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## ***Pediculus humanus*, human louse**

This short review is a product of hard work of bringing many lengthy, contradictory, and sometimes self-contradictory reviews to common denominator. The main focus is pediculosis caused by head lice. Review of crab louse (*Pthirus pubis*) is under development.

- **Taxonomy**
- **Brief facts**
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- **Appendix:** Reed DL et al. Genetic Analysis of Lice Supports Direct Contact between Modern and Archaic Humans. *PLoS Biol.* 2004 Nov.

## ***Pediculus humanus* taxonomy**

cellular organisms - Eukaryota - Fungi/Metazoa group - Metazoa - Eumetazoa - Bilateria - Coelomata - Protostomia - Panarthropoda - Arthropoda - Mandibulata - Pancrustacea - Hexapoda - Insecta - Dicondylia - Pterygota - Neoptera - Paraneoptera - Phthiraptera - Anoplura - Pediculidae - Pediculus - Pediculus

## humanus

- **Lice** is general name for small, wingless, parasitic insects that feed on blood. Though exact taxonomy is still controversial, they can be grouped in the suborders *Anoplura* (sucking lice), *Amblycera* (chewing lice), *Ischnocera* (biting or chewing lice), and *Rhynchophthirina* (elephant lice and wart-hog lice).
- Elephant lice suborder has just one family and one genus, *Haematomyzus*. They parasitize primarily Asian elephants and to a lesser degree, African elephant (*H. elephantus*), the warthog (*H. hopkinsi*), and the bush pig of eastern Africa (*H. porci*). They are unusual in that their drill-like mouthparts allow them to penetrate the thick skin of their host, so they are firmly attached to the skin in a "tick-like" manner (which is understandable given their hosts do not have much hair on their bodies). One fascinating fact about *H. elephantus* is that populations of the louse in African and in Asian elephants does not appear to be separable, yet the elephant species are not believed to co-exist in close proximity with each other for thousands of years. Four hypotheses were advanced to explain this phenomenon.
- *Pediculus humanus* belongs to order *Anoplura*. *Anoplura* parasitize eutherian (placental) mammals exclusively. Note: non-placental mammals are monotremes (duck-billed platypus, short-beaked echidna), and marsupials (kangaroos, opossums, bandicoots, and wombats).
- Two kinds of *Pediculus humanus* are recognized: *Pediculus humanus capitis* (human head louse) and *Pediculus humanus corporis* (human body louse, human clothing louse). The question whether they represent two distinct species or are merely subspecies of *Pediculus humanus* is still under dispute. Genetic analysis had shown significant differences between the two forms of lice, however even greater differences were found between lice from different countries. In addition, head and body

lice are able to interbreed under laboratory conditions, and it seems that sometimes head lice can infest clothing (which is different ecological niche) as successfully as the body lice.

## Brief facts

- **Pediculosis capitis** is medical name for head lice infestation.
- Louse is a vector of "classic" form of epidemic **typhus** caused by **Rickettsia prowazekii**. Currently, lice are not associated with serious medical problems.
- Most common manifestation of lice infestation is itching of the scalp caused by louse salivary or fecal antigens. Intense scratching can damage scalp skin and lead to secondary infections.
- Lice infestation causes anxiety and embarrassment which are increased by children' exclusion from school under "no-nit" policy. Lice infestations combined carry huge economical burden: lost work for parents, missed education, lost governmental grants for schools due to absenteeism, cost of therapy, etc. It was estimated that pharmacotherapy alone for head lice infestations costs the US economy hundreds of million dollars per year.
- The golden standard for diagnosing head lice infestation before and after treatment is finding a mobile louse form (adult or nymph) in the hair. Presence of eggs (nits) that remained on the hair after the treatment does not signify failure of the treatment especially when they were located more than 1 cm from the scalp.
- Immunization of the organism to the lice may occur during active infestation and protect the host from next infestations: antibodies circulating in the blood cause digestive failure in the feeding lice, lessen their fecundity and egg viability. This is why lice infestations on sick hosts with immune deficit are usually more severe. There was a case when after

infested person was cured from primary illness (meningitis), lice "died out naturally" without special anti-lice treatment (personal communications).

## Developmental stages (life cycle)

### Life Cycle Stages

The development from egg to egg-laying adult takes from 15 to 23 days. The optimal laboratory conditions for rearing head lice eggs are 27-31 °C and 45-75% relative humidity.

- egg

eggs are laid within 14-18 hours after mating; eggs are firmly attached to hair close to the scalp by "cement" or glue consisting of peptides and lipids that are very close in composition to some components in human hair (this is why egg-loosening agents might damage hair); egg stage is most resistant to pediculicides; egg casings found on hair are often called **nits**; nit may or may not contain a viable egg; egg stage takes from 7 to 12 days

- egg with eyespot

nervous system started to develop around day 4<sup>th</sup> after laying, from this point in development eggs can be killed with agent that act on nervous system of lice

- nymph

immature louse; nymph molts 3 times

before becoming mature egg-laying adult; this stage takes from 8.5 to 11 days; second treatment by pediculicide need to be applied within this time

- 1<sup>st</sup> instar nymph

nymph that hatched from the egg; the nymph has to start feeding immediately in order to survive

- 2<sup>nd</sup> instar nymph

nymph after first molting (changing the exoskeleton in order to grow)

- 3<sup>rd</sup> instar nymph

nymph after second molting; on this stage lice become sufficiently mobile to undertake transfer to the next host

- mature adult

young mature female louse lays up to 9 eggs daily for period of 8-9 days after single insemination, with time her fecundity decreases; adults live for up to 32 days taking blood meals every 4-6 hours; during adulthood lice are most motivated to transfer to another host; lice crawl with speed 6-30 cm per minute; they cannot jump or fly; in many cases lice are caught during the re-location and infestation is prevented

## Main concepts

- **Drug resistance:** under pressure of widely used pediculicides lice accumulate changes in their metabolism that render them unsusceptible to agents and formulations that were up to 99% effective a decade ago. For example, in the United States, lice developed resistance to many OTC formulations containing pyrethroids and lindane but not to malathion. Whereas in the United Kingdom malathion-resistant lice are not rare. In other words, lice drug resistance varies depending on the region: even within same country different lice lineages differ in resistance to drugs.
- **Ovicidal agent** is an agent which kills eggs as well as nymphs and adults.
- **One treatment vs two treatments:** one treatment is required if the formulation reliably kills eggs and adults; two treatments usually 7-9 days apart are required to kill all adults and nymphs on day 0 and then to kill all hatched nymphs that did not lay eggs yet (it is why timing is so important).
- The head lice are **obligate** parasites - ideally all stages of development have to be completed on the host, except for the time when adult louse senses that another potential human host is in close proximity and may undertake a short trip in attempt to re-locate to the new territory; head-to-head transmission mode is described as most common. Behavioral characteristics of lice that facilitate their spreading are not fully investigated, although overcrowding should stimulate lice to leave the host and increase their transmittability.
- **The lice are not like ticks:** "stray" louse does not sit and wait in an ambush waiting to be picked up by a passer-by - it starts suffering from dehydration and starvation right away and quickly loses its viability and ability to resume feeding and egg-laying.
- **The lice do not have dormant stages** that allow them to survive harsh conditions or off the host for long periods of time: theoretically viable loose eggs can hatch in the favorable environment but if the newly hatched nymphs do not have access to the blood right away they die almost immediately (they will not even have enough time to reach the scalp if they were caught at the end of the hair). Lice attach their eggs firmly to the hair and very close to the scalp to assure their youngs will have the first blood meal as soon as possible. This is why it is not necessary to throw away linen, pillows, etc. Extremists

can "incubate" all objects that theoretically may contain loose eggs or viable lice in plastic bags for 12-13 days but it is not recommended.

## **Pediculicides (not exhaustive list)**

- **Dichlorodiphenyl- trichloroethane (DDT)** was the first insecticide used in the treatment of lice. DDT was withdrawn from the market during the 1980s because of poor ovicidal activity, possible toxicity and growing resistance of the lice to the chemical.
- **Naturally occurring pyrethrins** (chrysanthemum flowers) cause respiratory paralysis and death. The pyrethrins can be allergic.
- **Permethrin** is a synthetic pyrethrin with same mechanism of action. Cases of lice resistance to permethrin in the United States are largely documented. Permethrin is main component of majority of OTC formulations and is marketed as pediculicidal as well as ovicidal agent. Two applications are recommended.
- **Piperonyl butoxide** is usually used in combination with pyrethrins. It is neurotoxic for lice and eggs with developing nervous system.
- **Lindane or gamma benzene hexachloride** is an organochloride. The product was taken from the U.S. market in 2003 because of potential neurotoxicity and other side effects as well as growing lice resistance to the agent and low ovicidal activity.
- **Malathion** is an organophosphate cholinesterase inhibitor that disrupts neurotransmission at acetylcholine receptors leading to death. The most effective formulation contains isopropyl alcohol and terpineol (tea tree extract). The formulation has unpleasant odor. The malathion containing formulations are only available by prescription in the US. Lice resistance to malathion was reported in the United Kingdom but not in the United States. Only one application is usually required. Malathion is considered more effective than pyrethrins.
- **Carbaryl** is not available in the United States and is sold in the United Kingdom by prescription only.

- **Antibiotics such as trimethoprim/sulfamethoxazole** were found effective when taken orally, presumably by killing symbiotic bacteria in guts of feeding parasites and causing vitamin B deficiency.

## Recommended measures

- **Laundering linen and other washables** (stuffed toys, hats, clothing) in warm 50-60 °C water following with 15 min drying in a heated dryer kills loose lice and eggs.
- **Not sharing toiletries and combs** prevents from other pathogens' transfer, not only lice.
- **Routine screening:** if child was noticed to scratch his/her head more frequently and vigorously as usual, parents are encouraged to examine the child's hair and scalp closely, using wet combing techniques if necessary.

## Unorthodox or alternative measures

- **Head shaving:** although effective because it deprives the lice of their primary egg-laying environment, it can be traumatic for school children psychologically, so deciding whether it is a choice depends on the situation. This measure can be warranted in military settings, in prisons, during mass epidemic of lice-transmitted diseases such as typhus, etc.
- **Herbal therapy:** some botanical extracts are considered pediculicidal, because they contain plant oils with high concentration of monoterpenoids - naturally occurring insecticides. The following plants are used in herbal therapy: cardamon ceylon (*Elettaria cardamomum*), clove bud, myrtle, rosewood, eucalyptus, tea tree, neem (*Azadirachta indica*), lavender, jeranium, and several other plants.

## Not recommended or unnecessary measures

- **Spraying bedclothes with permethrin-containing formulation:** it does not kill a stray louse or loose eggs unless

it fell directly on them, maybe not even then; stray lice are sufficiently rare to pose a real threat of re-infestation, also lice can survive for 6-24 hours off-host but become unable to feed far before this time because of dehydration and starvation; eggs are more resilient but re-infestation by eggs is remote because of many factors.

- **"Suffocating lice"** by heavy application of petroleum oil, butter, mayonnaise, etc.
- **"Intoxicating lice" by household chemicals** such as vinegar, isopropyl alcohol, kerosene, etc.
- **Wet hair combing used exclusively** - labor and time consuming, and tedious - wet hair combing is considered ineffective when used without pediculicidal drugs.
- **Increasing pediculicide concentration or a number of recommended applications:** if treatment failed because lice were resistant to the drug or combination of drugs, none of the above mentioned strategies will work.
- **"No-nit" policy in schools:** more often than not children are immediately excluded from school if nit or even nit-like object was found in child's hair. These policy is considered obsolete.

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### PubMed articles

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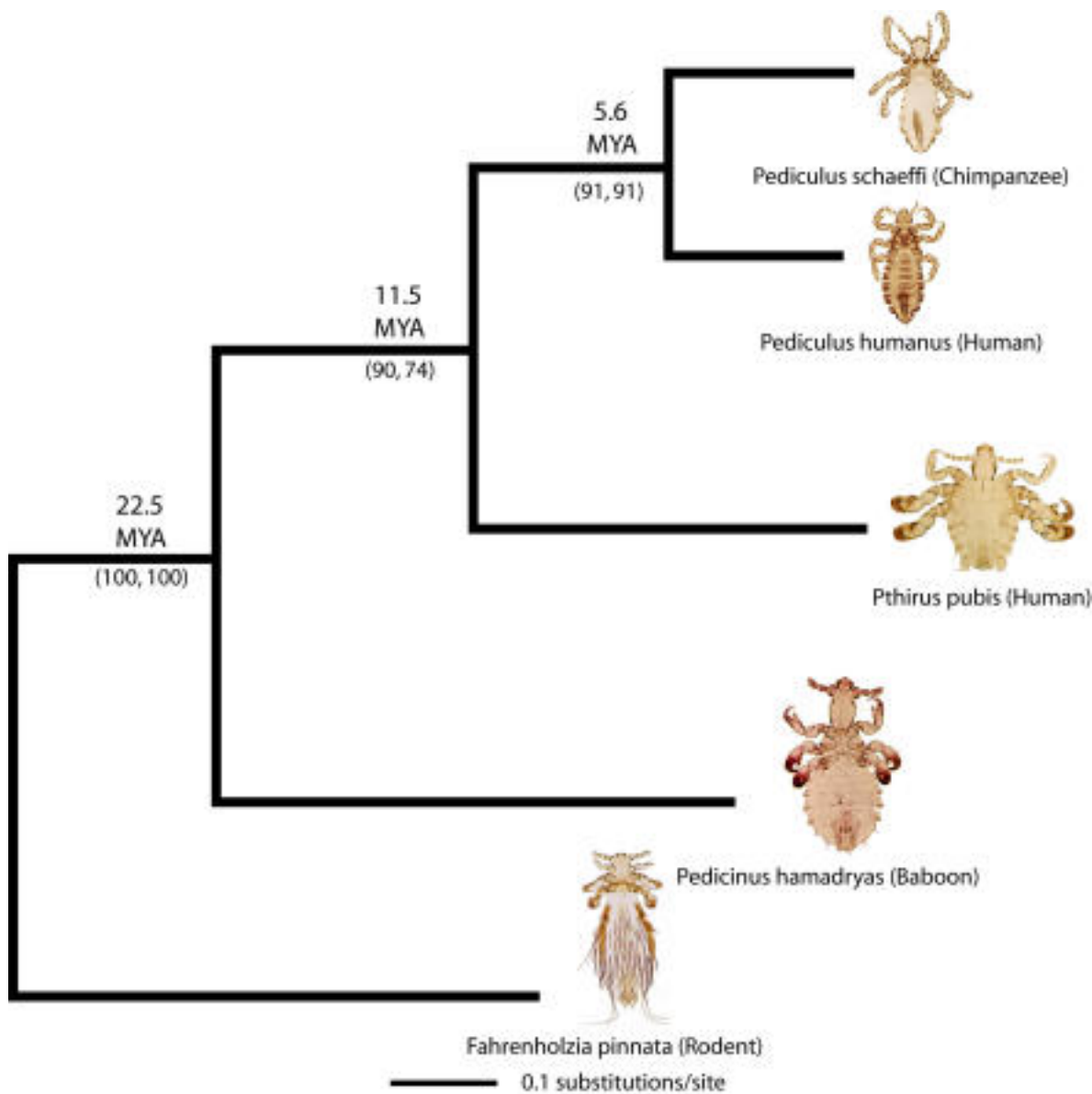
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## Websites

- **Phylogeny of the lice (Insecta, Phthiraptera) inferred from small subunit rRNA by Barker SC et al., 2003 (.pdf)**
- **A new species of *Haematomyzus* Piaget (Phthiraptera, Insecta) by Theresa Clay, 1962 (.pdf)**

## Appendix

Reed DL et al. Genetic Analysis of Lice Supports Direct Contact between Modern and Archaic Humans. *PLoS Biol*. 2004 Nov. **PMID: 15502871**



*P. humanus* is one of a few ancient host-specific parasites of primate and humans whose evolution goes hand in hand with evolution of its hosts for millions of years. Parasites can be powerful tool for reconstructing host evolutionary history because they provide data that are independent of host data. Molecular studies show that the modern human head lice, *P. humanus*, are composed of two ancient lineages, whose origin predates modern *Homo sapiens* by more than million years. One of the two lice lineages is distributed worldwide whereas the other lineage is found only in the New World where it appears to be isolated for some 1.18 million years. The ancient divergence between these two lice is contemporaneous with a split between now extinct archaic species of *Homo* and the lineage leading to modern *H. sapiens*. How two lineages of lice converged again in the modern species of lice? Authors hypothesize that lice parasitized on modern humans were brought in contact with the lice that parasitized on co-existing at the time archaic humans by direct physical contact between modern and

archaic forms of *Homo*. Introgression between the two lineages of lice allowed archaic lice to switch to modern *H. sapiens* hosts.

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