Persian J. Acarol., 2021, Vol. 10, No. 2, pp. 155–166.
https://doi.org/10.22073/pja.v10i2.65624
Journal homepage: http://www.biotaxa.org/pja

Article

A checklist of halacarid mites (Acari: Halacaridae) associated with decapod crustaceans (Arthropoda, Crustacea, Decapoda)

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ABSTRACT
A compilation of halacarid mite species (Halacaridae) found associated with decapod crustaceans (Arthropoda, Crustacea, Decapoda) has been carried out based on published records. In this paper, we listed 24 species associated with crustaceans altogether. These 24 species belong to 10 genera, viz. *Arhodeoporus* (1 species), *Astacopsiphagus* (1 species), *Copidognathus* (11 species), *Halacarellus* (2 species), *Limnohalacarus* (1 species), *Lohmannella* (1 species), *Porohalacarus* (1 species), *Porolohmannella* (1 species), *Soldanellonyx* (2 species), *Thalassarachna* (3 species). Majority of the association types are probably commensals or occasional invaders in nature and only a few species are assumed to be parasitic.

KEY WORDS: Association; commensals; decapod; halacarid mites; occasional invader.

PAPER INFO.: Received: 19 November 2020, Accepted: 20 December 2020, Published: 15 April 2021

INTRODUCTION

Halacarids are primarily the denizens of marine environments but may also be found in brackish and freshwater habitats. Halacarid mites live in a variety of substrata ranging from fronds, holdfasts, tufts of algae, in and on colonies of sponges, hydrozoans, bryozoans, barnacles, mussels, and polychaetes to sediments, flocculent ooze, coarse and fine sands (Chatterjee and Sarma 1991; Bartsch 2006a, 2008). Some species are associated with mangroves (Chatterjee *et al*. 2018). The mites are also known to dwell on the rough and hairy body surfaces of macrofauna like crustaceans, gastropods, and between spines and in the gut of echinoderms (Bartsch 2006a). There are a few parasitic forms or suspected to be parasitic species (Chatterjee 2020). The genera *Enterohalacarus*, *Parhalixodes* and *Spongihalacarus* are thought to be obligate associates of echinoids, nemerteans and sponges, respectively (Viets 1938; Laubier 1960; Otto 2000).

A list of halacarid mites associated with decapod crustaceans was given in Normant *et al.* (2013), which is in need of being updated and lacks much information. Present paper provides an updated checklist of halacarid mites found associated with decapod crustaceans. A particular species if recorded from other hosts/substrata is also mentioned.

METHOD

The present checklist is prepared based on published literatures on halacarid mites by the end of

How to cite: Chatterjee, T. (2021) A checklist of halacarid mites (Acari: Halacaridae) associated with decapod crustaceans (Arthropoda, Crustacea, Decapoda). *Persian Journal of Acarology*, 10(2): 155–166.

June 2020. The genera, and species within genera, are arranged in an alphabetical sequence.

RESULTS

Genus *Arhodeoporus* Newell, 1947

Arhodeoporus arenarius Newell, 1947

Records associated with decapod crustaceans – This species was found associated with spider crab *Libinia emarginata* (Arthropoda, Crustacea, Malacostraca, Decapoda) from Rhode Island, USA (Bartsch 1979a).

Other records – This species was reported from intertidal and subtidal sediments from North America: Woods Hole, Massachussetts, New Haven County, Connecticut, Beaufort, North Carolina (Newell 1947).

Remarks – Newell (1947) commented that this is a subtidal form, appears consistently and often in appreciable numbers in the intertidal, especially in the low tide zone and it can be considered a truly arenicolous species rather than a psammoxene form.

Genus *Astacopsiphagus* Viets, 1931

Astacopsiphagus parasiticus Viets, 1931

Records associated with decapod crustaceans – This species was reported as parasite on the fresh water crayfish *Euastacus spinifer* (syns.: *Euastacus serratus*, *Astacopsis serratus*) (Crustacea: Decapoda) from Moran's Creek, Roberts Plateau, MacPherson Range, Queensland National Park in Queensland, Australia, south of Brisbane (Viets 1931) based on nymphs attached to the gills of the host by the chelicerae. Womersley (1943) reported adult male and female which were collected by process of dissecting out the adult inside advanced nymphs found attached to the gill chambers of fresh water crayfish *Euastacus sulcatus* from Lamington National Park, Queensland, Australia.

Remarks – This is an ectoparasitic species associated with crayfish.

Genus *Copidognathus* Trouessart, 1888

Copidognathus celatus Bartsch, 1979

Records associated with decapod crustaceans – This species was found amongst cuticular structures of spider crab *Libinia emarginata* (Arthropoda, Crustacea, Malacostraca, Decapoda) from Rhode Island, USA (Bartsch 1979a).

Other records – This species was also found mid-tide to subtidal region in coarse sediment, kelp holdfasts, algae from eastern North America (Bartsch 1979a, 1982).

Copidognathus gasconi (Gil & Garzón, 1979)

Syn.: *Velardoacarus gasconi* Gil & Garzón, 1979

Records associated with decapod crustaceans – This species was reported from gill chamber of a marine crab *Peltarion spinulosum* (Crustacea: Decapoda) in Uruguayan coast (Gil and Garzón 1979).

Remarks – There was question on the validity of the genus *Velardoacarus*. Bartsch (1987) commented that *Veladacarus* could also be a *Copidognathus* species. Pepato *et al*. (2005) stated that

the description of *Velardoacarus gasconi* has a lot of inaccuracies and it is possible that *Velardeacarus* is a junior synonymous of *Copidognathus*. Bartsch (2009) kept this species under the genus *Copidognathus* as *Copidognathus gasconi* (Gil and Garzón 1979).

Copidognathus libiniensis Pepato, Santos & Tiago, 2005

Records associated with decapod crustaceans – This species was reported associated with *Libinia spinosa* from 25 m depth at Poço Beach, São Sebastião Island, Ilhabela, São Paulo, Brazil (Pepato *et al*. 2005).

Other records – This species was also reported among phytal samples from Martins de Sá Beach, Caraguatatuba, São Paulo, Brazil (Pepato *et al*. 2005).

Remarks – Pepato *et al*. (2005) reported that only male specimens of host crab *Libinia spinosa* were infested and they also commented that the absence of infested females of *L. spinosa* might be due to the differences observed in morphology of abdomen in males and females of this crab species; the ventral side of the abdomen of males is more delicate than that of females, this softness might enable the halacarids to pierce the exoskeleton in this area to obtain nutrients from the crab host. But Pepato *et al*. (2005) also commented that there is no direct evidence of feeding on crabs. Moreover, this species was also reported among phytal samples from Martins de Sá Beach, Caraguatatuba, São Paulo, Brazil.

Copidognathus maculatus Bartsch, 1979

Records associated with decapod crustaceans – This species was found amongst cuticular structures of spider crab *Libinia emarginata* (Arthropoda, Crustacea, Malacostraca, Decapoda) from Rhode Island, USA (Bartsch 1979a).

Other records – It is also found in lower tidal and subtidal algae, barnacles and sediments (Bartsch 1979a, 1982).

Copidognathus matthewsi Newell, 1956

Records associated with decapod crustaceans – This species was found on the gills lobster *Parribacus antarcticus* (Decapoda, Scyllaridae) from Hawaiian Islands (Newell 1956).

Remarks – This species lives as a parasite on the gills of *Parribacus antarcticus*. Newell (1956) also commented that the filaments of gills infested by mite sometimes show necrotic spots apparently due to the feeding activities of the mite.

Copidognathus menippensis Pepato, Santos & Tiago, 2005

Records associated with decapod crustaceans – This species was reported associated with crab *Menippe nodifrons* from intertidal at Figueira Beach, São Sebastião, São Paulo, Brazil.

Remarks – This species was found on ovigerous or postovigerous females of *Menippe nodifrons* and might be an egg-predator (Pepato *et al*. 2005).

Copidognathus novus Bartsch, 1980

Syn.: *Copidognathus septentrionalis* sensu Newell 1947 (non *Copidognathus septentrionalis* (Halbert, 1915), *Copidognathus septentrionalis* sensu Bartsch 1979.

Records associated with decapod crustaceans – This species (reported as *Copidognathus septentrionalis*) was found amongst cuticular structures of spider crab *Libinia emarginata* (Arthropoda, Crustacea, Malacostraca, Decapoda) from Rhode Island, USA (Bartsch 1979a).

Other records – Recorded from intertidal to subtidal sediments of Atlantic coasts of North America (Newell 1947; Barsch 1982).

Copidognathus punctatissimus (Gimbel, 1919)

Syn.: *Halacarus* (*Copidognathus*) *punctatissimus* Gimbel, 1919

Records associated with decapod crustaceans – This species was found amongst cuticular structures of spider crab *Libinia emarginata* (Arthropoda, Crustacea, Malacostraca, Decapoda) from Rhode Island, USA (Bartsch 1979a).

Other records – This species was recorded at various tidal and subtidal substrata; brackish to marine habitat of eastern United States (Gimbel 1919; Newell 1947; Bartsch 1982).

Copidognathus stevcici Bartsch, 1976

Records associated with decapod crustaceans – This species was reported between *Maja squinado* eggs in Adriatic Sea (Bartsch 1976b). This species was reported walking on the eggs of *Maja squinado* collected at Plymoth, England, UK (Green and MacQuitty 1987). Green and MacQuitty (1987) also reported this species in the 'Michael Collection at the British Museum Natural History' and collection containing label 'Portgwarra, spider crab'. This species was also found associated with adult females of the spider crabs *Maja brachydactyla* and *M. squinado* under laboratory conditions; mites were observed alive on their host for extended periods and direct evidence of feeding on crab's eggs was also provided (Guerao *et al*. 2011).

Remarks – Guerao *et al*. (2011) observed the feeding behaviour of *C. stevcici* on eggs; mites support palps on the surface of the egg and the rostrum passes through the chorion and vitelline membrane for sucking on the eggs obtained from an ovigerous female of *M. brachydactyla*; it provides direct evidence of feeding on crab's eggs.

Copidognathus sp. A (in Normant *et al*. 2013)

Records associated with decapod crustaceans – This species was found on chelipeds of Chinese mitten crab *Eriocheir sinensis* from fresh water, Germany (Normant *et al*. 2013)

Copidognathus sp. B (in Normant *et al*. 2013)

Records associated with decapod crustaceans – This species was found on chelipeds of Chinese mitten crab *Eriocheir sinensis* from brackish water, Poland (Normant *et al*. 2013).

Genus *Halacarellus* Viets, 1927

Halacarellus hyrcanus (Viets, 1928)

Syns.: *Caspihalacarus hyrcanus* Viets, 1928, *Caspihalacarus hyrcanus danubialis* Motas & Soarec-Tanasachi, 1943

Records associated with decapod crustaceans – This species was found setae-covered claws of Chinese mitten crab *Eriocheir sinensis* from Germany (Normant *et al*. 2013). This species

(reported as variety of *Caspihalacarus hyrcanus danubialis* Motas & Sorec) was found in association with amphipod crustaceans *Corophium* and *Dikerogammarus* (cf. Green & MacQuitty 1987).

Other records – This species was reported from Caspian Sea, Black Sea, and rivers flowing to Black Sea. The majority of findings are from river. This species most likely inhabits unsorted sediments, well aerated and rich in organic matters (Bartsch 2006a); epibenthic in and on sediment amongst roots of vascular plants, green algae and tubes of an associated fauna (Bartsch 1979; Martens *et al*. 2006; Bartsch and Gerecke 2011). This species was also reported from Isparta, Lake Eğirdir at about 910 m a.s.l. on sediments and stones (Durucan 2020).

Remarks – This species was recorded from freshwater to salinity 12.5‰. *Caspihalacarus hyrcanus* Viets, 1928 moved to *Halacarellus* as *H. hyrcanus* (Viets, 1928) by Bartsch & Gerecke (2011).

***Halacarellus petiti* (Angelier, 1950)**

Syns.: *Halacarus* (*Halacarellus*) *petiti* Angelier, 1950, *Thalassarachna petiti* (Angelier, 1950) - Green & MacQuitty (1987), *Halacarellus balticus* - Pahnke (1974)

Records associated with decapod crustaceans – This species was found on chelipeds of Chinese mitten crab *Eriocheir sinensis* from brackish water, Poland (Normant *et al*. 2013).

Other records – This species was recorded from eastern North Atlantic, Baltic, Mediterranean in Shallow water among various substrata, often soft sediment, epibenthic in and on sediment amongst roots of vascular plants, green algae and tubes of an associated fauna, found from brackish to almost fresh water (Angelier 1950, Bartsch 1976a, 1979b; Morselli and Mari 1979; Green & MacQuitty 1987).

Genus *Limnohalacarus* Walter, 1917

***Limnohalacarus wackeri* Walter, 1914**

Syns.: *Halacarus wackeri* Walter, 1914, *Limnohalacarus wackeri* var. *astacicola* Viets, 1927, *Limnohalacarus astacicolus* Viets, 1927 - K.O. Viets 1987, *Limnohalacarus mauritzi* Romijn & Viets, 1924

Records associated with decapod crustaceans – This species was found on cray fish *Astacus astacus* (syn.: *Potamobius astacus*) from Germany (Viets 1927). This species was also found on branchial cavity of *Astacus astacus* from Poland (Wiszniewski 1939). It was also reported on branchial cavity of *Orconectes limosus* from Lake Ińsko, Poland (Zawal 1998).

Other records – It was found at the bottom sediments of standing, slow flowing waters (Bartsch 2006b).

Genus *Lohmannella* Trouessart, 1901

***Lohmannella falcata* (Hodge, 1863)**

Syns.: *Leptognathus falcatus* Hodge, 1863, *Trouessartella falcata*, - Lohmann 1901, *Leptognathus marinus* Lohmann, 1889

Records associated with decapod crustaceans – This species was found amongst cuticular structures of spider crab *Libinia emarginata* (Arthropoda, Crustacea, Malacostraca, Decapoda) from Rhode Island, USA (Bartsch 1979a).

Other records – This species was reported from eastern and western Northatlantic, North Sea, Baltic, Mediterranean, Black Sea among hydrozoans, algae, and sediment (Newell 1947; Bartsch (1977a, 1982, 2003, 2009).

Genus *Porohalacarus* Thor, 1922

Porohalacarus alpinus Thor, 1910

Syns.: *Halacarus alpinus* Thor, 1910, *Halacarus alpinus decaporus* Walter, 1919, *Halacarus* (*Porohalacarus*) *alpinus* var. *duodecimpora* Thor, 1923, *Halacarus octoporus* Viets, 1924, *Porohalacarus vietsi* Thor, 1922

Records associated with decapod crustaceans – This species was reported on cray fish *Astacus astacus* (syn.: *Potamobius astacus*) from Germany (Viets 1927). This species was also found on branchial cavity of cray fish *Astacus astacus* and *Orconectes limosus* from Poland (Wiszniewski 1939). It was also reported on branchial cavity of *Orconectes limosus* from River In and Lake Ińsko, Poland (Zawal 1998). This species was found on chelipeds of Chinese mitten crab *Eriocheir sinensis* from freshwater water, Germany (Normant *et al*. 2013).

Other records – Common in oligotrophic and mesotrophic waters; present amongst mosses, vascular plants, on bryozoans, between shells of *Dreissena* (Bivalvia) (Bartsch 2006b).

Genus *Porolohmannella* Viets, 1933

Porolohmannella violacea (Kramer, 1879)

Syns.: *Leptognathus violaceus* Kramer, 1879, *Raphignathus falcatus* Macer 1899, *Trouessartella violacea* (Kramer, 1879) - Lohmann 1901, *Lohmannella violacea* (Kramer, 1879) - Lohmann 1907

Records associated with decapod crustaceans – This species was reported on cray fish *Astacus astacus* (syn.: *Potamobius astacus*) from Germany (Viets 1927). This species was also found on branchial cavity of cray fish *Astacus astacus*, *Astacus leptodactylus* (syn.: *Potamobius leptodactylus*) and *Orconectes limosus* from Poland (Wiszniewski 1939). It was also reported on branchial cavity of *Orconectes limosus* from River In and Lake Ińsko, Poland (Zawal 1998). This species was found on chelipeds of Chinese mitten crab *Eriocheir sinensis* from freshwater water, Germany (Normant *et al*. 2013).

Other records – This species has been reported from standing surface waters, swamps, ponds and lakes, groundwater to mountain lakes in more than 2000 m a.s.l. and brackish water in a variety of substrata, sand, flocculent ooze, vascular plants, mosses, algae (Bartsch 2006a, b; Chatterjee and Durucan 2021).

Genus *Soldanellonyx* Walter, 1917

Soldanellonyx chappuisi Walter, 1917

Records associated with decapod crustaceans – This species was found on chelipeds of Chinese mitten crab *Eriocheir sinensis* from freshwater water, Germany (Normant *et al*. 2013).

Other records – This species was reported in the groundwater, depth of lakes, caves, springs, sand filters among gravel, soft sediment and mosses from North America, Europe (Walter 1917; Viets 1959; Bartsch 2006a, 2011).

Soldanellonyx monardi Walter, 1919

Records associated with decapod crustaceans – This species was found on chelipeds of Chinese mitten crab *Eriocheir sinensis* from freshwater water, Germany (Normant *et al*. 2013).

Other records – This species was recorded in hypo- and epigean waters, amongst sediment, debris, roots of vascular plants and mosses, also in moist debris of dried up beds of streamlets; the species is also known to live in slightly saline (0.5–5 ‰) coastal surface sediments (Bartsch 2006a, 2014).

Genus *Thalassarachna* Packard, 1871

Thalassarachna basteri (Johnston, 1836)

Syns.: *Acarus basteri* Johnston, 1836, *Halacarus ctenopus* Gosse, 1855, *Thalassarachna verrilli* Packard, 1871, *Halacarus spinifer* Lohmann, 1889, *Halacarus globosus* Trouessart, 1889, *Halacarus* (*Halacarellus*) *basteri* (Johnston, 1836) - Viets 1927, *Halacarellus basteri* var. *septentrionalis* Gimbel, 1938, *Halacarus* (*Thalassarachna*) *basteri* (Johnston, 1836) - Newell 1947

Records associated with decapod crustaceans – This species was found amongst cuticular structures of spider crab *Libinia emarginata* (Arthropoda, Crustacea, Malacostraca, Decapoda) from Rhode Island, USA (Bartsch 1979a).

Other records – This species occurred on various algae, among sediments, on colonial hydroids, and on ectoproct polyzoans in Arctic Sea, Baltic Sea, Atlantic coasts of North America and Europe, Mediterannean and Black Sea, UK from intertidal to more than 100m depth (Newell 1947; Green and MacQuitty 1987; Bartsch 1982).

Thalassarachna dissimilis (Bartsch, 1979)

Syns.: *Halacarellus dissimilis* Bartsch, 1979

Records associated with decapod crustaceans – This species was found on spider crab *Libinia emarginata* (Arthropoda, Crustacea, Malacostraca, Decapoda) from Rhode Island, USA (Bartsch 1979a).

Other records – This is also found in subtidal sediments from Rhode Island, USA (Bartsch 1979a).

Thalassarachna longipes (Trouessart, 1888)

Syns.: *Leptopsalis longipes* Trouessart, 1888a, *Halacarus longipes* (Trouessart, 1888) - Trouessart 1888b, *Halacarus Murrayi* Lohmann, 1889, *Halacarus* (*Halacarellus*) *longipes* (Trouessart, 1888) - Viets 1927b, *Halacarus* (*Thalassarachna*) *longipes* (Trouessart, 1888) - Newell 1947

Records associated with decapod crustaceans – This species was found amongst cuticular structures of spider crab *Libinia emarginata* (Arthropoda, Crustacea, Malacostraca, Decapoda) from Rhode Island, USA (Bartsch 1979a).

Other records – It was recorded on various substrata: sediments, algae, sponges, and bryozoans from Boreal North Atlantic, European and American shores (Newell 1947; Bartsch 1998).

DISCUSSION

In this paper, we listed 24 species associated with crustaceans altogether. These 24 species belong to 10 genera, viz. *Arhodeoporus* (1 species), *Astacopsiphagus* (1 species), *Copidognathus* (11 species), *Halacarellus* (2 species), *Limnohalacarus* (1 species), *Lohmannella* (1 species), *Porohalacarus* (1 species), *Porolohmannella* (1 species), *Soldanellonyx* (2 species), *Thalassarachna* (3 species). Majority of the associations are probably commensals or occasional invaders in nature and only a few species like *Astacopsiphagus parasiticus*, *Copidognathus gasconi*, *C. matthewsi*, and *C. stevcici* are assumed to be parasitic.

Guerao *et al*. (2011) provides direct evidence of feeding behaviour of *Copidognathus stevcici* on crab's eggs; mites support palps on the surface of the egg and the rostrum passes through the chorion and vitelline membrane for sucking on the eggs obtained from a crab ovigerous female of *M. brachydactyla*; this provides direct evidence of feeding on crab's eggs. Feeding takes 2–5 min and could increase the volume of the idiosoma up to 25% of mite.

Pepato *et al*. (2005) reported two species *Copidognathus libiniensis* and *C. menippensis* associated with crabs. Pepato *et al*. (2005) commented that both mite species have chelicerae with broad movable digits that could be used to pierce the delicate exoskeleton present at the ventral side of the host abdomen of males of *Libinia spinosa* or the egg membrane of *Menippe nodifrons*. Pepato *et al*. (2005) also commented that no direct evidence of feeding on crabs or crab' eggs was found in the study and the possibility that these species feed on accompanying species, such as cirripeds, copepods and nemerteans could not be rejected; they also pointed that the samples obtained were insufficient to determine the nature of the relationship between mites and crabs. Moreover, one female specimen of *Copidognathus libiniensis* was collected among phytal samples from Martins de Sá Beach (Caraguatatuba, São Paulo), which indicates that this species is not only found associated with crabs but may also be found in other substrata.

Seven halacarid species viz. *Copidognathus* sp. A, *Copidognathus* sp. B, *Halacarellus petiti*, *Porohalacarus alpinus*, *Porolohmannella violacea*, *Soldanellonyx chappuisi*, and *Soldanellonyx monardi* are found associated with setae on the claws of *Eriocheir sinensis.* It seems that the mites occurring on *E. sinensis* are commensals, which use the dense setae on the crabs' claws only as a habit; association is probably facultative and temporary, where they probably find diverse items of food, like fungi, organic matter and algae, as well as potential prey in the case of predators (Normant *et al*. 2007, 2013). Normant *et al*. (2013) commented that the considerable migration capabilities of Chinese mitten crab *E. sinensis* appear to be beneficial to epibiotic mites, promoting their dispersal as well as their introduction to new environments. Normant *et al*. (2013) also pointed that the Chinese mitten crab, a semi-terrestrial species, spends a considerable amount of time out of the water, the dense setae prevent the epibiotic mites suffering from desiccation.

Proper collection of more crustacean specimens for epibiotic mites from different areas may result in uncovering many more epibiotic mite species and give a better idea about the nature of the association between mites and crustaceans.

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فهرست کنه‌های دریازی (Acari: Halacaridae) مرتبط با سخت‌پوستان ده‌پا (Arthropoda, Crustacea, Decapoda)

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چکیده

فهرست کنه‌های دریازی (Halacaridae) مرتبط با سخت‌پوستان ده‌پا (Arthropoda, Crustacea, Decapoda) بر اساس گزارش‌های چاپ شده گردآوری شد. در این مقاله روی هم رفته ۲٤ گونه مرتبط با سخت‌پوستان فهرست شد. این ۲٤ گونه به ۱۰ جنس یعنی *Arhodeoporus* (یک گونه)، *Astacopsiphagus* (یک گونه)، *Copidognathus* (۱۱ گونه)، *Halacarellus* (دو گونه)، *Limnohalacarus* (یک گونه)، *Lohmannella* (یک گونه)، *Porohalacarus* (یک گونه)، *Porolohmannella* (یک گونه)، *Soldanellonyx* (یک گونه) و *Thalassarachna* (یک گونه) تعلق دارند. بیشتر این ارتباط‌ها به احتمال هم‌سفره‌ها یا مهاجمان اتفاقی در طبیعت هستند و گونه‌های اندکی انگل فرض می‌شوند.

واژگان کلیدی: ارتباط؛ هم‌سفره‌ها؛ ده‌پا؛ کنه‌های دریازی؛ مهاجم اتفاقی.

اطلاعات مقاله: تاریخ دریافت: ۱۳۹۹/۸/۲۹، تاریخ پذیرش: ۱۳۹۹/۹/۳۰، تاریخ چاپ: ۱٤۰۰/۱/۲٦