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Biodiversity and Evolution of Parasitic Life in the Southern Ocean

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Chapter 10
Lice on Seals in the Antarctic Waters and Lice in Temperate Climates

Birgit Mehlhorn and Heinz Mehlhorn

10.1 Introduction

Lice (Phthiraptera) are ectoparasites, which stroll on the surface of their warm-blooded hosts. The members of the suborder *Anoplura* suck blood, while the so-called biting lice (*Mallophaga*) feed on skin particles and/or hair of their hosts. The species of the skin feeding mallophages parasitize practically exclusively at terrestrial animals, while among the bloodsucking species of the Anoplura also semi-aquatic species exist, which parasitize permanently at marine mammalian animals.

It is known since 200 years that the bloodsucking lice may occur on the skin – especially along the flippers – of marine mammals in cold or even polar regions (von Olfers 1816). Comparing the facts known at this time and looking at the material obtained during several German South Polar expeditions, Enderlein described the new genus, *Antarctophthirius*, in 1906 with the type species *Antarctophthirius ogmorhini* (Enderlein 1906). This taxonomic work includes four genera (*Proechinophthirus, Echinophthirus*, *Lepidophthirus,* and *Antarctophthirus*) within the family Echinophthiriidae. Leonardi et al. (2014) published a survey on the recent status of body lice of such aquatic (often Antarctic) biotopes in our days. These authors listed 13 lice species (belonging to 5 genera) within the single family Echinophthiriidae.

The genus *Antarctophthirius* contains up to now seven recognized species:

- *A. callorhini* on fur seals
- *A. microchir* on sea lions

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- *A. trichechi* on walruses
- *A. lobodontis* on Antarctic true seals
- *A. ogmorhini* on Antarctic true seals
- *A. mawsoni* on Antarctic true seals
- *A. carlini* on Weddell seals

The other six species belong to the following four genera:

- *Echinophthirius* (1 species: *E. horridus* on Antarctic true seals)
- *Lepidophthirius* (*L. macrorhini* and another species on Antarctic true seals)
- *Latagophthirius* (1 species on river otters)
- *Proechinophthirius* (*P. fluctus* and another species on fur seals and sea lions)

However, the exact host specificity of these species is not completely elucidated. For example, *A. ogmorhini* is found on the leopard seal (*Hydrurga leptonyx*) and on the Weddell seal (*Leptonychotes weddelli*), while *A. callorhini*, *A. trichechi*, *A. lobodontis,* and *A. mawsoni* are considered as host specific. However, the available data material is rather scarce due to the fact that it can only be obtained during rather short expeditions.

Anyway, all these bloodsucking insects have to survive the influences of high-graded saltwaters, very low temperatures as well as high pressures, since their hosts are divers catching their food often in deeper zones (up to 450 m) of their water biotopes (Plötz et al. 2001).

10.2 Morphology of *Antarctophthirius ogmorhini*

The morphology of the until now described seal lice species is rather similar, so that the following features obtained from studies on *A. ogmorhini* will cover the available sound facts of the whole group (without neglecting species specificities).

10.2.1 General Aspects

1. All stages have a moderately swollen (rounded) hind body (Fig. 10.1) with visible borders of the segments. The abdomen of males appears more ovoid than spherical.
2. Their eyeless, conical head is longer than wide (Fig. 10.2).
3. The antennae of the adults have five segments which appear marbled in light microscopy by broad, dense annuli (Fig. 10.2).
4. The forelegs are smaller and more slender than the middle and hind legs and are equipped with claws being different from those of the other legs (Figs. 10.1 and 10.2). The claws of the foreleg appear needle-like, while those of the other legs are strong and bended.

Fig. 10.1 Prof. Dr. Mehlhorn and a veterinarian colleague from the German Dallmann Summer Research Station on King George Island (Antarctica) checking elephant seals (*Mirounga leonina*) for lice

Fig. 10.2 Light micrograph of a female louse of the species *Antarctophthirius ogmorhini* attached at a hair

5. The quadratic thorax of all stages is closely connected to the abdomen (Fig. 10.1).
6. The pseudopenis of males appears v-shaped.
7. Females have patches of genital setae which are arranged convergently.
8. The dorsal and ventral surfaces of the abdomen are covered by differently shaped scales which apparently trapped bubbles of air around the body.
9. The dorsal and ventral surfaces are covered with strands of stout spines of different lengths which appear in different arrangements.
10. The intersegmental regions of the thorax and the abdomen are insignificantly invaginated compared, for example, to lice from terrestrial mammals (e.g., pigs and humans).
11. The outer margin of the abdomen does not form deep invaginations along the border of segments, but is rounded, giving rise to a more or less spherical appearance of the whole abdomen especially in females.
12. The females glue their eggs onto the hair of the seal with the operculum pointing towards the tip of the shaft.
13. The glue is so tenacious that it cannot be dissolved without disrupting the hair, although it covers only one fourth of the egg.
14. The ovoid eggs (Fig. 10.3) reach a length of about 0.4–0.5 µm and thus are large compared to the size of the females (Table 10.1).
15. The egg operculum (cover) has in contrast to human head lice only a single, rather large opening (stigma) being situated in the center of the cover (Fig. 10.3). This is in contrast to the nits of human head lice, where several small openings occur at special place of the operculum.

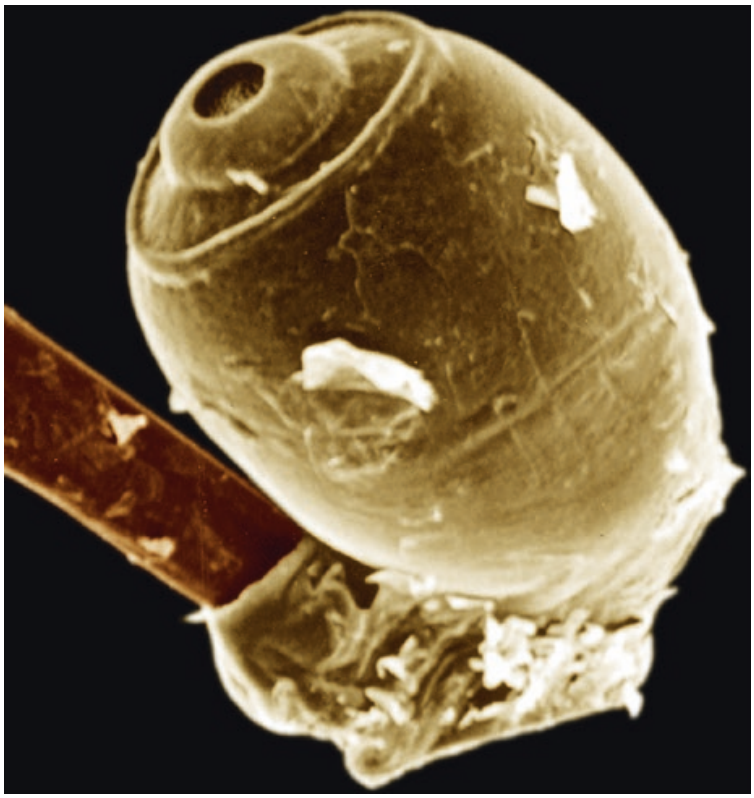

Fig. 10.3 Scanning electron micrograph of an egg of *Antarctophthirius ogmorhini*. Note the central opening on the upper surface of the operculum

Table 10.1 Body measurements (length) of some "aquatic" lice

Species	Males (mm)	Females (mm)	Body shape
Antarctophthirius carlinii	2.29 (±0.23)	2.77 (±0.52)	Ovoid-spherical
Antarctophthirius microchir	2.48 × 1.26	2.78 × 1.64	Ovoid
Antarctophthirius ogmorhini	2.0 × 1.2	2.2 × 1.3	Ovoid

10.2.2 Peculiarities of *Antarctophthirius ogmorhini*

1. The diameter of the cuticle is rather thick compared to sucking lice from terrestrial hosts and reaches about 1/6–1/10 of the whole diameter in the abdominal region of the body.
2. In general, it has at least double the width on the dorsum compared to the ventral part of the body.
3. The cuticle of the head is thinner than that in other portions of the body.
4. At the segmental borders of the abdomen, the cuticle is rather smooth and the plates are connected by intersegmental membranes.
5. Along the inner side of each of the three thoracic segments, a thick ridge is formed which is used as an anchor-point for strong muscle strands. These ridges are also visible from outside (Fig. 10.2) and run to a central point in the metathorax, where a depression can be seen when seen from above.
6. The thorax and the abdomen are closely covered by small scales which are arranged in a tile-like manner. The scales of the dorsal side of the body appear like the leaves of a European lime tree on the dorsal surface, while those on the ventral side of the body have an arrowhead shape on the ventral surface. In both cases, however, there was some air-filled space between the scales and the solid layers of the cuticle. This space is apparently filled by air bubbles during diving.
7. The segmental plates of the thorax and the abdomen, as well as the head, are spotted with regular rows of short, arrowhead-like, solid spines which are formed by the cuticle. These spines, which are directed obliquely to the posterior end of the louse, are shorter and broader in the head region and along the mid-thorax and abdomen, while they were longer and more pointed on the lateral sides of the body. These spines are apparently used to envelope the louse in a thick layer of the seal's sebum and thus provide another additional means of protection against low temperatures.
8. The dorsal hind border of the head as well as the dorsal surface of the thoracic segments has symmetrically arranged, long, cuticular hairs. These are found in a semicircular arrangement on the head, but occur only at the margin of the thorax (mostly in groups of four).
9. At the posterior end of the lice – especially around the genital openings – smooth hairs are found. These are considerably shorter than the thoracic hairs but longer and smoother than the body spines.
10. Similar, rather short hairs can be seen along the five segments of the relatively thick antennae, which appear striated due to alternating dense and white bands when studied by help of light microscopy. Other fine hairs can be found on the segments of the legs.

10.2.3 Comparisons to Other Lice

1. All genera of Antarctic lice of pinnipedia except for *Echinophthirius* have forelegs, which are smaller than the middle and hind ones. A similar phenomenon is seen in the human crab louse *Phthirus pubis* (Figs. 10.4 and 10.5), while human head and body lice (*Pediculus humanus capitis, P. h. corporis*) have legs all of the same size and shape (Figs. 10.6, 10.7, and 10.8).
2. The cover (operculum) of the lice eggs of other species is different and seems species specific, too (Figs. 10.3, 10.4, 10.5, 10.9, and 10.10).

Fig. 10.4 Scanning electron micrograph of an egg of the human head louse *Pediculus humanus capitis*

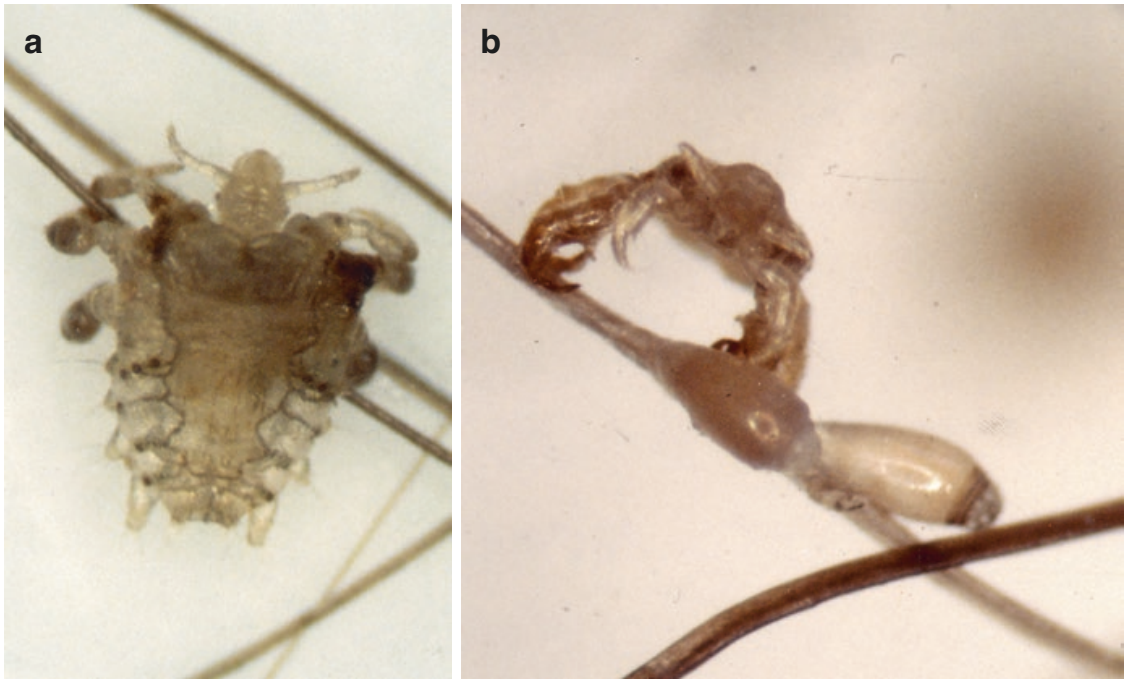

Fig. 10.5 Light micrographs of an adult human crab (pubic) louse (**a**) *Phthirus pubis* and the egg (**b**)

Fig. 10.6 Light micrograph of a human head louse

Fig. 10.7 Scanning electron micrograph of a human body louse (*Pediculus humanus corporis*) and its eggs on clothes

Fig. 10.8 Scanning electron micrograph of a pig louse (*Haematopinus suis*). Note the prolonged head

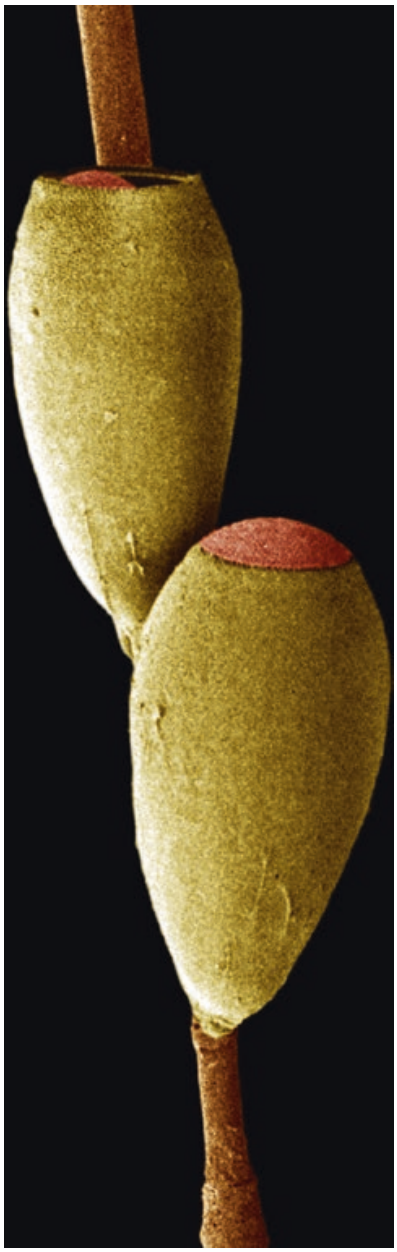

Fig. 10.9 Scanning electron micrograph of two eggs of the pig louse *Haematopinus suis*. One egg is empty (the larva has hatched and thus the cover is lacking)

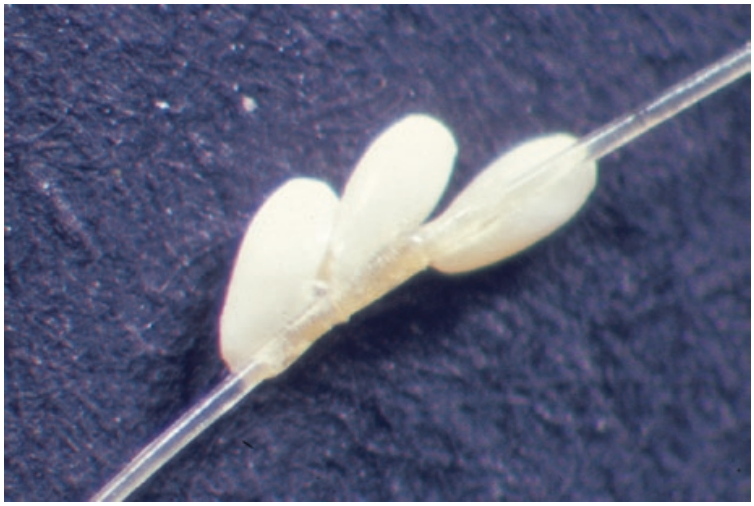

Fig. 10.10 Light micrograph of eggs of the pig louse *Haematopinus suis*. Note their whitish appearance

3. All species studied so far have a characteristic body shape. While the closely related human body lice and head lice have, for example, a rather slender abdomen with marginal striations at the segmental borders, the hind body – especially in species of the genus *Antarctophthirus* – appears more ovoid to spherical with rounded margins, although the segmental borders are visible even at low magnification. The abdominal and thoracal portions of the pubic louse (*Phthirus pubis*) appear fused and thus appear unique (Fig. 10.5).
4. The outer surface of lice of the family Echinophthiriidae is absolutely unique and apparently represents an adaptation to the cold temperatures in the biotopes of their hosts.

   (a) The body surface is covered with regular rows of *stout spines* of a species-specific length. Those of *A. ogmorhini* are medium-sized in comparison to *Echinophthirius horridus*, *Lepidophthirus macrorhini,* or *A. trichechi* (Murray 1976; Scherf 1963). The spines on the ventral surface of the body and on the outer body margin are considerably larger and thicker than those on the mid-body and thorax. The main function of these spines became evident in our scanning electron micrographs. They are apparently used to fix a thick layer of the seal's sebum to their body surface. This sebum layer would offer protection against low water temperatures. The contact of the host's body surface with the spines of the lice probably induces an increased production of sebum.
   (b) In addition to these stiff body spines, there is *longer hair* seen on the dorsal surface of the louse's body. These thoracic hairs – probably representing sensillae (setae) – are species specific. Thus, *A. ogmorhini* has groups of four while *A. trichechi* (Scherf 1963) has only two on each side. The function of these longer hairs, however, is unknown.

5. Another prominent characteristic of the surface of the Antarctic lice (except for *Echinophthirius*) is the presence of numerous *small scales* which cover the abdomen and thus are produced by the rather thick cuticle. These scales, which may cover some air-filled space, are postulated to function in the same way as the plastron found in other insects, and apparently trap bubbles of air when the louse (together with its host) is immersed in water. These structures would therefore increase the oxygen uptake of the lice via the body surface, when direct contact via the stigmata is impossible (Hinton 1976; Murray 1976).
6. The fact that the dorsal cuticle of specimens of the family Echinophthiriidae is considerably thicker (reaching up to 1/6 of the whole diameter) than that of the ventral cuticle may also be explained as an adaptation to the cold environment, since the dorsal surface interfaces directly with the cold water, while the ventral surface, with the thinner cuticle, is attached to the warmer surface of the seal's body. In contrast to these Antarctic lice, the lice of terrestrial animals are much thinner and the dorsal and ventral cuticle plates are connected by rather thin membranes. This helps to regulate the body temperature.

7. Thus, considering items 4–6, the body surface of these lice from cold waters has three peculiarities that do not occur in lice from temperate climates, and guarantee that they can maintain a suitable body temperature. In addition, the surface scales, which apparently trap air bubbles, may help the lice to survive the rather long (30 min) and deep (up to 450 m) diving periods of the seal (Plötz et al. 2001).

10.3 Transmission of Agents of Diseases

Since some louse species change the hosts (apparently during body contacts when resting close together at the shore), agents of diseases may be transmitted. While it is well known that body lice transmit (via the oral-fecal route) the agents of the classic "spotted fever" induced by *Rickettsia prowazekii* (Mehlhorn 2011), the knowledge of transmissions of Antarctic lice is scarce. However, the paper of Linn et al. (2001) showing the transmission of α-viruses by the seal louse indicates that there is a large unknown background in the transmission story.

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