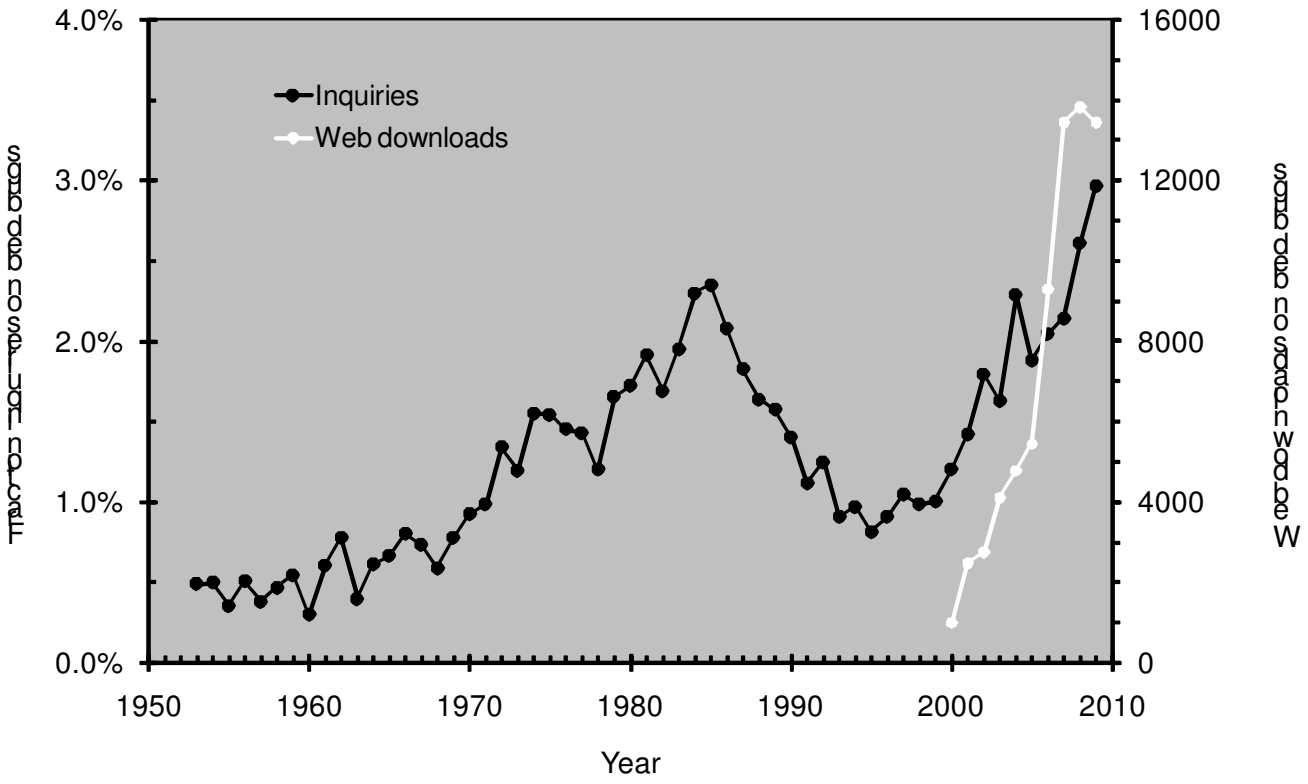
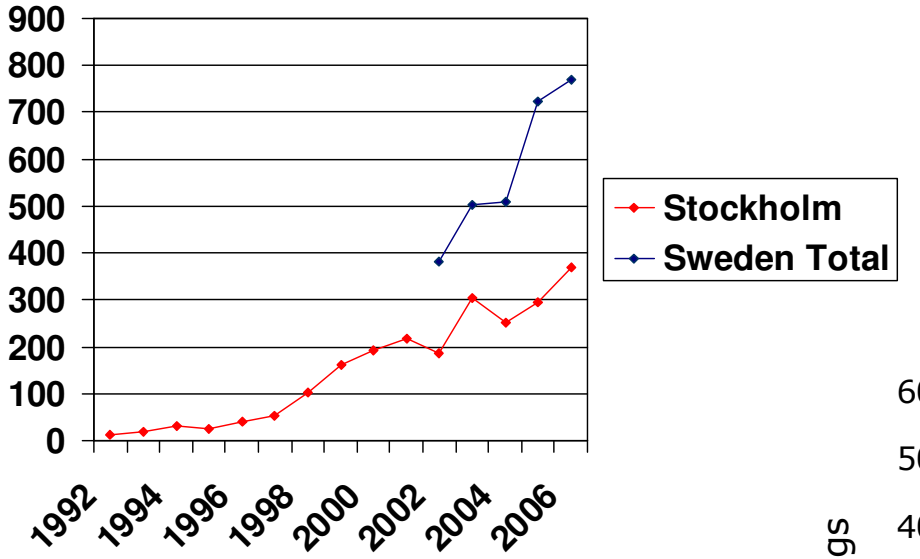


- Bed bug problems in Europe
- Bed bug biology -new results and importance for control
  - Host location
  - Pheromones
  - Heat/cold tolerance
  - Mating biology
  - Human importance
- Conclusions

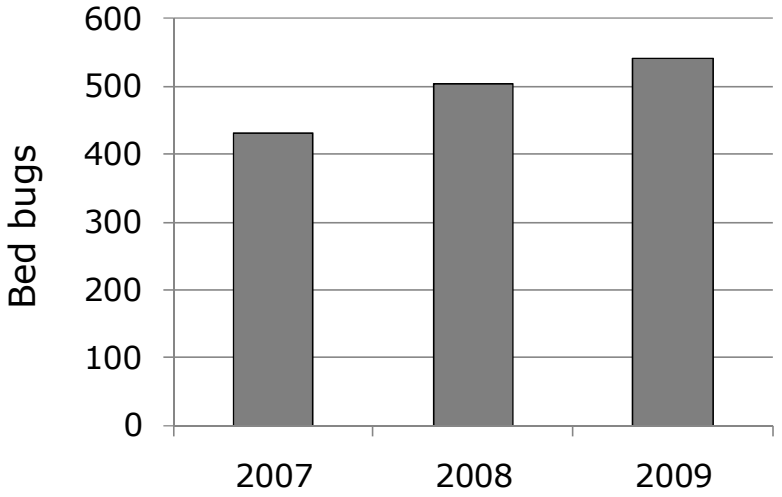
Inquiries to the Danish Pest Infestation Laboratory



Bed bug jobs by a major Swedish PCO

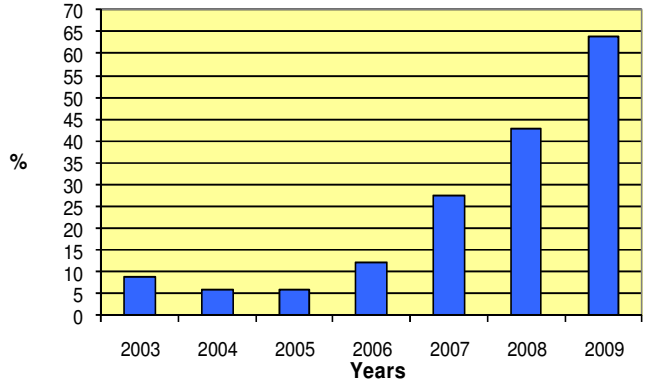


Voluntary reports from the pest control industry to the Norwegian Institute of Public Health



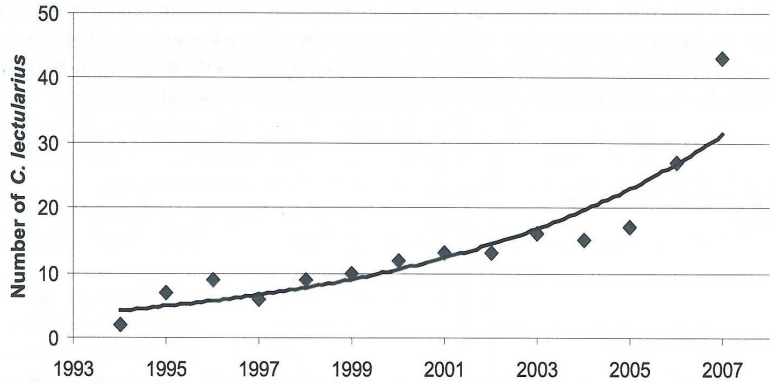
From: www.fhi.no

Proportion of treatments on bed bugs



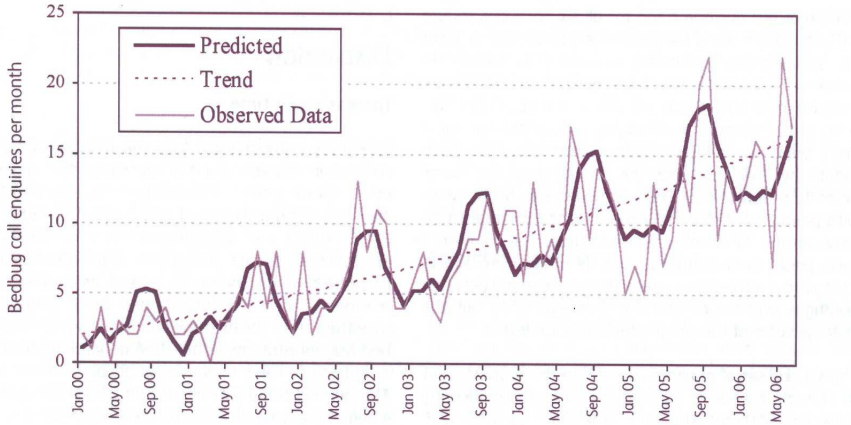
From: BÁBOLNA BIO Ltd

Inquiries to Urban Pest Advisory Service, Switzerland.



From: Mueller et al. (2008) Proc. 6. Int Conf Urban Pests, 15

Inquiries to local authority pest control team in one London borough.



From: Richards et al. (2009) J Env Health Res 9, 17.

- Bed bug problems are increasing all over Europe
- Important to follow the trends to evaluate the outcome of control programs

GENERAL BIOLOGY

- Many different bed bug species, but only 2 known to feed on humans
- 5 nymphal stages that all need a blood meal and the female needs repeated blood meals to keep laying eggs
- Males also feed regularly
- Ingest 2.5 to 6 their own weight in blood (up to 8mg) during 5-10 minutes
- Feeds mainly in the dark
- Needs to locate a host for each blood meal and return to a hiding place
- Thigmotactic behaviour - preference for narrow hiding places

HOST LOCATION

Host location process generally divided into 3 phases:

1. **Appetitive searching**

   Do bed bugs come out of their hiding places in an empty room?

2. **Activation and orientation**

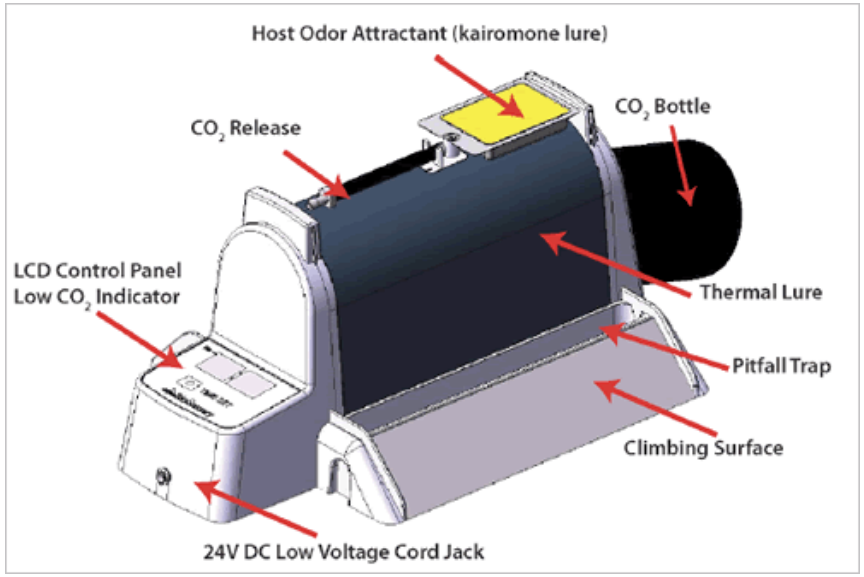
   Activated and attracted by CO_2, like most ectoparasites

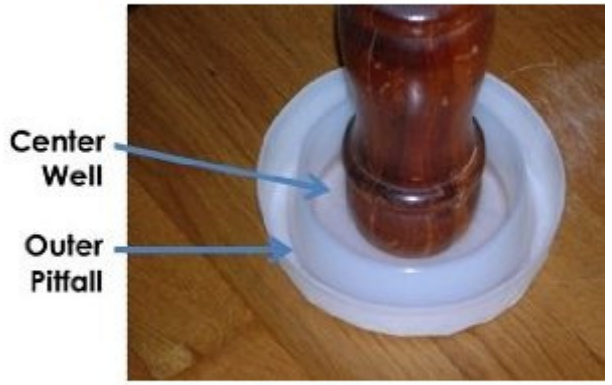
   Some commercial monitoring systems exploit octenol and some short chain fatty acids like lactic acid as attractants

3. **Attraction**

   Heat is probably the most important attractant at close range

Monitoring traps exploiting host attractants





Interceptor

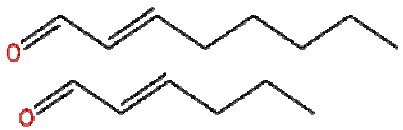
One night of heat

Continuous heat

PHEROMONES

- Bed bugs are well-known for their characteristic smell, shown early to consist mainly of 2-hexenal and 2-octenal
- First characterized as alarm pheromones, but also considered as aggregation pheromones
- Siljander et al 2007 and 2008: also 2 of the10 essential components in aggregation pheromone
- Is concentration important for function?

Trans-2-octenal



Trans-2-hexenal

- Conflicting reports about the propensity to aggregate for different life stages and how the aggregation process is influenced by pheromones
- Some indications that females have a lower tendency to aggregate than males and juveniles, thus could be the most likely dispersal stage

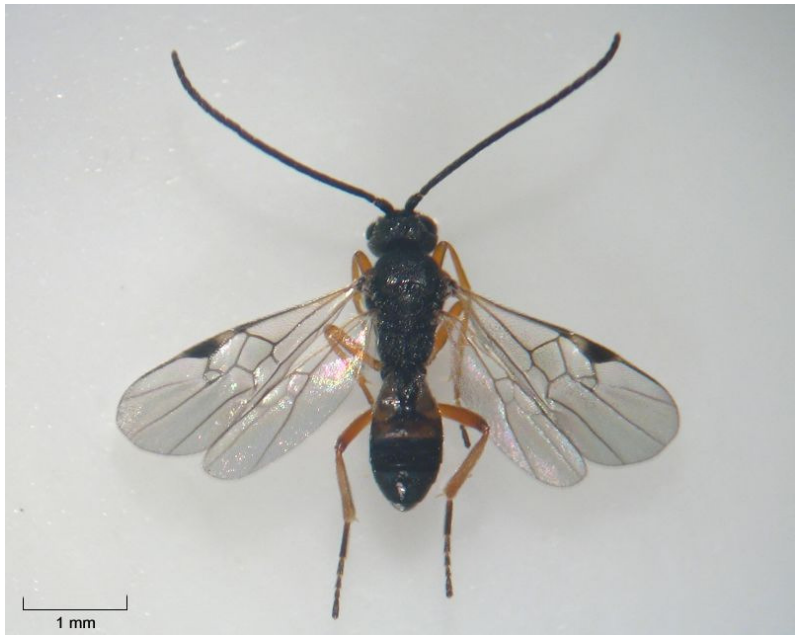
Monitoring traps mimicking hiding places

No attractants yet

Sniffer dogs

Trained to detect bed bugs

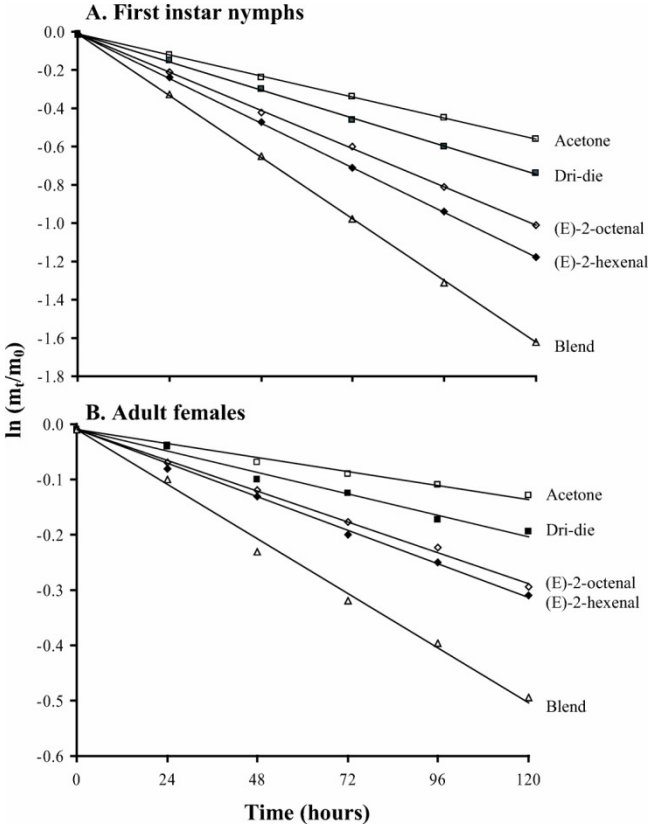
Can discriminate between active and inactive infestations

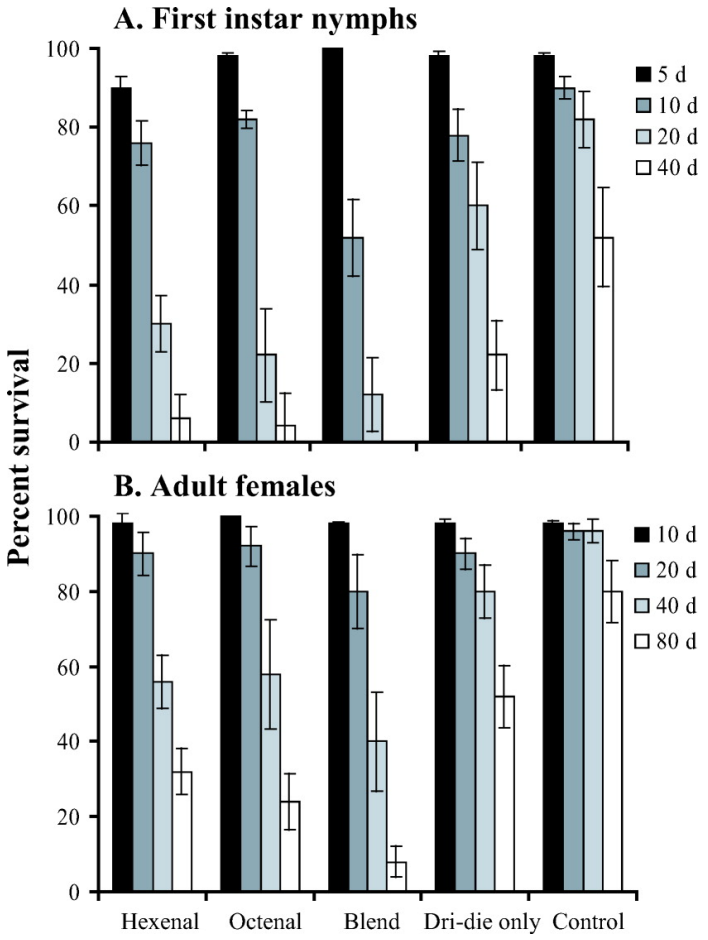


Brachonid wasps

Can be trained easily to detect specific odours

Adding 2-hexenal and 2-octenal to a treatment of desiccant dust results in increased water losses and higher mortality



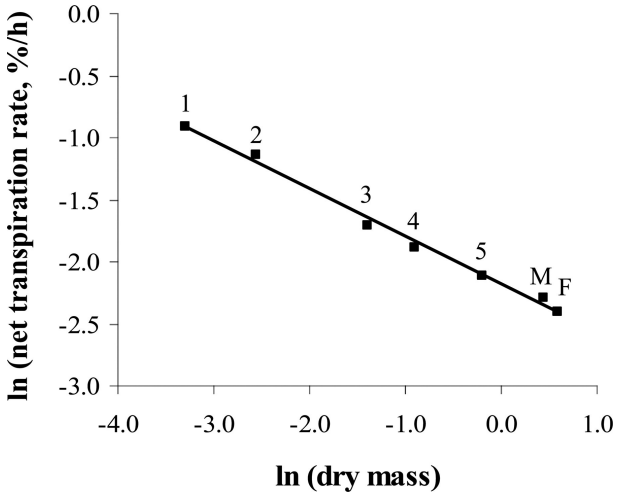


From: Benoit et al. (2009) J Med Entomol 46, 572

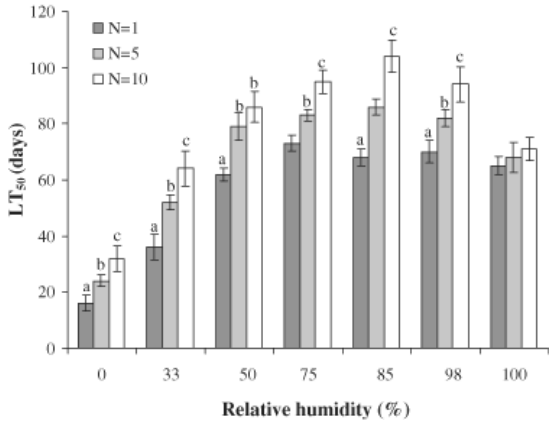
HEAT/COLD TOLERANCE

- Bed bugs are adapted for surviving long periods off host
- Dehydration is a main problem
- Treatments with heat or cold are well known from other pest insects

Relationship between water loss and body size

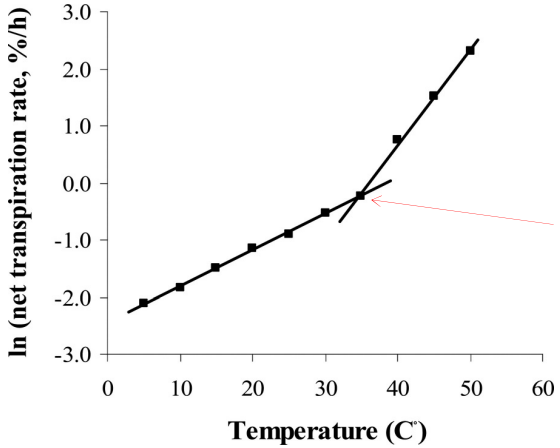


Groups of adult females resist dehydration



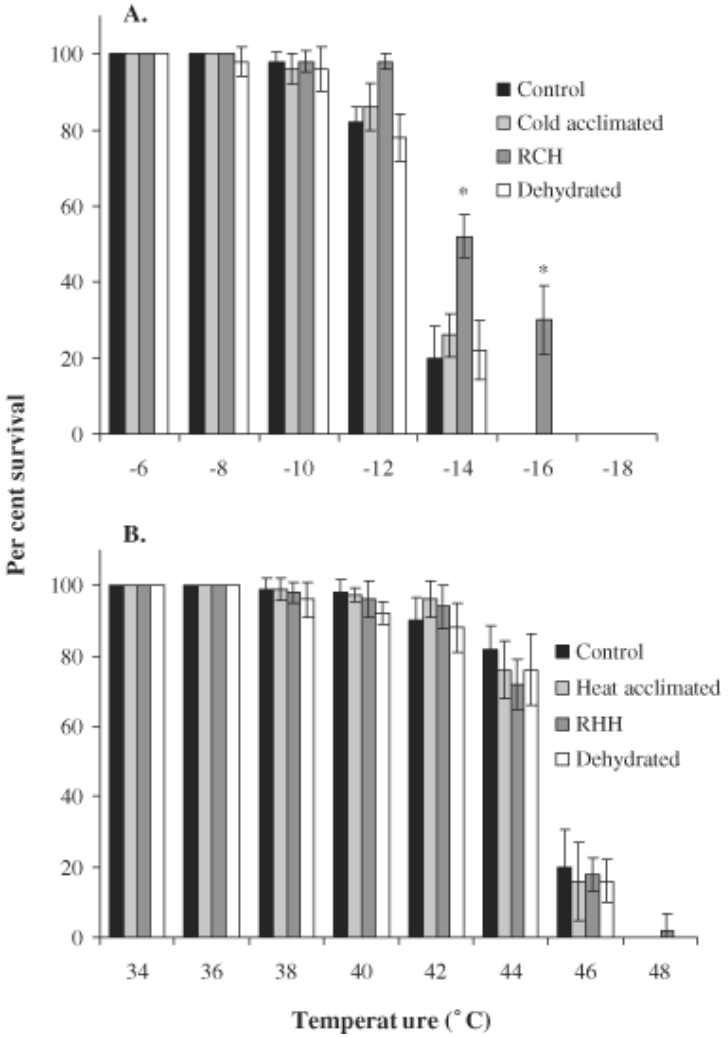
From: Benoit et al. (2009) Med Vet Entomol 23, 418

Rate of water losses from first instar nymphs at different temperatures



Critical Transition Temperature (CTT)

From: Benoit et al. (2007) Am. J. Trop. Hyg. 76, 987,



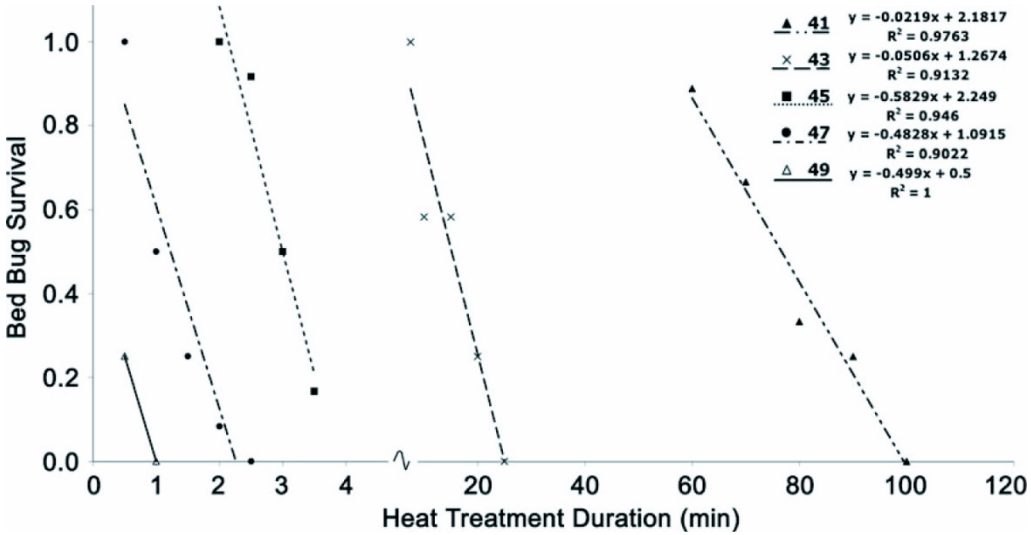
Survival of adult female bed bugs after 1 hour exposure to temperature extremes

Cold acclimation = 2 weeks at 4 ℃
Rapid cold hardening = 0 ℃ for 1 hour

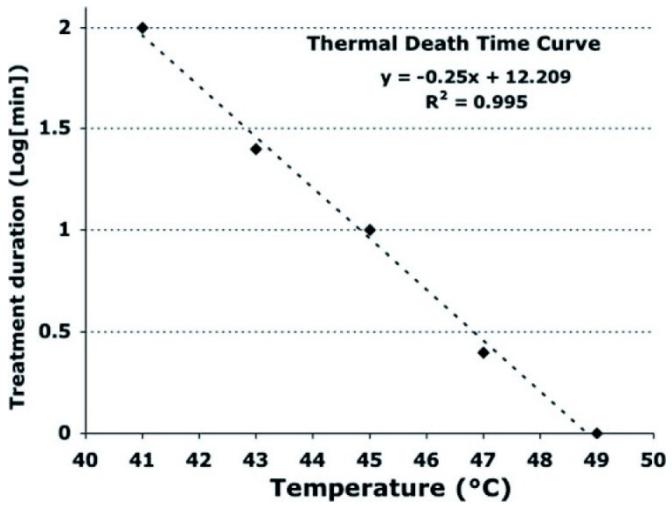
Heat acclimation = 2 weeks at 30 ℃
Rapid heat hardening = 37 ℃ for 1 hour

From: Benoit et al. (2009) Med Vet Entomol 23, 418

Mortality of adult bed bugs at different temperatures and exposure time



No mortality after 240 min exposure to 39°C
No humidity control



Relationship between exposure time and temperature to obtain 100% mortality

From: Pereira et al. (2009) J Econ Entomol 102, 1182

Temperature extremes can function in control programs

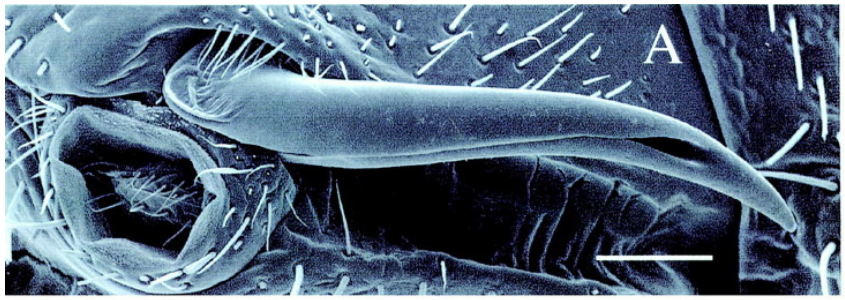
- Naylor & Boase (2010) J Econ Entomol 103, 136:
  - Washing at 40°C killed all adults and nymphs, but eggs needed 60°C
  - Hot tumbling for 30 min needed to kill all life stages (temperature >40°C after 15 in)
  - Freezing at -17°C for 2 hours kills all stages
- Systems for applying CO_2 snow against bed bugs
- Can elevated temperatures bring bed bugs out of their hiding places?

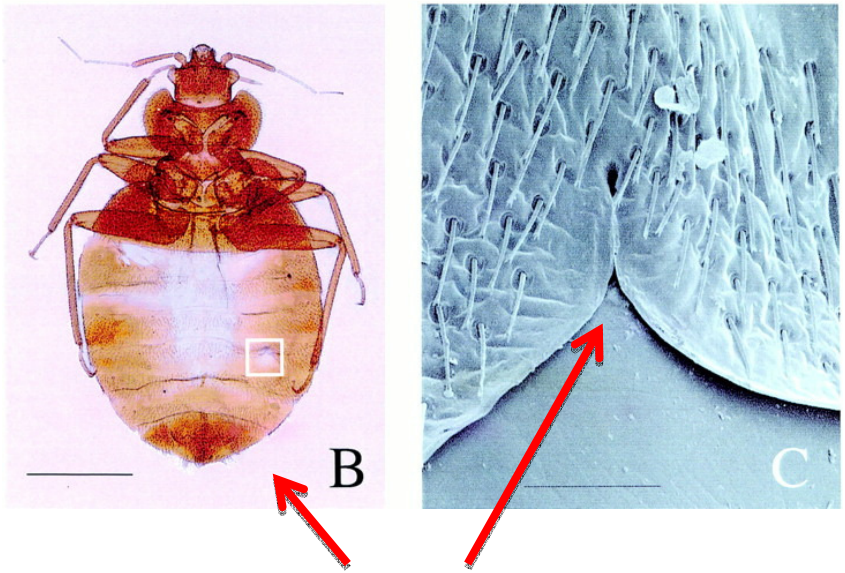
Cryonite system

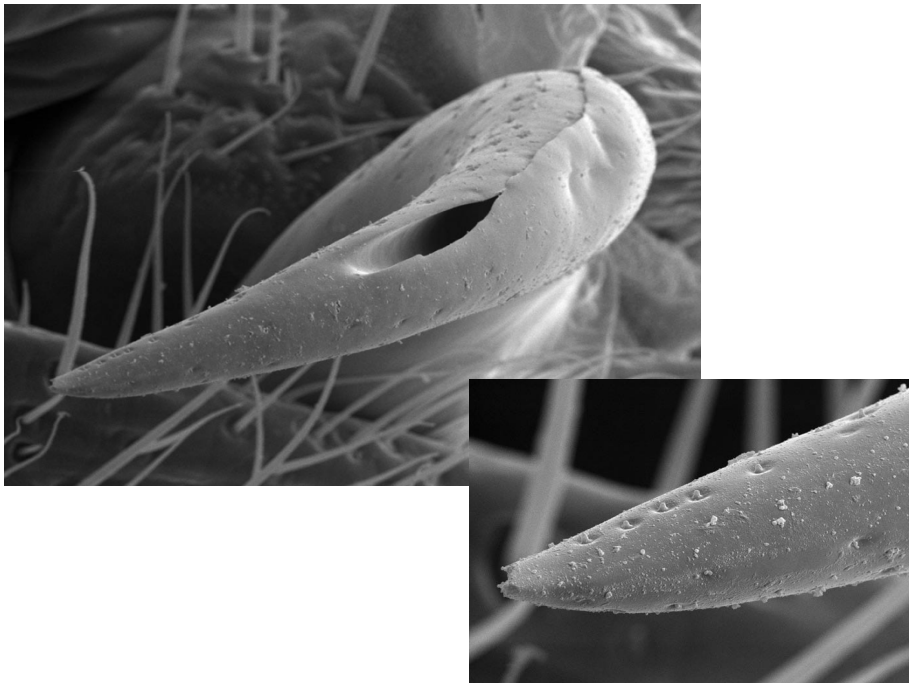
MATING BEHAVIOUR

- Traumatic insemination, may injure the female, females have evolved structures to minimize damage
- Females can be mated several times after a feeding
- Female needs new mating after 1-2 months of sexual isolation

Sensory structures on the male intromittent organ that can detect if the female is recently mated => reduction in copulation duration and ejaculate size







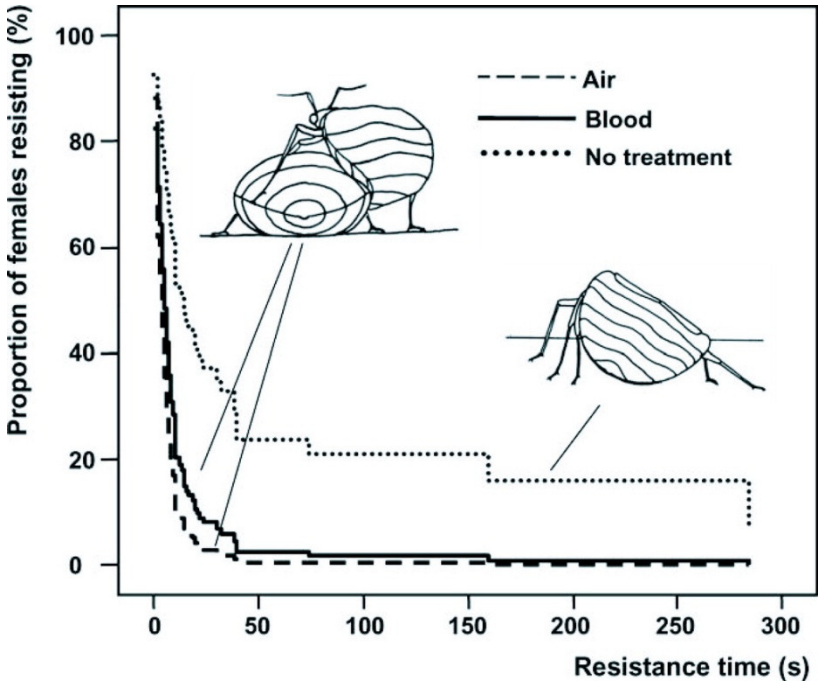
Female secondary "genital opening"
ectospermatolege overlying mesospermatolege

From: Stutt & Siva-Jothy (2001) PNAS 98, 5683

From: Siva-Jothy & Stutt, (2003) Proc R Soc Lond B 270, 649

Female resistance to male mating attempts is influenced by body size

Females release defensive chemicals to avoid matings, but this cannot explain the difference between fed and unfed females

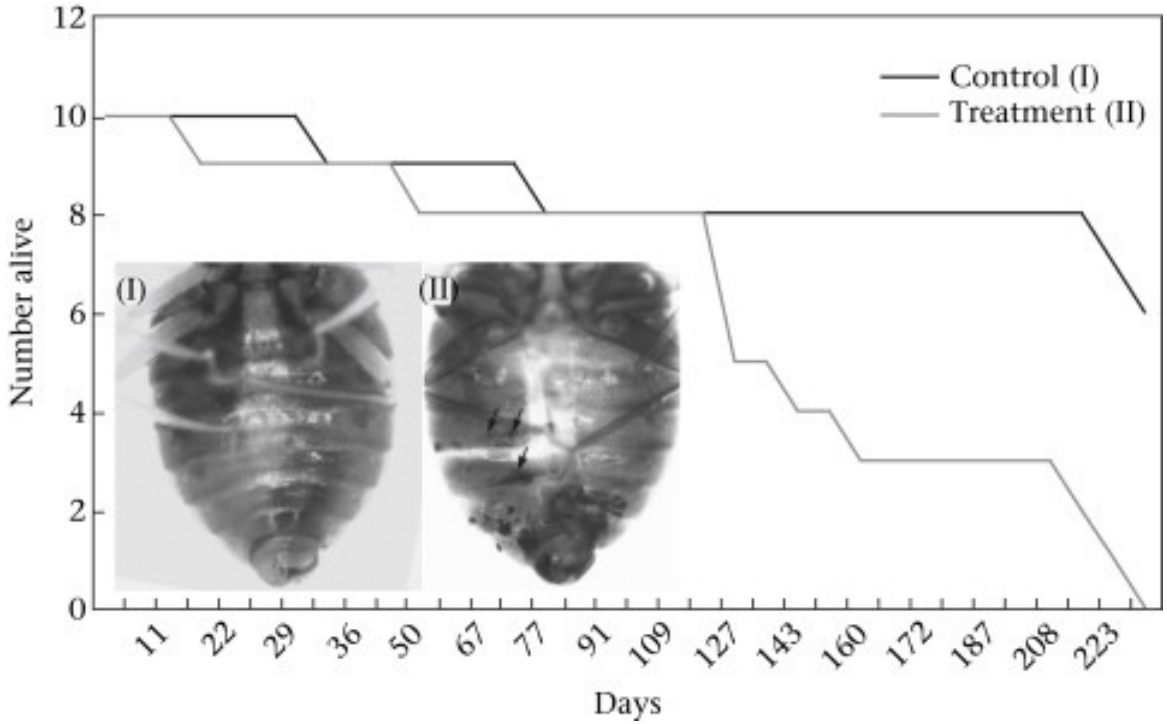


From: Reinhardt et al. (2008) Evolution 63, 29

In laboratory studies males will try to mate most other bed bugs particularly larger ones (fed)

Males release alarm pheromones to prevent mating attempts by other males

Isolated males live longer than males kept in groups of 5



From: Ryne (2009) Anim Beh 78, 1471

- Behavioural studies under more realistic conditions
- Will females ever actively search for males?
- Mating pheromones?
- Is there an interaction between female avoidance behaviour and dispersal?

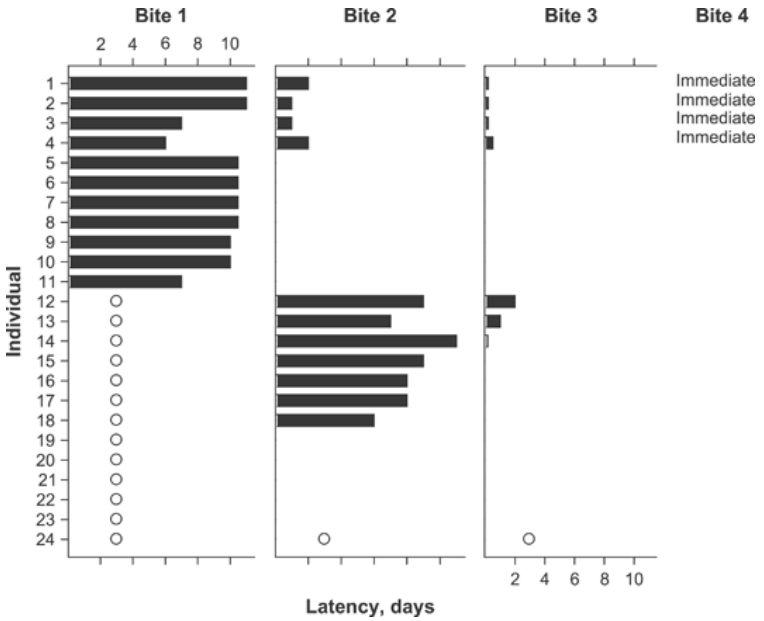
HUMAN IMPORTANCE

- Nuisance pest -no disease transmission
- Red itchy wheals -mostly on arms and legs
- Saliva causes allergic reactions
- Secondary infections, sometimes systemic reactions
- Social reactions

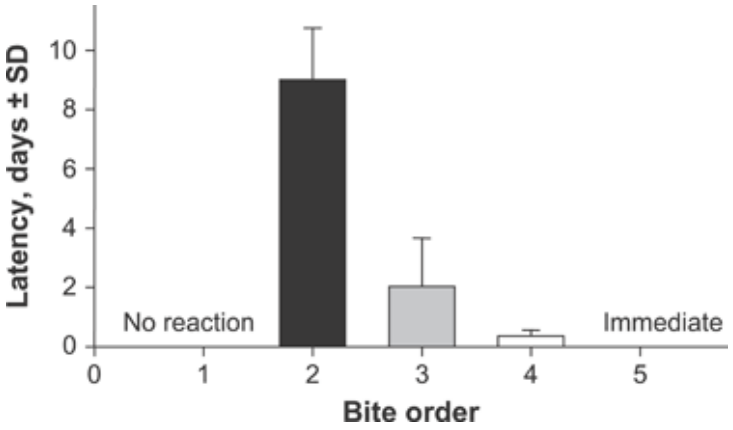
- Survey of 474 persons living in houses/apartments with known bed bug infestations of variable intensity
- 70% reported reactions to bites
- 28% of these reported itching without wheals
- No correlation with infestation level
- Older persons react less than younger
- Correlation between reaction to mosquito bites and to bed bug bites

Potter et al. PCT Febr 2010

Latency of skin reactions



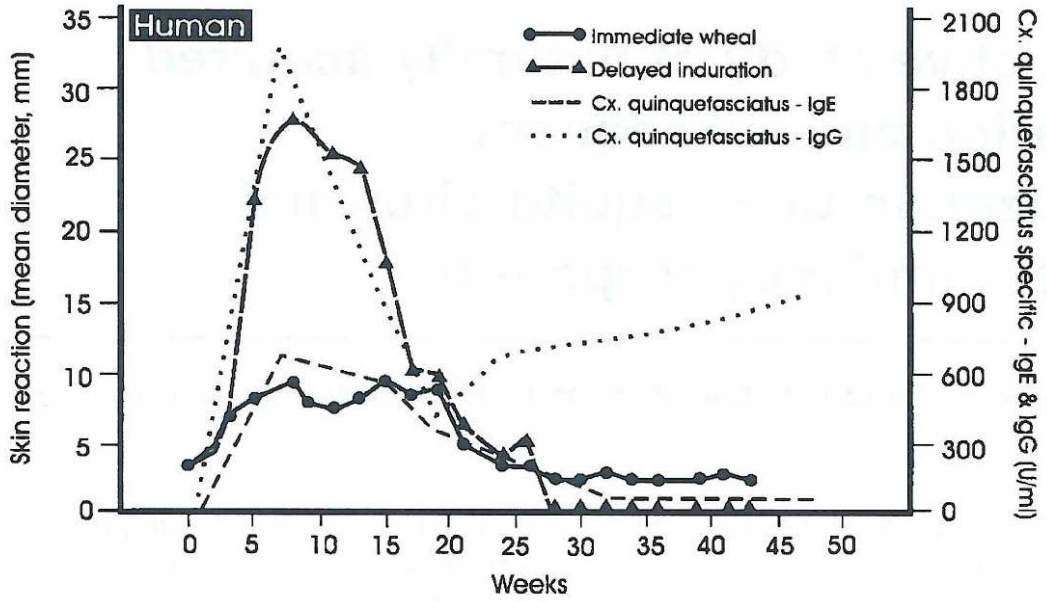
Proposed hypothetical scheme for skin reaction latency to bed bug bites



No discrimination between immediate and delayed reactions

From: Reinhardt et al. (2009) Med Vet Entomol 23, 163

Immediate and delayed immune reaction from person receiving 100 mosquito bites every 2 weeks



From: Peng & Simons (1998) J Allergy Clin Immunol 101, 284

- Variability in reactions between persons - and over time
- important for detection of infestations before dispersal

CONCLUSIONS

- The bed bug is a major urban pest problem in Europe
- Important to keep monitoring the magnitude of the problems particularly as control methods changes
- Our knowledge of bed bug biology is increasing rapidly, but still many unanswered questions
- Many new control methods relies more on knowledge of bed bug biology than traditional chemical control methods
- New EU research or coordination programs on bed bugs?