Scanning electron microscopic observation of *Acarothrix grandocularis* (Acari, Halacaridae) and notes on the species of the genus *Acarothrix*

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Abstract Scanning electron microscopic observations of some characters of *Acarothrix grandocularis* Chatterjee, Marshall, Guru, Ingole, Pešić 2012 is presented. Distribution and characters of species belonging to the genus *Acarothrix* are also discussed.

Cechy Acarothrix grandocularis (Acari, Halacaridae) widoczne dzięki zastosowaniu mikroskopu skaningowego na tle rodzaju Acarothrix

Słowa kluczowe	Acarothrix grandocularis, SEM, rozmieszczenie
Streszczenie	Artykuł prezentuje cechy <i>Acarothrix grandocularis</i> Chatterjee, Marshall, Guru, Ingole, Pešić 2012 – widoczne dzięki zastosowaniu mikroskopu skaningowego. Dyskutowane są również
	cechy i rozmieszczenie gatunków należących do rodzaju Acarothrix.

Introduction

Acarothrix grandocularis Chatterjee, Marshall, Guru, Ingole and Pešić (2012) was first described from India and Brunei Darussalam among algal turf growing on pneumatophores of mangroves in estuarine habitats (Chatterjee et al., 2012). Bartsch (2015) reported this species from Kranji, Singapore among green and red algae on trunks of mangrove trees. In the present paper some morphological characters of *A. grandocularis* is studied in detail, based on scanning electron microscopic observation of specimens from Goa, India. Distribution and characters of species belonging to the genus Acarothrix are also provided.

Material and Methods

Specimens were collected from Chorao Island (North Goa), Virnoda Pernem (North Goa), Chicalim Vasco (South Goa) and Chinchinim (South Goa) among algal turf growing on pneumatophores of mangroves or in mud flat associated with mangroves.

Specimens for scanning electron microscopy (SEM) were prefixed overnight at 4°C in 2.5% glutaraldehyde, followed by post fixation in 2% cold osmium tetroxide. After dehydration through a graded series of ethanol (50–100% at 10% interval) for 30 minutes each, the material was critical-point dried, and coated with a platinum-palladium mix in a high evaporator, and then examined with a scanning electron microscope.

The following abbreviations are used in the text and figure legends: AD, anterior dorsal plate; AE, anterior epimeral plate; ds1-5, dorsal setae 1–5 on the idiosoma; GA, genitoanal plate; GO, genital opening; OC, ocular plate(s); PAS, parambulacral seta(e); PD, posterior dorsal plate; PGS, perigenital setae; P1-4, first to fourth palpal segment; SGS, subgenital setae.

Study area: Chorao Island (North Goa), west coast of India: Latitude 15° 30' 45.74" N, Longitude 73° 52' 11.25" E. The Chorao Island is situated 5 kms from Panaji. Island present in Mandovi river, water is brackish in nature and salinity from 3–7‰. Samples collected from algal turf associated with pneumatophores of *Avicennia* sp, *Rhizophora* sp.

Chicalim Vasco (South Goa), west coast of India: Latitude 15° 24' 20.49" N, Longitude 73° 53' 18.97" E. Samples collected from algal turf associated with pneumatophores of *Avicennia* and *Rhizophora* sp. Samples also collected from mud flat associated with mangroves.

Virnoda Pernem (North Goa), west coast of India: Latitude 15° 40' 13.85" N, Longitude 73° 43' 22.19". Samples collected from algal turf associated with pneumatophores of *Rhizophora* sp.

Chinchinim (South Goa), west coast of India: Chinchinim is located between Lat: 15° 12' N. Long: 73° 58' E and 15.20° N 73.97° E. Samples collected from mud flat in mangrove area. *Avicennia* sp dominated.

Results and Discussion

Acarothrix grandocularis Chatterjee et al. 2012

Acarothrix grandocularis Chatterjee et al. (2012, pp. 542–546, figs. 1A-D, 2A-F, 3A-D); Bartsch (2015, 100–102, figs. 2H-O).

Description: The original description of this species is given in Chatterjee et al. (2012) based on the specimens collected from Goa, India and Brunei Darussalam. Some characters referred in that paper are described in more details according to present SEM study based on the specimens collected from Goa, India.

AD, OC and PD are separate (Figure 1A). Areolae and costae on dorsal plates slightly raised with porose panel (Figures 1F, 2A); remainder of plates panelled (2B). AD with one anterior and two posterior areolae; 1st pair of gland pores inserted near anterolateral edge of posterior areolae; posterior margin of AD triangular. OC elongate, setae ds₂ on OC (Figure 1D, E). PD with a pair of longitudinal porose costae, 2 porose panels wide (Figures 1F, 2A); setae ds₃–ds₅ on PD (2C, D). AE, PE and GA separate (Figure 1B, C). AE almost smooth (Figure 2E) with 3 pairs of ventral setae and a pair of epimeral pores, epimeral pore shown in Figure 2F. Three pairs of PGS present. Pair of SGS located at the anterior end of genital sclerites (Figure 3A).



Figure 1. *Acarothrix grandocularis* Chatterjee et al. 2012, SEM figures, female. A. Idiosoma dorsal; B, C. Idiosoma ventral; D. Magnified view of parts of AD, OC and PD; E. OC and PD; F. Part of costa and panels on PD.



Figure 2. *Acarothrix grandocularis* Chatterjee et al. 2012, SEM figures, female. A. Part of costa on PD; B. Panels between two costae on PD; C. seta ds3 on PD; D. Seta ds4 on PD; E. Part of AE; F. Epimeral pore on AE.



Figure 3. *Acarothrix grandocularis* Chatterjee et al. 2012, SEM figures, female. A. GO of female; B. Gnathosoma ventral view; C. Gnathosoma ventrolateral view; D. Anterior part of gnathosoma and palp; E. Part of tibia I and tarsus I; F. Part of tibia II and tarsus II (arrow indicating pectinate seta on tibia).



Figure 4. *Acarothrix grandocularis* Chatterjee et al. 2012, SEM figures, female. A, Part of tibia II and tarsus II (arrow indicating pectinate seta on tibia); B. Anterior part of tarsus II (arrow indicating 1., 2: PAS; 3: solenidion); C. Anterior part of tarsus II (arrow indicating PAS); D, E. Part of tibia and tarsus III (arrow indicating pectinate seta on tibia); D. Tip of tarsus III.

Rostrum triangular, tip of rostrum not surpassing the anterior end of P_2 . P_1 and P_3 without any setae; P_2 with 1 dorsal seta; P_4 with 3 long proximal setae and 1minute distal seta. Proto and deuto- rostral setae situated at the tip of rostrum, long maxillary setae of rostrum anterior to middle of rostrum, gnathosomal base with a pair of setae (3B, C). Rostral sulcus is extending posteriorly to just beyond the tritorostral setae (Figure 3B, D).

Tibiae I–IV with 1-1-1-0 bipectinate ventromedial setae . Pectinate seta shown in figures 3E, F, 4A, D, E. Tarsus I with 3 dorsal setae, 1 solenidion, 2 ventral setae, 2 doublet eupathid PAS (Figure 3E). Tarsus II with 3 dorsal setae, 1 solenidion, 2 single eupathid PAS (4B, C). Tarsus III with 4 dorsal setae and 2 PAS (4F). All tarsi with 2 lateral claws, a small bidentate medial claw, and a carpite; lateral claws smooth ventrally.

Remarks. In India. *A. granocularis* is found from both pneumatophores turf and mud flat also. The salinity of mangrove area ranges from 3–7‰ A detailed study based on SEM and molecular analysis for specimens from different localities is necessary to reveal variations in this species between the localities.

Notes on species of the genus Acarothrix

Acarothrix is a genus of halacarid mites that was proposed by Bartsch (1990) and has A. palustris Bartsch 1990 as the type species. There are five species viz. A. palustris Bartsch (1990), A. longiunguis Bartsch (1997), A. umgenica Procheş (2002), A. ampliata Bartsch (2004) and A. grandocularis Chatterjee et al. (2012) so far recorded under this genus.

The genus has been recorded from Southern China, Singapore, northern Australia, southeastern Africa, Florida and India. All species are known from tropical or warm temperate regions. Table 1 shows detail distribution of the species in *Acarothrix* along with the habitats and references.

Name of the species	Locality	Oceanic provinces	Habitat	References
1	2	3	4	5
Acarothrix ampliata Bartsch 2004	USA: Gulf of Mexico at Tampa Bay, Florida	ATW: Atlantic Ocean, tropical west	Little Manatee River, which empties into Tampa Bay	Bartsch (2004)
Acarothrix ampliumeris Bartsch 2006	Singapore	PTW: Pacific Ocean, tropical west	Cladophora mat, Chlorophyta, on muddy and sandy sediments in mangrove area	Bartsch (2006)
	Singapore: End of Lim Chu Kang Road	PTW: Pacific Ocean, tropical west	Among green (Cladophorales) and red algae (<i>Catenella</i> sp., Gigartinales) on pneumatophores of <i>Avicennia</i> sp. (Avicenniaceae) mangroves	Bartsch (2015)

Table 1. Species of Acrothrix: Localities with habitats

1	2	3	4	5
<i>Acarothrix</i> <i>grandocularis</i> Chatterjee, Marshall Guru	Brunei Darussalam: Batu Marang	PTW: Pacific Ocean, tropical west	Algal turf growing on <i>Rhizophora</i> sp. pneumatophores	Chatterjee et al. (2012)
Ingole, Pešić 2012	India: Chorao Island, North Goa	ITE: Indian Ocean, tropical east	Algal turf growing on Avicennia, Rhizophora pneumatophores	Chatterjee et al. (2012); Present report
	Singapore: Kranji	PTW: Pacific Ocean, tropical west	landward edge of mangrove area, green and red algae on trunk, high water edge	Bartsch (2015)
	India: Chicalim Vasco (South Goa)	ITE: Indian Ocean, tropical east	Algal turf growing on pneumatophores of mangroves; mud flat associated with mangroves	Present report
	India: Virnoda Pernem (North Goa):	ITE: Indian Ocean, tropical east	Algal turf growing on pneumatophores of mangroves;	Present report
	India: Chinchinim (South Goa)	ITE: Indian Ocean, tropical east	Mud flat on the mangrove area.	Present report
Acarothrix longiunguis Bartsch 1997	Australia: Sadgroves Creek, near Darwin, Northern Australia,	PTW: Pacific Ocean, tropical west	Soft mud from mangrove area	Bartsch (1997)
<i>Acarothrix</i> <i>palustris</i> Bartsch 1990	Hong Kong: southern China	PTW: Pacific Ocean, tropical west	Algal turf on salt marshes and mangrove flats	Bartsch (1990)
	Singapore: Pandan River, southern coast of Singapore	PTW: Pacific Ocean, tropical west	Green algae and epibiota on <i>Avicennia</i> pneumatophores in a rockpool	Bartsch (2006)
	Singapore: End of Lim Chu Kang Road, northern coast of Singapore	PTW: Pacific Ocean, tropical west	Cladophora mat on muddy and sandy sediment in mangrove area	Bartsch (2006)
	India: Chorao Island, North Goa	ITE: Indian Ocean, tropical east	From algal turf growing on Avicennia pneumatophores	Chatterjee et al (2013)
Acarothrix umgenica Procheş 2002	South Africa: Beachwood and Bayhead Lagoon, near Durban, KwaZulu-Natal	ITW: Indian Ocean, tropical west	sediment on <i>Avicennia</i> pneumatophores	Procheș et al. (2001)
	South Africa: Beachwood mangroves in Durban, and Richards Bay, KwaZulu-Natal	ITW: Indian Ocean, tropical west	Sediment or algae covering the pneumatophores of the <i>Avicennia marina</i> mangrove tree	Procheş (2002)

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All species live in intertidal muddy environments characterized by fluctuating salinities. Four species of *Acarothrix* are found to be associated with mangroves (Chatterjee, Pfingstl, Pešić, 2018a).

Sexual dimorphism is common in many groups of Arthropoda. Sexual dimorphism is also found in some species of halacarid mites (Chatterjee, Guru, 2012). 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 comparison of important characteristics between species in the genus *Acrothrix* is compiled in Table 2.

Characters	Acarothrix ampliata	Acarothrix ampliumeris	Acarothrix grandocularis	Acarothrix longiunguis	Acarothrix palustris	Acarothrix umgenica
Idiosoma length	Male 326–340 Female 340	Male 314–325 Female 294– 309	Male 278–291 Female 291–293	Male 278–286 Female 279– 294	Male 287–322	325–385
Posterior end of AD	Triangular	Triangular	Triangular	Rounded	Rounded	Triangular
Cornea on OC	Remnants of cornea	Absent	Present	Present	Present	Present
Position of ds1	Anterior part on AD	About middle on AD	Posterior part of AD	About middle of AD	About middle of AD	Posterior part of AD
Position of ds2	OC	Membranous cuticle	OC	OC	OC	OC
Position of ds3	OC	OC	PD	OC	OC	OC
Costae on PD	Very faint line like	Absent	Present, two porose panel wide	Absent	Present	Absent
Panels on PD	Reticulate panels on PD	Median portion deliculately reticulate	Reticulate panels on PD	Smooth area on PD	Reticulate panels on PD	Reticulate panels on PD
Wart on membranous cuticle on idiosoma dorsal	Present	Absent	Absent	Absent	Present	Absent
Setae on basifemur III	3	3	2	3	3	3
Bipectinate seta in tibiae I to IV	1-1-1-0	1-1-1-1	1-1-1-0	1-1-1-0	1-1-1-0	1-1-1-?
Distance between anterior end of GO and GA in male	0.7 of GO length	Slightly less than GO length	1.1 of GO length	0.7 of GO length	Equal with GO length	1.8 of Go length

Table 2. Comparison of important characteristics between species in the genus Acarothrix

Suctorian and Peritrich ciliate epibionts have been found on several halacarid mites (Chatterjee, Dovgal, Pešić, Zawal, 2018b). Bartsch (2015) reported suctorian ciliate *Praethecacineta halacari* (Schulz, 1933) on *Acarothrix grandocularis* from Singapore.

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