There and back again – The return of the nasal mite Halarachne halichoeri to seals in German waters

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ABSTRACT

The nasal mite Halarachne halichoeri (Acari; Halarachnidae) is adapted to live in the marine environment with pinnipeds as its primary host and can cause different levels of upper respiratory disease in both harbour seals (Phoca vitulina) and grey seals (Halichoerus grypus). Historical reports of H. halichoeri occurring in seals from German waters date back to the end of the 19th century. However, with the disappearance of the grey seal from German waters as a consequence of human over-exploitation, the mite vanished from the records and the fauna found in Germany for more than a century. Although a stranding network has been monitoring marine mammal health along the German coasts since the mid 1980s with extensive post-mortem investigations, this study reports the first and subsequent findings of H. halichoeri in grey and harbour seals from the North and Baltic Sea from 2014 onwards. The re-emergence of this endoparasitic mite in North and Baltic Sea habitats seems to have occurred simultaneously with the recolonisation of its primary host, the grey seal. During the course of its recolonisation, it was probably transmitted to harbour seals sharing the same haul-out sites. Molecular analyses showed a high similarity of rDNA sequences with H. halichoeri collected from sea otters (Enhydra lutris) in the USA. However, more thorough analyses of additional gene loci are required to fully assess the exchange and diversity of this parasite between geographically isolated regions and species.

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1. Introduction

Marine mammals are upper trophic level predators and important bioindicators for ecosystem health. Their distribution, health status and pollutant burdens can indicate changes in the ecosystem (Hilty and Merenlender, 2000). Marine mammal parasites are increasingly used as biomarkers for habitat use, health monitoring, understanding migrations of marine mammal hosts in various geographical areas as well as species interactions and their ecology (Balbuena et al., 1995; MacKenzie, 2002; Vidal-Martínez et al., 2010; Lehner et al., 2014).

Mites (Arachnida; Acari) are usually free-living or ectoparasites of land vertebrates. However, the family Halarachnidae (Acari, Gamasida) mainly consists of obligatory endoparasitic mites of the respiratory tract. They coevolved with the carnivorous ancestors of pinnipeds in the marine environment and during their long evolutionary history they established a relatively benign relationship with their phocid hosts. Their morphological adaptations to life in a semi-aquatic host make them uniquely different from other Gamasidae and specific to their host and its habitat (Furman, 1979; Fain, 1994). Two genera are parasites of the respiratory tract in pinniped species: Halarachne spp. Allman (1847) have been observed affecting the nasal tract of phocids, while Ortho-halarachne spp. Newell (1947) is commonly found in otariids and odobenids (Newell, 1947; Furman and Dailey, 1980).

The first specimen of Halarachne (H.) halichoeri (Allman, 1847) was found in July 1837 by Dr O’Brien Bellingham in the posterior nares of a grey seal (Halichoerus grypus) shot on the Dublin coast of Ireland (Allman, 1844). Nonetheless, the first detailed and official description of fresh specimens was published in 1847 by George James Allman. This peculiar naso-pharyngeal mite instigated broad research interest during the late 19th century (Oudemens, 1925). German zoologist and palaeontologist Alfred Nehring described the first finding of H. halichoeri in German waters from a dead Baltic grey seal from the Bay of...
### Background information of harbour and grey seals infected with *Halarachne halichoeri* from the North and Baltic Sea, including general pathological findings

| Species ID | Date of death/discovery | Number of nasal mites | Observations |
|------------|--------------------------|-----------------------|--------------|
| H.g. 1     | 13.02.2016               | 6                     | Multiple adults & larvae with *Phochoerus acheilognathus* and *Halarachne halichoeri*. | Moderate interstitial oedema, multifocal interstitial emphysema, diffuse alveolar oedema, multifocal interstitial oedema, severe interstitial oedema, multifocal interstitial emphysema, diffuse alveolar oedema, multifocal interstitial emphysema, severe alveolar and interstitial oedema and emphysema, severe alveolar and interstitial oedema and emphysema. |
| H.g. 2     | 13.02.2016               | 6                     | Multiple adults & larvae with *Phochoerus acheilognathus* and *Halarachne halichoeri*. | Moderate interstitial oedema, multifocal interstitial emphysema, diffuse alveolar oedema, multifocal interstitial emphysema, severe alveolar and interstitial oedema and emphysema, severe alveolar and interstitial oedema and emphysema. |
| H.g. 3     | 13.02.2016               | 6                     | Multiple adults & larvae with *Phochoerus acheilognathus* and *Halarachne halichoeri*. | Moderate interstitial oedema, multifocal interstitial emphysema, diffuse alveolar oedema, multifocal interstitial emphysema, severe alveolar and interstitial oedema and emphysema, severe alveolar and interstitial oedema and emphysema. |
| H.g. 4     | 13.02.2016               | 6                     | Multiple adults & larvae with *Phochoerus acheilognathus* and *Halarachne halichoeri*. | Moderate interstitial oedema, multifocal interstitial emphysema, diffuse alveolar oedema, multifocal interstitial emphysema, severe alveolar and interstitial oedema and emphysema, severe alveolar and interstitial oedema and emphysema. |

### Material and methods

#### 2.1. Animals and post-mortem examination

Post-mortem investigations on all marine mammals found on the coasts of the German Federal State of Schleswig-Holstein (S-H) are performed at the Institute for Terrestrial and Aquatic Wildlife Research (ITAW) in regard to their decomposition status (Lehnert et al., 2005; Siebert et al., 2007). Within a coordinated stranding network that was established in 1990, carcasses are screened for ecto- and endoparasites and histopathological and microbiological investigations are conducted (Siebert et al., 2007, 2017). In the federal state of Mecklenburg-West Pomerania, a similar network collects marine mammal carcasses for inspection at the Deutsches Meeresmuseum. In the context of this...
continuous marine mammal health monitoring project, six seals, four grey seals (H.g. 1–4) and two harbour seals (P.v. 1, 2) were found to harbour nasal mites (Table 1). Of these six individuals, one seal (P.v. 1) was only examined macroscopically as it was too decomposed for further investigations.

Mite individuals were collected with soft forceps, cleaned in tap water and preserved in 70% ethanol. For histopathology, samples of nasal tissue sections of 3 were cut and subsequently stained with haematoxylin and eosin (HE). Representative mite specimens (adults n = 45 and larvae n = 45) from four grey seals and one harbour seal were measured. The total idiosoma length was measured to the base of the gnathosoma, while the width was taken caudally to the last leg pair. Dorsal shield measurements were only taken where shield margins could be clearly determined. Selected H. halichoeri examples were photographed using CellSens Entry software with a Stereomicroscope (Olympus CX 41) with 100x magnification and attached camera (Olympus SC30). For documenting and comparing historical specimens at the Centre of Natural History of the Zoological Museum Hamburg, Germany (CeNak), two adults and two larvae were photographed using the BK Plus Lab System (Dun, Inc.) with 5x and 10x LD Mitutoyo objectives and integrated Canon camera. The images were captured and stacked with the Zerene Stacker software version 1.04.

2.2. Morphological and molecular identification

Larval and adult mites were identified on the basis of their morphological characteristics and in accordance with the descriptions by Oudemans (1925), Newell (1947) and Furman and Dailey (1980). To also achieve parasite identification using gene sequence data, genomic DNA was isolated from seven mite specimens (five adults and two larvae) from two hosts using a QIAamp Tissue Kit (Qiagen, Hilden, Germany). The ribosomal DNA (rDNA) ITS-2 was amplified from six individuals. DNA concentrations and purity were determined using a NanoDrop 2000c (Thermo Scientific) spectrophotometer. Approximately 300 bp of the 545/683 large subunit ribosomal ribonucleic acid (LSU rRNA) gene was amplified using oligonucleotide primers 5’- TCC AACGGTGCCCAG -3′ (forward) and 5’- CAGCTGAACTCACAACCA ACG -3′ (reverse) designed from the H. halichoeri sequence available at GenBank (Sequence ID: MH426848.1). Reactions were performed in a total volume of 50 mL, comprising MyTaq Red DNA polymerase (Bioline) and MyTaqTM Red reaction buffer (Bioline (Aust) Pty Ltd., Alexandria, New South Wales, Australia), primers at 20 μM each and 2–4 μl of DNA template in a TGradient cycler (Biometra). Cycling conditions were initial denaturation at 95 °C for 1 min, followed by 35 cycles of denaturation at 95 °C for 15 s, annealing at 60 °C for 15 s and extension at 72 °C for 10 s. PCR products were visualised in a 1.5% agarose gel using SYBRSafe DNA Gel stain on a gel documentation system (Vilber Lourmat, France). PCR products were sent premixed with primers to Microsynth (Göttingen, Germany) for Sanger Sequencing. The closest match to the sequence was determined using BLASTn on GenBank. Voucher specimens were deposited at the CeNak Department of Arachnology, Zoological Museum - University Hamburg, Germany (accession nos. ZMH-A0002181, ZMH-A0002182).

2.3. Comparative material from museum collections

An extensive literature review and comparison of old H. halichoeri descriptions was conducted to find historical records of H. halichoeri from Germany. Specimens from 1890 (11 larvae, two teneral females, two specimen slides; ex H.g. Zoological Garden Hamburg, List No. 635; classified by A. C. Oudemans in 1910, reviewed by D. P. Furman in 1979) and 1901 (one larva, three females, two specimen slides; ex H.g. Bay of Greifswald; classified by A. C. Oudemans in 1910, reviewed by D. P. Furman in 1979) were found archived in the collection of the CeNak’s Arachnology Department, University of Hamburg, Germany. The mites collected within this study were compared with this historical material.

3. Results

3.1. Parasitological findings

The first new discovery of H. halichoeri occurred in an adult female grey seal from the Baltic island of Ruegen, Germany, in 2014. Subsequently, three grey seals and two harbour seals from the Baltic and North Sea were found to harbour nasal mites between 2015 and 2018 (Table 1). The level of infection varied among cases without a clear pattern (Table 1). All nasal mites were found within the nasopharynx, anchored to the choanae and palate (Fig. 1). Halarchane halichoeri individuals from H.g. 2 stayed alive for at least three days after their host’s death.

The adults of H. halichoeri presented a whitish elongated opisthosoma with a prominent dorsal shield on the prosoma and smooth body cuticle, typical setae on the legs and four pairs of long maxillary ventral setae (Fig. 2). The mean idiosoma length of 45 randomly chosen adult individuals was 2783.11 μm (± 148.37 μm SD) and the mean length was 927.95 μm (± 93.74 μm SD, n = 26). The larvae measured 1174.18 μm (± 57.13 μm SD, n = 26). The larvae were smaller with a spider-like habitus, a blunt ovoid idiosoma, setae on the legs, two large claws on tarsi II and III and post-anal setae longer than the adanal setae (Fig. 3). The mean idiosoma length of 45 randomly chosen larvae was 174.18 μm (± 57.13 μm SD, n = 45). The 300 bp sequence obtained confirmed this identification, the closest match when blasted in GenBank being H. halichoeri (Sequence ID: MH426848.1) with 99% identity.

3.2. Pathomorphological findings

In most cases, H. halichoeri infection was associated with...
epithelialised granulation tissues with marked diffuse, predominantly plasmacytic infiltration.

4. Discussion

This study reports the first findings of a re-emerging arthropod endoparasite in seal species of the German North and Baltic Sea. *Halarachne halichoeri*’s disappearance and subsequent re-occurrence after more than a century is most likely correlated to the recovery and recolonisation of grey seals throughout the last decades. Coextinctions of associates with extinction events of their hosts are a known phenomenon in other species (Dunn, 2005). The absence of further *H. halichoeri* records for over 100 years could be related to minimal sampling efforts in the past. However, an ever improving network has been monitoring marine mammal strandings along the German coasts since the mid 1980s, including extensive post-mortem investigations on hundreds of seals (Siebert et al., 2007, Lehnert et al. 2007). Thus, the absence of *H. halichoeri* over the past decades is unlikely to be related to an insufficient sampling and examination effort, rather than to an actual absence of the parasite from the German fauna.

*Halarachne halichoeri*’s prevalence in harbour seals and grey seals underlines that both species live in close proximity in German waters and often use the same haul-out sites, e.g. on Helgoland, where interspecies contacts occur and mites can be transmitted. *Halarachne halichoeri* seems to have evolved as a generalist arachnid endoparasite in the marine environment, which can occur in a broad geographical range from the Alaskan waters (Fay and Furman, 1982) to the Galician coast (Alonso-Farré et al., 2012). It can form parasite-host-complexes with carnivorous marine mammals, including several seal species, e.g. spotted seals (*Phoca largha*) (Fay and Furman, 1982) and also sea otters (Kenyon et al., 1965).

General pathological findings reported in Table 1 were not directly related to *H. halichoeri* infections, but influenced the hosts’ health and contributed to the cause of death. Pathomorphological nasal mucosa alterations of the presented cases were mild, including hyperaemia and inflammation. For the two polyp-like proliferations of H.g. 4, it could not be established whether the mites were just incidental or causative agents.

The morphology and measurements of the present specimens corresponded to the historic specimens previously described by Oudemans (1925) and by Furman and Dailey (1980). The larva from the Hamburg Museum depicted in Oudemans’ 1925 publication measured 1320 μm in idiosoma length and 725 μm in width and an adult female from the same host measured 2818 μm in idiosoma length and 891 μm in width. It can thus be assumed that Oudemans used the still existing CeNak specimen for his studies, just like Deane P. Furman had done in 1979 for his subsequent publication. Furman described mature females as being up to 2820 μm in idiosomal length, while measured dorsal shields were 1000 to 1180 μm long and 403–540 μm wide. A slight variability among the current and historic measurements may be due to physiological individual differences, the preservation and fixation as well as the age of the historical samples.

The rDNA sequences derived from *H. halichoeri* specimens from seals in German waters showed a close similarity between *H. halichoeri* specimens from the US coast where the samples originated from sea otters (Pesapane et al., 2018). Further research also investigating other gene loci is needed to investigate whether geographical isolation between areas has contributed to genetic variation.

Many museums house century-old and unique collections of skeletal parts, frozen and fixed tissues, as well as mounted parasites of various marine mammal species. These materials and data sets are highly valuable for current research since they facilitate investigations into global and local species fluctuations, human impacts, changes in ecosystem and animal health and the results of conservation and management efforts. The CeNak specimens archived from grey seals from 1901 (and 1890) enabled comparison of recent specimens from this
study with historical findings. Furthermore, they allowed new findings to be put in a historical context and a better understanding of the development of marine mammal ecology over longer periods of time. Unfortunately, much of the former Hamburg Natural History museum, its collection and catalogue were destroyed during the Second World War. Therefore, it is not possible to obtain further details such as host origin for the 1890 specimens. Further investigations at other collections revealed no additional archived samples. These historical findings in conjunction with the contemporary stranding and necropsy records dating back to the mid-1980s show no cases of *H. halichoeri* in German waters for over 100 years, while the mite was found in areas where the grey seal was still present (Anderson et al., 1974; Baker, 1980; Munro et al., 1992).

The prevalence of *Halarachne* in German waters might be under-reported, due to post-mortem emigration from dead host individuals or due to losses during carcass transport. The here presented cases are in agreement with previous findings that grey seals act as a major host species (Cooreman, 1958; Furman and Dailey, 1980), playing the most important role in the life cycle of *H. halichoeri*. However, since grey seals share their habitat with other marine mammals, interspecies transmission of the nasal mite occurs. Three live observed animals showed typical clinical symptomatology associated with respiratory tract infections. These symptoms were most likely due to bronchopneumonia and pulmonary emphysema diagnosed in these animals. These can, however, be adversely affected by nasal passage obstruction due to swollen mucosae or larger amounts of parasites. The extent of current pathological findings in seals from German waters supports preceding conclusions that this naso-pharyngeal mite commonly causes minor changes when not present in extensive numbers (Furman, 1979; Fay and Furman, 1982; Baker, 1987). Furthermore, it did not contribute to the cause of illness or death in the presented cases. Compared to a recent study from Spain, which identified the nasal mite as the primary cause of the upper respiratory tract infections of juvenile seals (Alonso-

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**Fig. 3.** Dark field binocular image of *Halarachne halichoeri* larvae ventral and dorsal view (A) from H.g. 2 in comparison with (B) CeNak museum specimen from 1890.

**Fig. 4.** Grey seal, nasal mucosa with severe, diffuse lympho-plasmacytic infiltration; HE; E = epithelium; bar = 100 μm.
Further examinations, including genetic studies comparing specimens from different hosts and different localities are desirable to gain more knowledge about this neglected parasite.

5. Conclusion

This study reports on the occurrence of a re-emerging parasitic nasal mite in grey and harbour seals in German waters. Halarachne halichoeri had vanished from the German Baltic and North Sea fauna during the course of the last century with the disappearance of its main host. However, due to successful reestablishment of grey seal populations in both Seas, the seal nasal mite has likewise returned to German waters. Further examinations, including genetic studies comparing specimens from different hosts and different localities are desirable to gain more knowledge about this neglected parasite.

Conflicts of interest

The authors declare no conflict of interest.

Ethical standards

Not applicable.

References

Allman, G.J., 1844. In: Thompson, W. (Ed.), Report on the Fauna of Ireland, Div. Inverteterata. Report of the Thirteenth Meeting of the British Association for the Advancement of Science; Cork, August 1843, pp. 291.

Allman, G.J., 1847. Description of a new genus and species of tracheary arachnids. Ann. Mag. Nat. Hist. 20, 47–52.

Alonso-Farré, J.M., D’Silva, J.I.D., Gestal, C., 2012. Naso-pharyngeal mites Halarachne halichoeri (Allman, 1847) in grey seals stranded on the NW Spanish Atlantic Coast. Vet. Parasitol. 183, 317–322.

Anderson, S.S., Bonnet, W.N., Baker, J.R., Richards, R., 1974. Grey seals, Halichoerus grypus, of the Dee Estuary and observations on a characteristic skin lesion in British seals. J. Zool., Lond. 174, 429–440.

Baker, J.R., 1980. The pathology of the grey seal (Halichoerus grypus). II. Juveniles and Adults. Br. Vet. J. 136, 443–447.

Baker, J.R., 1987. Causes of mortality and morbidity in wild juvenile and adult grey seals (Halichoerus grypus). Br. Vet. J. 143, 203–220.

Balbuena, J.A., Aznar, F.J., Fernandez, M., Raga, J.A., 1995. The use of parasites as indicators of social structure and stock identity of marine mammals. In: Blix, A.S., Walloe, I., Ulltang, O. (Eds.), Developments in Marine Biology. 4. Whales, Seals, Fish and Man: Proceedings of the International Symposium on the Biology of Marine Mammals in the Northeast Atlantic. Tromso, Norway, 29 Nov.–1 Dec., 1994. Elsevier Science, Amsterdam, pp. 133–139.

Bonner, W.N., 1972. The grey seal and common seal in European waters. Oceanogr. Mar. Biol. Annu. Rev. 10, 461–507.

Brasseur, S.M.J.M., Van Polanen Petel, T.D., Gerrodette, T., Meesters, E.H.W.G., Kirkwood, R., 2017. Gray seal tracking reveals different behaviours of resident and transient population components. (Chapter 6) (PhD Thesis) In: Brasseur, S.M.J.M. (Ed.), Seals in Motion – How Movements Drive Population Development of Harbour Seals and Grey Seals in the North Sea. Wageningen University, The Netherlands, pp. 98–109.

Cooreman, J., 1958. Halarachne halichoeri Allman, acarine parasite du phoque Halichoerus grypus (Fabricius). Bull. ann. Soc. r. belge entomologie, 94, 159–168.

Dunn, R.R., 2005. Modern insect extinctions, the neglected majority. Conserv. Biol. 19, 1030–1036.

Fay, F.H., Furman, D.P., 1982. Nasal mites (Acarini: Halarachnidae) in the spotted seal, Phoca largha Pallas, and other pinnipeds of Alaskan waters. J. Wildl. Dis. 18, 63–68.

Fain, A., 1994. Adaptation, specificity and host-parasite coevolution in mites (Acarini). Int. J. Parasitol. 24, 1273–1283.

Furman, D.P., 1982. The genus Halarachne (Acari: Halarachnidae), with the description of a new species from the Hawaiian Monk Seal. J. Med. Entomol. 17, 352–359.

Furman, D.P., Smith, A.W., 1973. In vitro development of two species of Orthohalarachne (Acarina: Halarachnidae) and adaptations of the life cycle for endoparasitism in mammals. J. Med. Entomol. 10, 415–416.

Furman, D.P., 1979. Specificity adaptation and parallel evolution in the endoparasitic Mesostigmata of mammals. In: In: Rodriguez, J.G. (Ed.), Recent Advances in Acarology, vol. II. Acad Press, New York, pp. 329–337.
Geraci, J.R., St Aubin, D.J., 1987. Effects of parasites on marine mammals. Int. J. Parasitol. 17, 407–414.

Hilty, J., Merenlender, A., 2000. Faunal indicator taxa selection for monitoring ecosystem health. Biol. Conserv. 92, 185–197.

Harding, K.C., Haerkoenen, T.J., 1999. Development in the Baltic grey seal (Halichoerus grypus) and ringed seal (Phoca hispida) populations during the 20th Century. Ambio 28, 619–627.

Kenyon, A.S., Salyer, I.O., Kurz, J.E., Brown, D.R., 1965. Large-scale elution fractionation of polymers. J. Polym. Sci. C. 8, 205.

Kiely, O., Lidgard, D., McKibben, M., Connolly, N., Baines, M., 2000. Grey Seals: Status and Monitoring in the Irish and Celtic Seas. Maritime Ireland/Wales INTERREG Report No, vol. 3. Marine Institute, Dublin, pp. 77 ISSN: 1393-9025.

Lehnert, K., Raga, J.A., Siebert, U., 2005. Macroparasites in stranded and by caught harbour porpoises from German and Norwegian waters. Dis. Aquat. Org. 64, 265–269.

Lehnert, K., Raga, J.A., Siebert, U., 2007. Parasites in harbour seals (Phocoena vitulina) from the German Wadden Sea during the 20th Century. Ambio 36, 550–557.

Lehnert, K., Seibel, H., Hasselmeier, I., Wohlein, P., Iversen, M., Nielsen, N.H., Siebert, U., 2014. Increase in parasite burden and associated pathology in harbour porpoises (Phocoena phocoena) in West Greenland. Polar Biol. 37 (3), 321–331.

Lotze, H.K., 2005. Radical changes in the Wadden Sea fauna and flora over the last 2000 years. Helgol. Mar. Res. 59, 71–83.

MacKenzie, K., 2002. Parasites as biological tags in population studies of marine organisms: an update. Parasitology 124, 153–163.

Measures, L.N., 2018. Helminths and parasitic arthropods. In: Gulland, F.M.D., Dierauf, L.A., Whitman, K.L. (Eds.), CRC Handbook of Marine Mammal Medicine, third ed. CRC Press, Boca Raton, FL, pp. 471–497.

Munro, R., Ross, H., Cornwell, C., Gilmour, J., 2002. Disease conditions affecting common seals (Phoca vitulina) around the Scottish mainland, September-November 1988. Sci. Total Environ. 115, 67–82.

Nehring, A., 1884. Ueber Halarachne halichoeri allmann, sowie ueber einige halichoerus schaedel. Sitzb. Ges. Naturf. Berlin 4, 57–64.

Nehring, A., 1895. Die nasenmilbe der Kegelrobbe. Naturw. Wochenschrift. 10, 225–226.

Newell, L.M., 1947. Studies on the morphology and systematics of the family Halarachnidae, Oudemans 1906 (Acari, parasitoidea). Bingham Oceanogr. Coll. Bull. 10, 235–266.

Oudemans, A.C., 1925. Halarachne-studien. Arch. Naturgesch., Abt. A. 91, 48–108.

Pesapane, R., Dodd, E., Favre, N., Miller, M., Foley, J., 2018. Molecular characterization and prevalence of Halarachne halichoeri in threatened southern sea otters (Enhydra lutris nereis). Int J Parasitol Parasites Wildl 7, 386–396.

Rejnders, P.J.H., 1983. The effect of seal hunting in Germany on the further existence of a harbour seal population in the Dutch Wadden Sea. Z. Saugetierkd. (Mamm. Biol.) 48, 50–54.

Rejnders, P.J.H., van Dijk, J., Kuiper, D., 1995. Recolonization of the Dutch Wadden Sea by the grey seal Halichoerus grypus. Biol. Conserv. 71, 231–235.

Requate, H., 1957. Zur nacheiszeitlichen geschichte der Saugetiere schleswig-holsteins. Bonn. Zool. Beitr. 8, 207–229.

Rolbiecki, L., Izdebska, J.N., Bidziński, K., Jankowska-Jarek, M., 2018. Nasopharyngeal mites Halarachne halichoeri (Allman, 1847) parasitizing the gray seal (Halichoerus grypus) (Fabricius, 1791) in the Baltic Sea with notes on other parasitic Halarachnidae associated with marine mammals. Oceanol. Hydrobiol. Stud. 47, 398–404.

Siebert, U., Wohlein, P., Lehnert, K., Baumgarner, W., 2007. Pathological findings in harbour seals (Phoca vitulina): 1996-2005. J. Comp. Pathol. 137, 47–58.

Vidal-Martínez, V.M., Pech, D., Sures, R., Parucker, S.T., Poulin, R., 2010. Can parasites really reveal environmental impact? Trends Parasitol. 26, 44–51.