Bedbugs – a Never Ending Story

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Families feeding on arthropods and warm-blooded animals

Reduviidae



Masked hunter Reduvius personatus

Cimicidae



Bed bugs Cimex lectularius



Kissing bugs (Triatominae)



Swallow bug *Oeciacus hirundinus*

These ectoparasitic bugs harbor symbionts in their bodies that produce the essential B vitamins they lack in their blood.

Appearance

Body shape:oval, strongly flattened dorso-ventral
secondary regression of wings to wing scales;
short and broad head with two protruding compound eyes and four-lobed antennae;
the prothorax is much longer than the meso- and metathorax.

Length:up to 6 mm, after blood meal up to 9 mmWidth:about 3mm

Colour: reddish brown after sucking blood dark brown

Mouthparts: proboscis made of 2 bristles, which form a double tube and are folded below the head and the Thorax

Eggs:whitish, partially yellowish to pink-colored,
approx. 1 mm long, Ø approx. 0.5 mm

The bugs emit a typical sweet smell from special glands when disturbed.





Hosts



Bats	55
Fruit bats	2
Birds	14
Hominids	1
Humans, birds, bats, domestic and wild animals	2







Development of the bedbug









Blood Intake



Adults take up about 10 µl of blood during a blood meal (Titschack 1930).







Hosts: Humans, bats, rodents, sometimes also poultry and cats (Clark et al 2002, Johnson 1941)





Blood meal duration: 10 to 15 minutes;





The male inserts his sperm into a special mating pouch (ribagasche or berleses organ) on the fourth segment of the left side of the abdomen.

The sperm penetrate the cuticle and enter the ovary across the mixocoil.



Kopula



Medical importance

Host spectrum:

Bed bugs (larvae and adults) infect humans, pets, rodents, but also poultry to take blood.

Symptoms:

Lentil to cent-sized, very itchy wheals, which are caused by the saliva of the bugs and usually only subside after several days.

The search for a blood capillary is often stabbed several times. The sting itself is usually not noticed. In sensitive or allergic people, the bug infestation can lead to extensive skin inflammation, asthma, impairment of vision or, in extreme cases, to anaphylactic shock.

Main activity:

At room temperature, bed bugs suck blood at night, mostly in the morning, every 3 to 7 days, and more often at higher temperatures and when there is a good supply of hosts.

Transmission of diseases:

Bed bugs only play a minor role in the transmission of pathogens.

Skin reactions to bug bites









Preferred hiding places



- 1. Dark areas
- 2. No air movement and no tremors
- 3. Approximately 10 mm deep cracks and crevices that are closed at the end
 - typical thigmotaxis behavior
- 4. Rough surfaces made of wood, textiles or paper
- 5. Smooth metal, plastic and glass surfaces are avoided;
- 6. Hiding spots close to the host are preferred.

Bed bug hiding places in 13 apartments in Kentucky (USA)



- Mattress 13%
- **Bed box 13%**
- **Bedside table 0,2%**
- Other hiding places 3,1%

- Slatted frame 35%
- **Sofa, Chairs 23%**
- Walls, ceiling 2,3%

M. F. Potter, University of Kentucky

Bed bug infestations along the seams of mattresses



Distribution of different stages in the hiding places



Nymphs and adults are often found in different harbourages

Signs of infestation on slatted frames



Infested Sofas – a Challenge in Bed Bug Control



Bed bugs are often well hidden inside the sofas

Do not forget bedside cabinets and doorframes







Infestation in picture frames



Survival time of *Cimex lectularius* without feeding

Survival rate after 4 months incubation (May to September 2012)

(~20°C without disturbances) (20 animals/dish)

1st stage:	0%	
2nd stage:	75%	Survival rate at 12 months (June 2010 – June 2011)
3rd stage:	35%	
4th stage:	85%	1 st - 3 rd stage 0%
5th stage:	100%	4th – 5th stage ~20%
Adults:	85%	Adults 0%

Factors that influence the survival time of the different stages:

temperature relative humidity disturbances

Ability of the bat bug Cimex pipistrelli to starve

Survival rate of the bugs in the absence of the host:

1st stage - < 2 weeks Adults - 50% mortality at one month Eggs - high survival rate for several months



Response of bats (*Pipistrellus pygmaeus*) to bug infestation:

Leaving the nursery Change of resting areas in spacious nursery rooms





Survival strategies of the swallow bug Oeciacus hirundinis

Occurrence: Europe to Central Asia, North Africa Hosts: swallows and swifts (especially nestlings), rarely other bird species and dormouse

Laboratory breeding of *O. hirundinis* is possible with human and pigeon blood!





Hibernation in the empty nests as L4/L5 and adults

Usinger 1966, Péricart 1972, Wachmann et al 2006

Bat bug feeding on a human host



Pheromones detected on *Cimex lectularius*

Aggregation pheromones = contact pheromones alarm pheromones sex pheromones ?

- 1. E-2-hexanal
- 2. E-2-hexenol
- 3. E,E-2,4-hexadienal
- 4. E-2-octenal



Bed bugs register pheromones over a distance of 6 to 7 cm. The pheromone receptors are located on the terminal segment of the antennas

Bedbugs smell together to stay together. Anonymous (1971), New Scientist



Aggregation Pheromones

Attractiveness of adult aggregation pheromones on female +++ male ++ nymphs 4-5 +

Adults and nymphs have different aggregation pheromone cocktails!

Pheromone source	male/female	nymphs
male	+++	+
nymphs	+	+++

Male and nymph aggregation pheromones sometimes have different significance for hiding places as safe refuges for nymphs and adults.

(Levinson et al 1974; Siljander et al 2007)

Alarm Pheromones

Volatile and unpleasant smelling substances

Source -3 abdominal glands (nymphs)Metathoracic glands (adults)Effect -triggers escape behavior of bed bugs

Composition of the imagine alarm pheromone:

- 1. trans -oct-2-en-1-al
- 2. trans -hex-2-en-1-al
- 3. butan-2-one
- 4. acetaldehyde
- 5. 2 unknown substances

No. 1 and 2 are the active components of this cocktail.

No. 1 is 5x more potent than no. 2.

The composition of the alarm pheromone is different in nymphs and adults.

History of the parasite/host relationship between bed bugs and humans

The bed bug's original hosts are bats.

Transition to humans 15,000-20,000 years ago during the migrations of Homo sapiens from Africa to the north.

1. Morphological changes as a result of

2. Genetic changes, etc.

sensory adaptations ingestion of human blood adaptation to the human environment in the sequences of subunit I and 16S of mitochondrial cytochrome oxidase

Transmission of C. lectularius:



Bed Bug Management As 'Teamwork' of the PMP with the Customer

The detailed discussion with the customer is the prerequisite for a successful bed bug management;

Training of he staff (especially in hotels);

Clearly defined instructions for the customer on what actions to take;

Public buildings (fire brigade, civil protection, aid organizations, etc.): Risk of importation from cots, overalls, blankets and other items brought into the building;

questions to the customers:

Origin of newly purchased objects/furniture (e.g. 'second hand' shop, flea market or bulky waste?);

Customer travel in the last 6 months.

Previous control measures

Control measures

Residual spray barrier treatment (bed, skirting boards, door frames);

Insecticidal dusts in hiding places for bed bugs (behind baseboards, door frames, empty pipes, etc.);

Silica gel as a flanking measure in the bed bugs' favorite hiding places;

Freezing sensitive objects and textiles (-18°C/72 hours) which must not be treated with insecticides;

Fumigation mattresses, textiles, electronic equipment, stuffed animals, books, etc;

Heat treatment

Superheated steam application Mattresses, curtains, textile coverings.



Resistances



Cimex lectularius		
Organochlorines	1958	(Busvine)
Cyclodienes	1963	(Guneidy et Busvine)
Organophosphates	1968	(Feroz)
Organophosphates + Carbamates	2006	(Karunaratne et al.)
Pyrethroids	2003	(Myamba et al.)
Carbamates + Pyrethroids	2006	(Boase et al.)
Pyrethroids	2006	(Romero et al.)
Cimex hemipterus		
organophosphates + carbamates	1991	(Newberry)

Bed bugs are a global problem.

The experience of pest management in other countries should be included in the control strategies (e.g. USA, Australia*).

Doggett, S.L. (2010): Code of Practice for the Control of Bed bug Infestations in Australia. 3rd Edition. Available on-line at: <u>www.bed bug.org.au</u>.

Madge, O. (2011): European Code of Practice – Bed Bug Management. <u>www.bedbugfoundation.org</u>, Version 1, 36pp.

Pinto R.J., Cooper R. & S.K. Kraft (2007): Bed Bug Handbook: The Complete Guide to Bed Bugs and Their Control. — Pinto & Associates, Inc. Mechanicsville MD (USA): 266 pp.

Doggett, S.L., Miller D.M. & C.-Y. Lee (2018): Advances in the Biology and Management of Modern Bed Bugs (ABMMBB). Wiley Blackwell, 472 pp

Behaviour of the Cimicidae as a successful model for an ectoparasitic lifestyle

Long ability to starve; adaptation to host lifestyle; use of different hiding places;

Rapid development;

High reproductive potential.

Low host specificity (C. lectularius and C. hemipterus)

Prerequisite for monitoring and control

Think like a bed bug

Thank you for your attention

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Questions ???

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