SEXUAL DIMORPHISM IN HALACARID MITES (ACARI, HALACARIDAE): AN UPDATED OVERVIEW

Abstract

An updated overview of sexual dimorphism in halacarid mites is presented in this paper. Males and females of halacarid mites morphologically differ in the genital region. Additionally, sexual dimorphism can be seen in some species in dorsal plates, ventral plates, chaetotaxy of legs, idiosoma, gnathosoma, which is the theme of the present paper. A distinction of males vs. female mites is sometimes reflected in size and fusion of various idiosomal plates and width of cuticular membranous areas. Other sexually dimorphic characters such as paragenital areolae, postgenital papillae, lamella in legs, fossary setae on tarsus found in some species of halacarids are also discussed.

Keywords: Sexual dimorphism, Halacaridae, Overview
Introduction

Sexual dimorphism is common in many groups of Arthropoda. Bartsch (1994a) surveyed the extent of sexual dimorphism in halacarid mites, but since then many new findings have been published. Moreover, some important details are not considered thoroughly by Bartsch (1994a). The aim of the present paper is to update and give an overview of sexual dimorphism in halacarid mites based on published literature. In marine species, the existence of separate sexes is most common, with a slight biased female to male ratio in some populations (Makaveeva 1966; Straarup 1968; Kirchner 1969; Bartsch 1972, 1996). In several limnic species males are extremely rare (Teschner 1963; Husmann & Teschner 1970; Bartsch 1981a, 1987) and are thought to be predominantly parthenogenetic (Bartsch 1996). Sexes in halacarids are usually distinguished by the genital area, and the number and arrangements of perigenital setae. Besides the genital area, sexual dimorphism also can be seen in some species in dorsal plates, ventral plates, chaetotaxy of legs, idiosoma, gnathosoma. In some species of halacarids, sexual dimorphism can be clearly recognized in the body size also, the male has smaller body than female. Other sexual dimorphic characters such as paragenital areolae, postgenital papillae, lamella in legs, fossary setae on tarsus are also surveyed and presented in this paper.

Abbreviation used in text: The following abbreviations are used in the text and figure legends: AD, anterior dorsal plate; AE, anterior epimeral plate; ds$_{1-6}$, dorsal setae 1–6 on idiosoma; GA, genitoanal plate; GO, genital opening; OC, ocular plate(s); PAS, parambulacral seta(e); PD, posterior dorsal plate; PE, posterior epimeral plate(s); PGS, perigenital setae; POC, post ocular plate; P$_{1-4}$, first to fourth palpal segment; SGS, subgenital setae.

Results & Discussion

Sexual dimorphism in idiosoma

*Idiosoma dorsal:* 
In most cases males are similar with females in the shape and size of the idiosomal plates and their chaetotaxy. But a distinction of sex is sometimes reflected
in size and fusion of various idiosomal plates, and width of cuticular membranous areas.

Although not common, sexual dimorphism can be observed on the size of the PD, position of dorsal setae, gland pores in some species of the genera like *Agaue, Halacarellus, Halacarus, Phacacarus, Thalassarachna, Copidognathus*. Examples are as follows:

In males of *Agaue marginata* Viets 1950, the PD is relatively wider and extends anteriorly beyond ds₄, while in the females, the PD extends just up to level of ds₄ (Viets 1950).

In males of *Halacarellus harioti* (Trouessart 1889), the PD is distinctly larger than that of females, extending far beyond the level of setae ds₄ and the ds₄ situated on or close to the lateral margin of PD; while in the females, the anterior margin of PD extends to level with the ds₄, and the ds₄ is outer to the PD (Bartsch 1990, 1993a).

Males of *Thalassarachna dissimilis* (Bartsch 1979) have the PD extending anteriorly to level of ds₃, going beyond the insertion of leg IV; while in the females, the PD is small, and anteriorly far away from ds₄. It also does not reach to the level of insertion of leg IV (Bartsch 1979a).

In males of *Thalassarachna striata* (Lohmann 1889) the PD extends anteriorly to near ds₃, up to and level with 1/3rd of OC, but in females, the anterior margin of the PD is far away from ds₃ and OC; setae ds₄ is inside the PD in male, while outside the PD in membranous cuticle in female (Bartsch 1976).

In males of *Halacarus arnaudi* Newell, 1984, the PD is rectangular anteriorly, setae ds₅ and gland pore are inside the PD anteriorly, while in females, the PD is anteriorly narrow and pointed, ds₅ and gland pores are outside the PD (Bartsch 1993a).

In females of *Halacarus ctenopus* Gosse, 1855, the PD is anteriorly away from ds₄ and the insertion of leg III, while in males the PD is anteriorly close to and level with ds₄ and the insertion of leg III (Newell 1984).

In the males of *Halacarus dictyotus* Bartsch, 1988, the PD is broad, and the gland pore 4 is inside the PD, while in females, the PD is narrow and the gland pore 4 is outside the PD, in the membranous area (Bartsch 1981b: figs. 10, 20 as *Halacarus reticulatus*).

In *Halacarus discophorus* Bartsch, 1993 a pair of platelets are present between gland pores gland pore 4 and gland pore 5 in the male, while such platelets are absent in the female (Bartsch 1993b).
In males of *Halacarus gracileunguiculatus* Lohmann, 1907 setae ds$_5$ and gland pore 4 are inside the PD, and the PD extends anteriorly well beyond the level of insertion of leg III, up to near the level of insertion of leg III; while in the female, the PD is anterior to and level with the insertion of leg IV, ds$_5$ and gland pore 4 outside the PD on the membranous area (Newell 1984).

In males of *Halacarus heraldensis* Otto, 2001, the PD is anteriorly somewhat rounded, while more pointed in the female; gland pore 4 and ds$_5$ are on small platelets separated from the PD in the female while inside the PD in the male (Otto 2001).

The male has wider and longer PD than the female in *Halacarus laterculatus* Viets, 1950; anterior end of PD is closer to ds$_5$ and gland pore 4 in male while far away in female (Bartsch 1993a).

In males of *Halacarus minor* Lohmann, 1907, the PD is larger than that of the female, extending anteriorly beyond ds$_5$ and gland pore 4, while in the female, the anterior end of the PD is far away from ds$_5$ and gland pore 4 (Bartsch 1993a).

In *Halacarus mitrellus* Bartsch, 1993 PD larger in the male than in the female, and anteriorly rectangular in male, while pointed in the female. ds$_4$ is outside the PD in the female while inside of PD in male (Bartsch 1993b).

In the males of *Halacarus newelli* MacQuitty, 1984, the PD is absent, while it is present in the females and the setae ds$_5$ are found inside the PD (MacQuitty 1984).

In *Halacarus peregrinus* Bartsch, 1981, males have a PD, while PD is absent in females (Bartsch 1981c).

In the males of *Halacarus rismondi* Viets, 1940, the PD is anterior and level with ds$_5$ and gland pore 4, while in the females, the PD is anteriorly far away from the ds$_5$ and gland pore 4 (Viets 1940).

Gland pore 4 and ds$_5$ on small platelets are separated from the PD in females of *Halacarus sabulonis* Otto, 2001, while inside the PD in the male (Otto 2001).

A pair of gland pores 4 is separated from the PD in the female, and seta ds$_5$ are either on the same platelet as gland pore 4 or separated from it, in membranous cuticle in females of *Halacarus striolus* Otto, 2001, while both are located inside the PD in the male (Otto 2001).

In males of *Halacarus subtilis* Viets, 1940, the PD is anteriorly oval extending to near the level of insertion of leg III and ds$_4$, while in females, the PD is anteriorly narrow, extending just above the level of insertion of leg IV, away from ds$_4$ (Viets 1940).
In males of *Halacarus turgidus* Viets, 1952 male PD is more extensive than in female (Viets 1952; Newell 1984).

In males of *Halacarus validus* Gimbel, 1919 and *H. zealandicus* Newell, 1984 the PD is present, while it is absent in female (Newell 1984; Bartsch 1993a).

In females of *Phacacarus flavellus* Bartsch, 1992, the PD extends anteriorly to level with more than half of the OC, while in the male the PD far removed from the posterior margin of the OC (Bartsch 1992a; 1994a).

Males of *Anomalohalacarus macellus* Bartsch, 1993 have PD longer than in female, extending to the level of insertion of leg III (Bartsch 1993c).

Sexual dimorphism in the size of the PD is also found in some species of the genus *Copidognathus*. For example, in *Copidognathus trouessarti* (Voinov 1896), the PD of the female is about 2.0-2.3 times longer than wide, while that of the male is distinctly wider, being about 1.7-1.8 times longer than wide (Bartsch 1991).

Idiosoma Ventral:
The length, width of GA, GO; distance between anterior end of GO and that of GA, distance between posterior end of GO and that of GA often varies between males and females. The genitoanal plate bears genital opening surrounded by perigenital setae (PGS). Subgenital setae (SGS) are found on the genital sclerites, which lie within the genital opening. In the female, the ovipositor is found anterior to GO. Males have a complex structure consisting of chitinous bars which lie internal to the genital opening and mould the spermatophore (a stalked structure which bears sperm sac). This organ has been referred to as the penis (eg. Newell 1947, 1951b), phorotype (eg. Newell 1984), ejaculatory complex (eg. Bartsch 1984), spermatophorotype (eg. Abé 1998, Pepato & Tiago 2005) and spermatopositor (eg. Bartsch 1993c, 1999a; Bartsch & Chatterjee 2001; Chatterjee et al. 2006).

Generally, the number of PGS is greater in the male than in the female. However, the number of PGS is greater in the female in a few cases. *Rhombognathus tenuiformis* Abé, 1996 has 35 to 45 PGS on each side of the genital foramen in females (total 76 PGS in holotype female) while 22 to 24 PGS in each side of genital foramen in the male (total 48 PGS in allotype male) (Abé 1996a). *Rhombognathus setellus* Bartsch, 1992 females have approximately 70 PGS around the GO, while the male has approximately 50 PGS (Bartsch 1992b). Some species of *Halacarus, Rhombognathus* show plumose/branched PGS in the male while
smooth (slender/filiform) PGS in the female. In *Acaromantis*, male PGS are often plumose. In a few species of the genus *Agauopsis* eg. *A. pseudoornata* Bartsch, 1985 the male has plumose PGS and female has smooth PGS.


Number of SGS often varies between males and females in various genera such as *Acanthohalacarus*, *Acarochelopodia*, *Acaromantis*, *Acarothrix*, *Actacarus*, *Agaue*, *Aguopsis*, *Anomalohalacarus*, *Arhodeoporus*, *Atelopsalis*, *Australalaracus*, *Bathyhalacarus*, *Bradyagaue*, *Camactognathus*, *Caspialcaracus*, *Coloboceras*, *Copidognathides*, *Copidognathus*, *Halacaroides*, *Isobactrus*, *Metarhombognathus*, *Mictognathus*, *Peregrinacarus*, *Rhombognathides*, *Scaptognathides*, *Simognathus*, *Thalassacarus*, *Tropihalacarus*, *Werthella*, *Winlundia*, *Xenohalacarus*. In these cases males have greater number of SGS than the females. But in some genera, such as *Rhombognathus*, in many species both the sexes have same number of SGS, although the position may vary.

Sexual dimorphism is also represented in few species of halacarids in the paragenital areolae/areolae around the GA, eg. In the males of *Arhodeoporus perlucidus* Bartsch, 1983 the paragenital areolae are elongated and extend much beyond the anterior level of GO, near the anterior margin of the GA, but in the female, the paragenital areolae are small and extends level with the anterior margin of GO and removed from the anterior margin of the GA (Bartsch 1983a).

Postgenital papillae present in many males of species of ‘*Copidognathus oculus*’ group while absent in females. Some examples are: *C. arnaudi* Newell, 1984; *C. commatops* Newell, 1984; *C. confuses* Newell, 1984; *C. cornatus* Newell, 1971; *C. crypticus* Newell, 1971; *C. foveolatus* Newell, 1984; *C. hureaui* Newell, 1984; *C. latisetus* Viets, 1940; *C. levigatus* Bartsch, 1999; *C. marcanadrei* Viets, 1950; *C. modestus* Bartsch, 1984; *C. oculatus* (Hodge, 1863), *C. pumicatus* Bartsch, 1999; *C. sigillatus* Newell, 1984; *C. vanhoeffeni* (Lohmann, 1907) (Newell 1971, 1984; Viets 1950; Bartsch 1977, 1984, 1999b). Similarly in many males of ‘*Copidognathus tricorneatus*’ group post genital papillae are present but are absent in the female.
Genital groove, genital acetabula also may vary in number and position in males and females. Some examples are:

In males of *Australacarus* genital groove is present posterior to GO, while this groove is absent in the female (Bartsch 1987a).

A pair of external genital acetabula is present on genital sclerites in males of the genus *Acarothrix*, while the external genital acetabula on genital sclerites are absent in the female.

A pair of genital acetabula posterior to GO on GA are present in males of *Caspialacarus hyracanus* Viets, 1928, while genital acetabula are not found posterior to GO in the female (Bartsch 1998a).

*Isobactrus uniscutatus* (Viets 1939): Genital acetabula in females inside GO, while in male two pairs of genital acetabula are located outside behind the GO (Bartsch 1972).

In females of *Porohalacarus alpinus* brachypeltatus Viets, 1927, genital sclerites mostly have four genital acetabula, while in the male there are two humps posterior to GO each containing 5–6 genital acetabula (Bartsch 1987b).

In some species of genus *Halacarus* female has swelled areas on either side of GA, while such swelled areas are absent in male eg. *Halacarus mitrellus* Bartsch, 1993, *H. turgidus* Viets, 1952.

In many genera and species sexual dimorphism is revealed in features of the ventral plates. Examples are as follows:

In *Isobactrus*, the GP in females is often reduced, while that of the male is relatively large.

In species of the genus *Anomalohalacarus* the GA of females is divided, with 2 pairs of perigenital setae on the genital plates and 1 pair within the striated integument, on a pair of small sclerites or on a single median sclerite, while in males GA is fused and large (Bartsch 1981d, Abé 1996b).

In the genus *Arenihalacarus*, the female GA is divided into 4 platelets, while in the male the GA is fused. The female of *Arenihalacarus* bears two pairs of PGS on a platelet immediately anterior to the genital slit (Abé 1991).

In females of *Parasoldanellonyx* the GP is separated from AP, while in the male GP and AP fuse to form GA.

In females of *Simognathus gibberosus* Bartsch, 1994 all ventral plates are separate, while in the males, AE and GA are broadly fused and PE is posteriorly fused with GA (Bartsch 1994b).
In males of *Copidognathus bairdi* Newell, 1947, the ventral plates are fused. ‘AE is fused with PE or separated from it by only a suture and is fused with GA. Membranous areas are completely absent’ (Newell 1947), while in the female, the AE, PE and GA are separate.

In the genus *Rhombognathus* many species exhibit sexual dimorphism in fusion of ventral plates. Some examples are given below.

In males of *Rhombognathus dictyotus* Bartsch, 1992, the AE is separate, while PE and GP are fused, and GP is partly fused with AP. In the females, all ventral plates are separate (Bartsch 1992b).

In females of *Rhombognathus gressitti* Newell, 1967, ventral plates viz. AE, PE, GP and AP are separate, but in males GP and AP are fused to form GA, which is confluent with PE. The fused plate of GA and PE is separated from AE by cuticular striae (Newell 1967).

In males of *Rhombognathus hirtellus* Bartsch, 1992, all ventral plates are fused while in the female, AE and PE are fused, and the genital plate is reduced to small elongate sclerites (Bartsch 1992b).

Bartsch (1979) found all ventral plates to be fused in males of *Rhombognathus lacunosus* Bartsch, 1979, but in females the PE and GP were distinctly intervened by a band of striated cuticle. However, AE is broadly fused ventrally with GP and marginally with PE (Bartsch 1979b).

In males of *Rhombognathus neotenus* Abé, 1996, AE is separate. PE and GP are completely fused to a single plate from which AP is partly separated by lateral incisions with membranous cuticle (Abé 1996), while in the female AE, PE are separate and the genital region is only weakly sclerotized without a distinct plate (Abé 1996a).

In males of *Rhombognathus setellus* Bartsch, 1992, all ventral plates are fused while in the female, AE and PE are fused, and GA fused to these with narrow bar (Bartsch 1992b).

In males of *Rhombognathus tenuiformis* Abé, 1996, AE is separate. PE and GP are completely fused to a single plate from which AP partly separated by lateral incisions with membranous cuticle, while in females AE, PE, GP and AP are separate (Abé 1996a).

In males of *Halacarellus lubricellus* Bartsch, 1990, AE and GA are fused and PE is separate, while in the female, AE, PE and GA are all separate (Bartsch 1990, 1993a).
In males of *Scaptognathus sabularius* André, 1961, the GA consists only of a pars sclerosum, with the pars membranosum lacking, while in the female, the GA consists anteriorly and posteriorly par sclerosum, in middle par membranosum (tripartite) (Bartsch 1986).

In males of *Scaptognathus tereninus* Bartsch, 1986, the GA mainly consists of a par sclerosum, with a small, anterior pars membranosum present, while in the female, the par sclerosum is located anteriorly and posteriorly with the par membranosum in the middle (tripartite) (Bartsch 1986).

In males of *Scaptognathus teuriensis* Abé, 1990, the GA consists of only pars sclerosum, with the pars membranosum lacking while in the female, GA consists of an anterior pars membranosum and a posterior pars sclerosum (bipartite) (Abé 1990a).

In males of *Scaptognathus ventridiscus* Abé, 1990, the GA consists of only a pars sclerosum, and the pars membranosum completely separated from GA, forming a disc present in the membranous area between AE and GA. In the female, GA consists of an anterior pars membranosum and a posterior pars sclerosum with a central disc lacking in the membranous area between AE and GA (Abé 1990b).

Platelets (sclerites) are present in the membranous cuticle between PE and GA in females of *Halacarellus subterraneus* Schulz, 1933; *Halacarellus micropectinatus* Bartsch, 1972 while in males, platelets are fused with GA (Bartsch 1998a).

**Gnathosoma**

**Basirostral setae:**

In some *Copidognathus* species, sexual dimorphism is found in basirostral setae (long maxillary setae on gnathosomal base) (Table 1). Many species in *Copidognathus* have been described from either the male or the female, so sexual dimorphism in this character is probably underrepresented.
<table>
<thead>
<tr>
<th>No.</th>
<th>Name of the species</th>
<th>Number of basirostral setae in Males (in pairs)</th>
<th>Number of basirostral setae in females (in pairs)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C. curtus Hall, 1912</td>
<td>2</td>
<td>1</td>
<td>Newell (1951a); Chatterjee et al. (In Press)</td>
</tr>
<tr>
<td>2</td>
<td>C. fistulosus Chatterjee &amp; Chang, 2005</td>
<td>2</td>
<td>1</td>
<td>Chatterjee &amp; Chang (2005)</td>
</tr>
<tr>
<td>3</td>
<td>C. granulatus (Hodge, 1863)</td>
<td>2</td>
<td>1</td>
<td>Green &amp; Macquitty (1987); Bartsch (1991a)</td>
</tr>
<tr>
<td>5</td>
<td>C. laevisetosus Chatterjee, Lee &amp; Chang, 2004</td>
<td>2</td>
<td>1</td>
<td>Chatterjee et al. (2004)</td>
</tr>
<tr>
<td>7</td>
<td>C. pseudosetosus Newell, 1949</td>
<td>3</td>
<td>1</td>
<td>Newell (1949)</td>
</tr>
<tr>
<td>8</td>
<td>C. richardi Trouessart, 1902</td>
<td>2</td>
<td>1</td>
<td>Bartsch (1983b, 1991a)</td>
</tr>
<tr>
<td>10</td>
<td>C. unalaskensis Newell, 1951</td>
<td>2</td>
<td>1</td>
<td>Newell (1951b)</td>
</tr>
</tbody>
</table>

**Seta on palpal segment:**
Distidorsal seta on P$_2$ of Agaue parva (Chilton, 1883) is frond shaped in the female while filiform in the male (Newell 1984).

Distidorsal seta on P$_2$ of Agaue agauoides (Lohmann 1907) is short and bifurcate in the female (Bartsch 1993a) while filiform in the male (Newell 1984).
Legs

PAS on tarsus:
In the genus, Halacarus, PAS of male tarsus IV are often plumose. In the Rhombognathus the medial PAS of male is normally plumose or branched.

In Copidognathus tupinamborum Pepato & Tiago, 2005 PAS on tarsus IV are branched in males, while in female a pair of tapering PAS present. (Pepato & Tiago 2005).

In Actacarus sinensis Bartsch, 1991 tarsus IV has a long flagelliform medial PAS, while in the female the medial PAS is seta-like (Bartsch 1991b).

Lamella on legs:
Phacacarus flavellus Bartsch, 1992 has larger lamella on legs in the female than those of male (Bartsch1992a, 1994a).

In males of Copidognathus dentipus Bartsch, 1989 the distal lamella on telofemora, genua, and tibiae of legs are smaller than those of the female (Bartsch 1989)

Fossary setae on tarsus IV:
In general, the shape of fossary setae on tarsus IV is the same in both male and female but in few cases apical fossary setae of male are distinctly more plumose than those of female eg. Isobactrus uniscutatus (Viets 1939), Rhombognathus peltatus Viets, 1939 (Bartsch 2003).

In several limnic species males are extremely rare or absent, while in marine species separate sexes are common. Unfortunately, many marine halacarid species have been reported based on one sex only (even though both sexes probably exist in nature), hindering studies on sexual dimorphism. More intensive surveys will hopefully recover both sexes and description of those marine species based on both genders will uncover more sexually dimorphic characters in halacarid mites.

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References


DYMORFIZM PŁCIOWY U HALACARIDAE (ACARI): ÔBECNY STAN WIEDZY

Streszczenie

W artykule zaprezentowano przegląd obecnego stanu wiedzy na temat dymorfizmu płciowego u Halacaridae. Samice i samce Halacaridae przede wszystkim różnią się morfologią rejonu genitalnego. Dodatkowo dymorfizm płciowy zaznacza się u niektórych gatunków w wyglądzie tarcz grzbietowych, tarcz brzusznych, chemotaksji odnóży krocznych oraz ogólnym kształtem idiosomy i gnatosomy. Odmienność samców i samic może czasami przejawiać się rozmiarach tarcz idiosomalnych, ich łączeniu się oraz szerokościach miękkich, kutykularnych odstępów pomiędzy tarczami. W pracy omówiono również inne różnice płciowe: przyssawki genitalne, płytki na nogach, zagłębione szczeciny na stopach.

Słowa kluczowe: dymorfizm płciowy, Halacaridae, przegląd