How do Echinophthiriidae on seals survive months of immersion? – A hypothesis for debate

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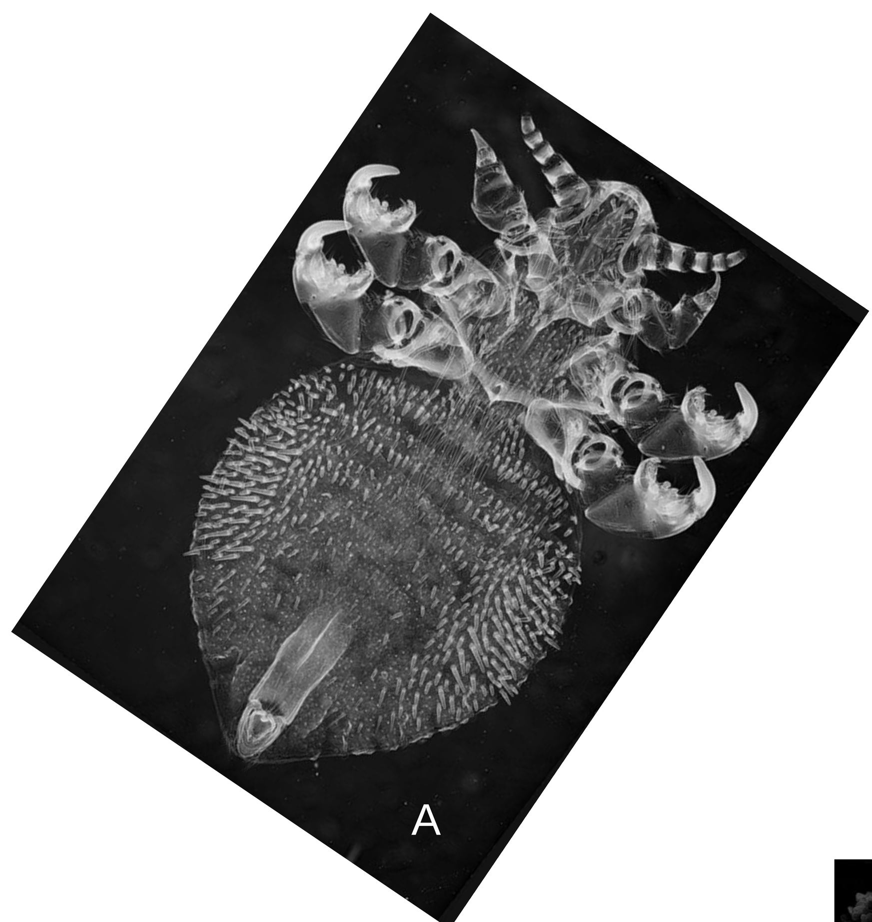
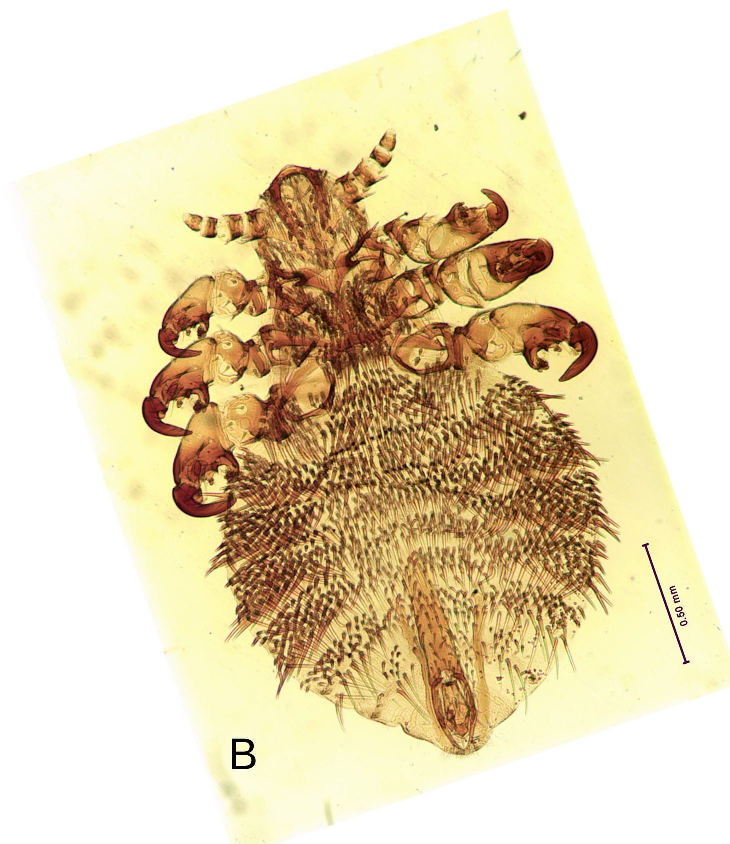
Introduction

Echinophthiridae are anopluran parasites of seals and a few other aquatic/marine species that are physically unusual, even bizarre, in appearance. All echinophthirids bear densely clustered long setae and scale-like setae on their cuticles (Figure 1).





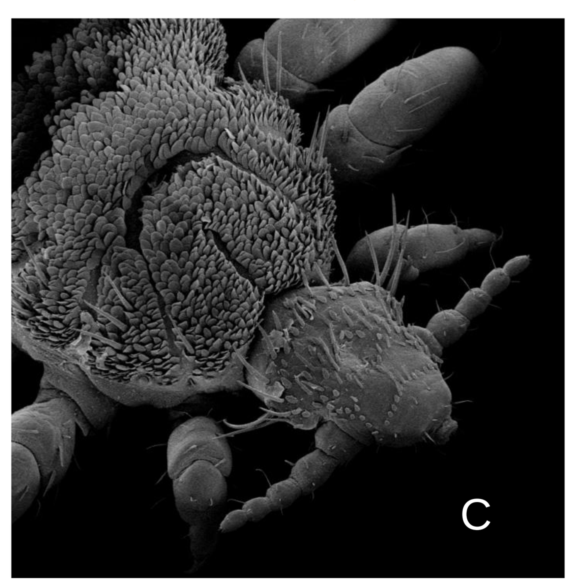


Figure 1. *Antarctophthirus microchir* (A); *Echinophthirius horridus* (B); *Antarctophthirus trichechi* (C) to show the numerous cuticular setae and scales

Because of their host selection, on seals, sea lions, and otters, echinophthirids may face restrictions of habitat on their hosts due to:

- Limited access to skin for feeding
  - Almost all the body hairy except the flippers
  - Extremely dense under coat makes penetration to skin difficult
- Lice often exposed to temperatures <5^o Celsius

All species inevitably spend a considerable proportion of their lives immersed in water, and on large seals, e.g. Elephant seals, this may be for up to 8 months at a time.

Clearly the lice cannot breath under water. But lice can survive for long periods without breathing, e.g. *Pediculus* immersed in fresh water can survive long periods, but they suffer osmotic influx of water within 24 hours. In sea water endosmosis is not a problem but, how to Echinophthiridae manage to get the right amount of oxygen to stay alive?

Survival in water

All Anoplura are adapted to moderate tolerance of immersion in water. After all most mammals have experienced periods when their coat remains soaked for hours or days at a time. All lice have spiracles that inhibit water ingress. However, in the Echinophthiridae this is taken to more extreme lengths than in other groups because their host pelage does not trap air, and they are constantly immersed for long periods.

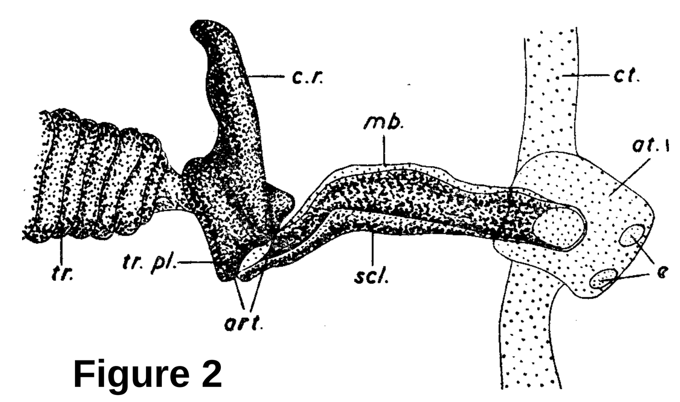


Figure 2. Diagrammatic representation of the abdominal spiracle atrium and distal trachea of *Antarctophthirus microchir*, showing protruding atrium and robust triangular closure plate.

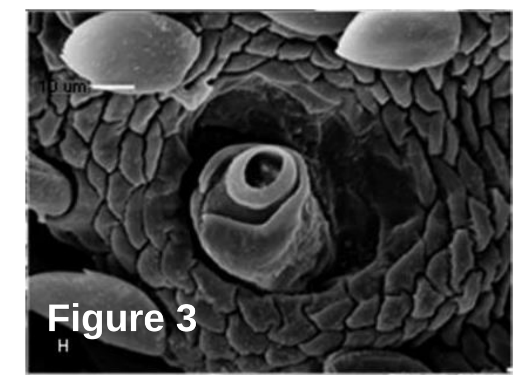


Figure 3. SEM of the opening of the spiracle atrium of *Antarctophthirus microchir*

Ferris suggested that seal lice may take breaths of air at the same time as their hosts when they surface – but, since most lice are on flippers when at sea and the flippers of most seals only leave the water while resting, this seems unlikely.

Murray suggested they may take up oxygen from the surrounding water by diffusion through the thinner cuticle on the ventral side of the thorax.

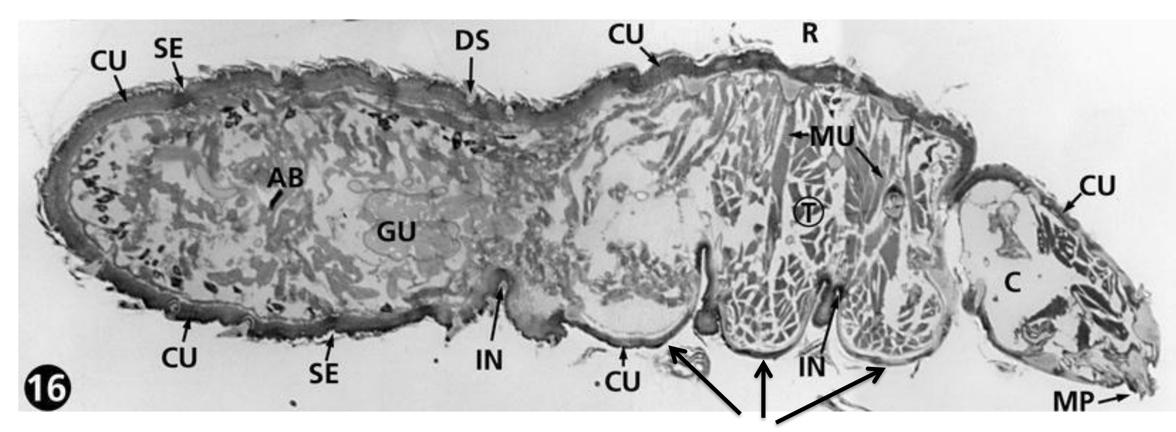


Figure 4. Section of *Antarctophthirus ogmorhini* showing thick cuticular integument on the dorsal surface and thin cuticle on the ventral surface (arrowed)

But, he also observed that lice burrowed into the host epidermis and remained in the burrow where there would be little exposure to flow of oxygenated water. More likely the thin cuticle facilitates uptake of heat from the host skin, which can occur as blood flow increases in the flippers when seals surface from a dive.

How much oxygen do these lice need anyway? They don't move about under water, they don't lay eggs or mate, and nymphs usually do not survive the swimming period. But they do feed even when immersed – presumably because the spiracle structure effectively prevents blockage, so they do not become immobilised in the same way as terrestrial lice whose spiracles become "blocked" when immersed or if the atrium is filled with fluid. Blocked lice appear to die because they run out of energy through starvation rather than from lack of oxygen.

Too much oxygen?

Murray showed that *Lepidophthirus macrorhini* survived for weeks unfed at 5-10^o C but on flippers, whether in water or out they all died in 10 days at temperatures between 15^o and 25^o C. This suggests they need to keep cool, and he also found that oxygen metabolism increased 5-10 fold between 10^o and 30^o C.

Lice on flippers feed at intervals under water . Seal blood contains more haemoglobin, more oxygen-efficient haemoglobin, and more erythrocytes than other mammals. Thus each blood meal has a high oxygen content.

In some cases the ingested blood may be too oxygen rich and has been shown to be quite toxic, for arthropods which is why most terrestrial insects limit spiracle opening and mainly use them for expiration of carbon dioxide.

- Thompson found a negative correlation between louse numbers and total erythrocyte count, haematocrit, and haemoglobin concentration for *Echinophthirius horridus* on harbour seals

- Murray found that lice on flippers of restrained seals lived only a few days in warm water – probably because the increased blood supply was over rich in oxygen.

I postulate that intermittent feeds by echinophthirids provide more than enough oxygen for the lice to sustain themselves, and there is no requirement to obtain oxygen by other means.

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