



The genital area of Halacaridae (Acari), life stages and development of morphological characters and implication on the classification

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Abstract

The genital region of juvenile and adult halacarid genera is described. Larvae are expected to be present in all, protonymphs at least in the majority of the genera. Two of the marine genera have three nymphal instars, in the others one or two nymphal instars are suppressed. Adults of marine species have one, two or three pairs of genital acetabula; intrageneric differences in the number of acetabula are present but rare. Derived from the number of perigenital setae and genital acetabula, in most genera it is the deutonymph which is suppressed, in a few others the tritonymph. Adults of species with two nymphal stages have either two or three pairs of acetabula, those with a single nymphal stage have either one or two pairs of acetabula. Two genera may lack the protonymphal stage, but more material is needed to prove the absence. The present-day classification is outlined and supplemented. *Anomalohalacarus* and *Arenihalacarus* are both assigned to the Anomalohalacarinae. The Halixodinae include *Agauae*, *Bradyagaue* and *Halixodes*, the knowledge of *Australacarus* and *Colobocerasides* is sparse, but they may have to be incorporated in the Halixodinae. The subfamily Halacarinae includes a single genus, namely *Halacarus*.

Key words: Halacaroidea, genital region, larvae, nymphs, adults, classification

Introduction

The first illustration of a marine mite was published by Baster (1758: pl. 10, fig. 7). It was a small animal which he called a marine insect (zee-insecten). Johnston (1836) honoured J. Baster in that he described a marine mite under the name of *Acarus basteri*, a mite living amongst corallines from the tide marks. That species is nowadays called *Thalassarachna basteri* (Johnston, 1836). Gosse (1855a) introduced the name *Halacarus* for a genus of microscopic marine mites and described two species and Murray (1877) introduced the term

Halacaridae, derived from the genus *Halacarus*, for a family of 'mites living habitually under the sea'. At that time ten species had been described (Johnston 1836; Gosse 1855a, b; Hodge 1860, 1863; Brady 1875, 1877; Packard 1871). Two years later, the first record and description of a freshwater halacarid was published (Kramer 1879). The number of genera and species increased and Viets (1927) proposed a classification with six subfamilies, namely Halacarinae Viets, 1927, Halixodinae Viets, 1927, Limnohalacarinae Viets, 1927, Lohmannellinae Viets, 1927, Rhombognathinae Viets, 1927, and Simognathinae Viets, 1927, in all including 23 genera or subgenera. In the nineteen thirties another three subfamilies were added, the Actacarinae Viets, 1939, Astacopsiphaginae Viets, 1931 and Enterohalacarinae Viets, 1938. Viets (1933a) proposed to distinguish between the halacarids living in the sea, characterized by internal acetabula, and those in freshwater, all with external acetabula, according to him, the family Halacaridae included all marine species, the Porohalacaridae the genera and species inhabiting freshwater. The classification of marine genera, proposed by Viets (1927, 1938, 1939b), was supplemented by Bartsch (1977b, 1983a, 1985b, 1986e) and Otto (1999c, 2000c, d). On the basis of studies on material from the Antarctic and adjacent seas, Newell (1984) raised the Lohmannellinae and Rhombognathinae to family rank. In the Lohmannellidae the genera of the former Lohmannellinae and Simognathinae were included, in the Rhombognathidae the four genera already mentioned by Newell (1947). The genera not belonging to any of these two families were retained in the family Halacaridae (Newell 1984).

The classifications were partly based on conspicuous external characters, characters correlated with the mode of living in a given environment and irrelevant from a phylogenetic standpoint. Since many years halacarid specialists have been aware that the classification of the Halacaridae is in need of a revision (Bartsch 1996a, 2007b, 2009a; Otto 1999c, 2000c; Pepato & da Rocha 2010). Morphological examinations have been extended, new data have been added to the list of characters which also include information of juvenile stages (Bartsch 2003c). Pepato & da Rocha (2007, 2010), Pepato (2010) and Pepato et al. (2010a, b) concentrated on the spermiogenesis and sperm cell morphology of halacarids. DNA analyses have been made of *Thalassarachna basteri*, *Halacarellus balticus* (Lohmann, 1889), *Rhombognathides pascens* (Lohmann, 1899), *Isobacetrus uniscutatus* (Viets, 1939) (S. Parent, M. Skvarla, personal communication, June and July 2004 and October 2013, respectively), *Copidognathus stevcici* Bartsch, 1976 (Guerao et al. 2011). Further molecular studies have been carried out (Otto & Wilson 2001; Meguro et al. 2010; Pepato 2010 and personal communication), but still the data sets are insufficient for an analysis of relationship between halacarid species, genera and subfamilies.

This survey is not meant to present a new classification but to describe and summarize morphological details often not included in the description of species and genera. It will concentrate on the genital area of adults and juveniles of each genus, the number, position and shape of the genital acetabula, perigenital and subgenital setae, and details of the ovipositor. The number of juvenile stages is mentioned. The survey includes the presence or absence of epimeral vesicles, tubes or pores, as these in some species or developmental stages fulfil a function similar to that of the genital acetabula.

Material and methods

The survey of characters of the genital region is prepared on the basis of published data and examination of slides stored in the Zoological Museum, Hamburg and the author's halacarid collection. If possible, more than one individual of a given species and more than one species of a genus have been examined, but often information was only available from a single individual or species. It is not known if the given data are valid for all species within a genus. The genera are arranged in an alphabetical order. The table of characters (Table 1) includes data of additional external characters of marine and freshwater genera extracted from Bartsch (1989a, 2006b, c).

Apart from a few exceptions, the second free-living nymphal stage is called deutonymph, independently if it is homologous to a deuto- or tritonymph.

Prospect

The descriptions of the first halacarid mites have been prepared with the help of light microscopes. With better microscopes, with oil-immersion, more morphological details could be recognized, described and illustrated. At present, the diagnoses of genera and subfamilies, the classifications and phylogenetic cladograms are mainly prepared on the basis of external, morphological characters. Forthcoming studies are expected to present information on spermiogenesis and spermatozoa, chromosomes, molecular and biological data and these may help to get a better insight into the degree of relationship and evolution of halacarid species and genera. Still light-microscopes are not out-dated. They are needed for identification and comparison of genera and species. Future descriptions should include epimeral pores, number and shape of genital acetabula, and, if possible, the shape of the ovipositor and spermatopositor. In preserved females the ovipositor in general is at rest, inside the genital opening, and especially the number of faintly sclerotized genital spines not reliably recognizable. If material alive is at hand, slight warming may cause ovigerous females to extrude the ovipositor. Details of larvae and nymphs should be included in the descriptions and diagnoses.

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Appendix

List of species illustrated and their geographical data

- Acanthohalacarus reticulatus* Bartsch, 2001, female, male; northeastern Atlantic, Great Meteor Seamount.
- Acarochelopodia biunguis* Bartsch, 1988, male, deutonymph; South Pacific, Australia, Queensland, Moreton Bay.
- Acaromantis armatus* Bartsch, 1977, female, protonymph; eastern Pacific, Ecuador, Galapagos Islands.
- Actacarus spinosus* Otto, 2000, female; South China Sea, Singapore (new record).
- Agauae galatea* Otto, 1999, deutonymph; South China Sea, Singapore.
- Agauopsis arabia* Bartsch & Chatterjee, 2001, female; Indian Ocean, India, Andaman Islands.
- Agauopsis arborea* Bartsch, 2003; female, male; South China Sea, Singapore.
- Agauopsis mokari* Otto, 1994, male; Indian Ocean, Australia, Western Australia, Esperance.
- Agauopsis moorea* Bartsch, 1992, female, male; South China Sea, Singapore (new record).
- Agauopsis* sp. (*A. furcata* group), female; southwestern Pacific, Australia, Queensland, Moreton Bay (new record of the *A. furcata* group).
- Arhodeoporus corallinus* Otto, 2000, female, male; Indian Ocean, Australia, Western Australia, Dampier.
- Arhodeoporus gracilipes* (Trouessart, 1889), female, male; northeastern Atlantic, North Sea, Sweden.
- Arhodeoporus bonairensis* (Viets, 1936), female; Indian Ocean, Australia, Western Australia, Dampier.
- Arhodeoporus bonairensis* (Viets, 1936), deutonymph; South China Sea, Singapore.
- Atelopsalis pacifica* Bartsch, 1985, female; South China Sea, Singapore.
- Atelopsalis pacifica* Bartsch, 1985, deutonymph; southwestern Pacific, Australia, Queensland, Moreton Bay (new record).
- Australacarus pustulatus* Bartsch, 1993, female, male; Indian Ocean, Australia, Western Australia, Rottne Island.
- Bathyhalacarus acutus* Bartsch, 1982, female; South Atlantic, Argentine Basin.
- Bradyagaue drygalskii* (Lohmann, 1907), female, male; southwestern Atlantic, off South Sandwich Islands.
- Bradyagaue drygalskii* (Lohmann, 1907), deutonymph, protonymph; South Atlantic, Antarctic Peninsula, off Elephant Island.
- Camactognathus tessellatus* (Morselli & Mari, 1982), female, deutonymph; Black Sea, Turkey.
- Coloboceras longiusculus* Trouessart, 1889, female, deutonymph; northeastern Atlantic, North Sea, Sweden.
- Copidognathides ampliatus* Bartsch, 1999, male; Black Sea, Turkey (new record).
- Copidognathus magnipalpus* (Police, 1909), female; Black Sea, Turkey.
- Copidognathus magniporus* Bartsch, 1973, female; northeastern Atlantic, Great Meteor Seamount.
- Copidognathus caelatus* Bartsch, 1994, female; Indian Ocean, Australia, Western Australia, Esperance (new record).
- Copidognathus wadjemupis* Bartsch, 1999, female; Indian Ocean, Australia, Western Australia, Esperance (new record).
- Enterohalacarus minutipalpus* Viets, 1938, female, nymph; western Pacific, Molucca Sea.
- Halacarellus balticus* (Lohmann, 1889), female; Baltic, Germany.
- Halacarellus capuzinus* (Lohmann, 1893), female; Baltic, Germany.
- Halacaropsis hirsuta* (Trouessart, 1889), female; Strait of Gibraltar, Morocco.
- Halacarus bisulcus* Viets, 1927, female, male; northeastern Atlantic, North Sea, Sweden.
- Halixodes novaezealandiae* Bartsch, 1986, male; southwestern Pacific, New Zealand.
- Isobacrus aspidotus* Bartsch, 2009, male, tritonymph, deutonymph, protonymph; southwestern Pacific, Australia, Queensland, Moreton Bay.
- Isobacrus hartmanni* Bartsch, 1972, female; northeastern Atlantic, North Sea, Germany.
- Isobacrus obesus* Bartsch, 1992, female, tritonymph; southwestern Pacific, Australia, Queensland, Moreton Bay.
- Isobacrus uniscutatus* (Viets, 1939), male; northeastern Atlantic, North Sea, Germany.
- Lohmannella falcata* (Hodge, 1863), protonymph; northwestern Atlantic, United States, Rhode Island.
- Makarovana spinosa* (Bartsch, 1978), female; northeastern Atlantic, Norway.
- Metarhombognathus nudus* (Viets, 1928), male; northwestern Atlantic, United States, Rhode Island.
- Mictognathus werthelloides* Newell, 1984, female; South Atlantic, off South Sandwich Islands.
- Mictognathus werthelloides* Newell, 1984, deutonymph; Drake Passage, off Graham Land.
- Phacacarus flavellus* Bartsch, 1992, female; Indian Ocean, Australia, Western Australia, Rottne Island.