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Diversity of Porifera in the Mediterranean coralligenous accretions, with description of a new species

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Abstract

Temperate reefs, built by multilayers of encrusting algae accumulated during hundreds to thousands of years, represent one of the most important habitats of the Mediterranean Sea. These bioconstructions are known as "coralligenous" and their spatial complexity allows the formation of heterogeneous microhabitats offering opportunities for a large number of small cryptic species hardly ever considered.

Although sponges are the dominant animal taxon in the coralligenous rims with both insinuating and perforating species, this group is until now poorly known. Aim of this work is to develop a reference baseline about the taxonomic knowledge of sponges and, considering their high level of phenotypic plasticity, evaluate the importance of coralligenous accretions as a pocket for biodiversity conservation.

Collecting samples in four sites along the coast of the Ligurian Sea, we recorded 133 sponge taxa (115 of them identified at species level and 18 at genus level). One species, *Eurypon gracilis* is new for science; three species, *Paratimea oxeata*, *Clathria* (*Microciona*) *haplotoxa* and *Eurypon denisae* are new records for the Italian sponge fauna, eleven species are new findings for the Ligurian Sea. Moreover, seventeen species have not been recorded before from the coralligenous community. The obtained data, together with an extensive review of the existing literature, increase to 273 the number of sponge species associated with the coralligenous concretions and confirm that this habitat is an extraordinary reservoir of biodiversity still largely unexplored, not only taxonomically, but also as to peculiar adaptations and life histories.

Keywords
Porifera, cryptic species, bioconstructions, Ligurian Sea

Introduction

The term “coralligenous” refers to a secondary hard substrate, formed by the concretion of algal thalli and, to a lesser extent, by animal skeletons. Two main types of coralligenous concretions can be distinguished: banks, which are built over more or less horizontal substrata, and rims, which develop in the outer parts of marine caves and on vertical cliffs (Ballesteros 2006). Coralligenous communities represent the temperate reefs of the Mediterranean Sea and along with the meadows of *Posidonia oceanica* (Boudouresque, 2004) are biodiversity hot spots in the basin. The holes and crevices of the coralligenous build-ups support a complex community dominated by suspension feeders (sponges, hydrozoans, serpulid polychates, molluscs, bryozoans and tunicates).

Laubier (1966) first emphasized the high biodiversity of the coralligenous and listed 544 invertebrate species from this assemblage in Banyuls. Later, Hong (1980), in an exhaustive survey of the coralligenous of Marseille, listed a total of 682 species, whilst other authors (Ros et al. 1984) reported 497 species of invertebrates from the algal concretions of the Medes Islands. Recently, Romdhane (2003) reported 35 algal species and 93 animal species from a coralligenous formation along a vertical cliff in the gulf of Tunis. However, the number of species living in the coralligenous assemblages is still undefined, because of the richness of the fauna (Laubier 1966), the habitat complexity (Pérès and Picard 1964, Ros et al. 1985), the wide depth range of the conglomerates (Ballesteros 2006), the sporadic presence of cryptic species and the scarcity of reference studies. A rapid, non-destructive protocol for biodiversity assessment and monitoring of coralligenous, based on photographic sampling, was recently proposed by Kipson et al. (2011).

Sponges, with 142 recorded species, are one of the most diverse group of sessile animals of the coralligenous assemblage (Ballesteros 2006). Some species, mainly belonging to the family Clionaidae, are active bioeroders representing the principal driving force in the turn-over of bioconstructions, both in temperate and tropical areas (Cerrano et al. 2001, Calcinai et al. 2000, 2005, 2007c)

In the present paper, the species diversity of the coralligenous sponge fauna was studied in four sites of the Ligurian Sea, focusing on the relatively poorly known cryptic species boring or insinuating into the calcareous concretions. A new species for science and ten poorly known species, rarely recorded in the Mediterranean Sea, are treated exhaustively.

Materials and methods

Samples were collected between 30 and 40 m depth by SCUBA diving from 6 stations along the Ligurian coast where coralligenous is more developed (Fig. 1). Stations (from West to East) are: Santo Stefano Shoals, station 1; Gallinara Island, station 2 (Falconara) and station 3 (Sciusciaù); Portofino Promontory, Punta del Faro, station 4 and 5 (northern and southern side of the point); Punta Manara, station 6. Four blocks of coralligenous concretion, with an average volume of 20 l, were collected from each station.

All the sponge species settled on the surface of these blocks were sampled and identified.

Two of the four blocks from each station were cut into slices about 2 cm thick and observed by a stereomicroscope to detect the cryptic, generally small, endolithic sponges.

The spicule complement of each sponge specimen was analysed according to Rützler (1978). From 30 measurements for each spicule type, size range, mean and standard deviation (in brackets) were calculated. Dissociated spicules were transferred onto stubs and sputtered with gold for SEM analyses and observed with a Philips XL 20 scanning electron microscope. Whenever possible, skeletal architecture was examined in light and scanning electron microscope (SEM) on hand-cut sections of the ectosome and choanosome. Unfortunately, due to small size and cavity dwelling habit, for most specimens it was impossible to study the skeleton.

We followed the classification given by Hooper and van Soest (2002) and the updated nomenclature reported in the World Porifera Database (van Soest et al. 2013). The geographic distribution of sponges in the Mediterranean Sea was compared with that reported by Pansini and Longo (2003, 2008), considering nine biogeographic areas for the Italian seas.

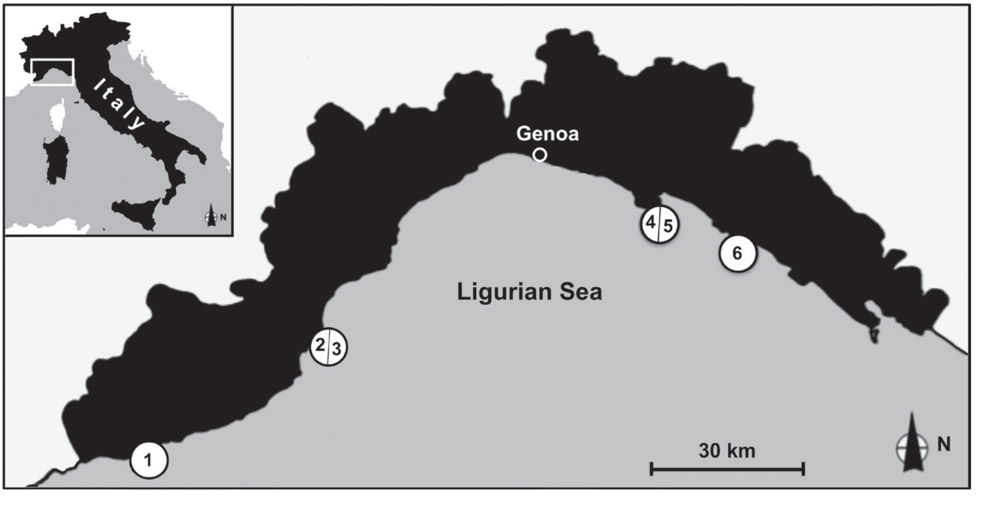

Figure 1. The four studied localities along the Ligurian Coast: Santo Stefano Shoal (station **1**), Gallinara Island (station **2–3**), Punta del Faro (Portofino Promontory) (station **4–5**) and Punta Manara (station **6**).

Results

During this survey we have recorded 133 sponge taxa (115 of them identified at species level and 18 at genus level). One species is new for science, 17 are new findings for the coralligenous conglomerate, 11 of which for the Ligurian Sea and 3 for the Italian sponge fauna (Table 1). In the following taxonomic part we provide the description of the new species and of ten poorly known ones.

On the surfaces of the blocks 103 massive or encrusting species were recorded; inside the crevices of the conglomerate 63 species were observed and 33 shared both positions. Thirty species are exclusively endolithic demonstrating the abundance of cryptic sponges thriving inside the porous matrix of the coralligenous substrate (Table 1) (Fig. 2).

Table 1. List of Demospongiae and Homoscleromorpha species living outside and inside the coralligenous blocks (SSS: Santo Stefano Shoals, station 1; GI: Gallinara Island, station 2-3; PF: Punta del Faro, station 4-5; PM: Punta Manara, station 6; * new finding for the coralligenous concretion; ** new finding for the Ligurian Sea; *** new finding for the Italian sponge fauna).

Species / Sites	SSS	GI	PF	PM	Epilithic	Endolithic
Oscarella lobularis (Schmidt, 1862)			+	+	+	
Plakina trilopha Schulze, 1880	+	+				+
Plakinastrella copiosa Schulze, 1880	+					+
Plakortis simplex Schulze, 1880			+		+	+
Samus anonymus Gray, 1867	+	+				+
Stelletta grubii Schmidt, 1862	+					+
Stelletta lactea Carter, 1871 *		+				+
Stelletta stellata Topsent, 1893 *				+		+
Jaspis incrustans Topsent, 1890 **		+	+	+		+
Jaspis johnstoni (Schmidt, 1862)	+	+	+	+	+	+
Penares euastrum (Schmidt, 1868)	+		+	+	+	+
Dercitus (*Stoeba*) *plicatus* (Schmidt, 1868)	+	+	+	+	+	+
Pachastrissa sp.	+					+
Erylus discophorus (Schmidt, 1862)	+			+	+	+
Geodia conchilega Schmidt, 1862	+	+	+		+	+
Geodia cydonium Schmidt, 1862	+		+		+	+
Pachastrella monilifera Schmidt, 1868		+	+			+
Poecillastra compressa (Bowerbank, 1866)	+		+		+	+
Triptolemma simplex (Sarà, 1959)	+	+	+		+	+
Cliona burtoni Topsent, 1932 *, **		+				+
Cliona celata Grant, 1826	+		+	+	+	+
Cliona janitrix Topsent, 1932	+	+	+	+	+	+
Cliona schmidtii (Ridley, 1881)				+	+	+
Cliona viridis Schmidt, 1862	+	+		+	+	+
Cliona sp.			+		+	+
Dotona pulchella mediterranea Rossell & Uriz, 2002	+					+
Spiroxya corallophila (Calcinai et al., 2002)			+			+
Spiroxya heteroclita Topsent, 1896	+	+	+		+	+

Spiroxya sarai Melone, 1965		+	+			+
Delectona ciconiae Bavestrello, Calcinai & Sarà, 1996			+			+
Delectona sp.		+	+		+	
Paratimea oxeata Pulitzer-Finali, 1978 *, **, ***	+					+
Polymastia sp.		+	+		+	
Diplastrella bistellata (Schmidt, 1862)	+	+	+		+	+
Aaptos aaptos (Schmidt, 1864)	+		+		+	+
Prosuberites longispinus Topsent, 1893		+				+
Pseudosuberites sulphureus (Bowerbank, 1866)			+	+	+	
Suberites carnosus (Johnston, 1842)				+	+	
Suberites domuncula (Olivi, 1792)			+		+	
Suberites sp.	+	+			+	
Terpios gelatinosa (Bowerbank, 1866)			+	+	+	
Timea stellata (Bowerbank, 1866)		+	+	+	+	+
Timea unistellata (Topsent, 1892)	+	+			+	+
Chondrosia reniformis Nardo, 1847	+		+	+	+	
Acarnus souriei Levi, 1952 *, **			+			+
Acarnus sp.			+			+
Clathria (*Microciona*) *armata* (Bowerbank, 1866) *, **		+			+	
Clathria (*Microciona*) *atrasanguinea* (Bowerbank, 1862)		+		+	+	
Clathria (*Microciona*) *gradalis* Topsent, 1925	+				+	
Clathria (*Microciona*) *haplotoxa* (Topsent, 1928) *, **, ***		+			+	
Clathria (*Microciona*) *toxistyla* (Sarà, 1959)			+		+	
Clathria (*Microciona*) *toxivaria* (Sarà, 1959)	+				+	
Clathria (*Microciona*) sp.		+	+			+
Antho (*Antho*) *involvens* (Schmidt, 1864)			+		+	
Eurypon cf. *cinctum* Sarà, 1960		+		+	+	
Eurypon clavatum (Bowerbank, 1866)	+	+	+	+	+	
Eurypon coronula (Bowerbank, 1874) **		+			+	
Eurypon denisae Vacelet, 1969 *, **		+			+	
Eurypon gracilis sp. n. Bertolino, Calcinai & Pansini		+		+	+	
Eurypon major Sarà & Siribelli, 1960	+	+	+	+	+	
Eurypon topsenti Pulitzer-Finali, 1983		+	+		+	
Eurypon vesciculare Sarà & Siribelli, 1960	+	+	+	+	+	
Eurypon sp.	+	+	+	+	+	
Raspaciona aculeata (Johnston, 1842)				+	+	
Raspaciona sp.				+	+	
Forcepia (*Leptolabis*) *brunnea* (Topsent, 1904) **		+	+		+	
Lissodendoryx (*Lissodendoryx*) *isodictyalis* (Carter, 1882)		+			+	
Lissodendoryx (*Anomodoryx*) *cavernosa* (Topsent, 1892)	+	+		+	+	+
Crambe crambe (Schmidt, 1862)	+	+	+		+	
Crella (*Crella*) *elegans* (Schmidt, 1862)		+			+	
Crella (*Crella*) *mollior* Topsent, 1925		+			+	
Crella (*Grayella*) *pulvinar* (Schmidt, 1868)	+	+	+	+	+	
Hemimycale columella (Bowerbank, 1864)	+				+	
Hymedesmia (*Hymedesmia*) *baculifera* Topsent, 1901 *	+	+				+
Hymedesmia (*Hymedesmia*) *rissoi* Topsent, 1936	+	+			+	+
Hymedesmia sp.		+	+		+	

Hymedesmia (*Stylopus*) *coriacea* (Fristedt, 1866)	+	+	+		+	
Phorbas fictitius Bowerbank, 1866	+	+		+	+	
Phorbas mercator (Schmidt, 1868) *		+			+	
Phorbas lieberkuhni (Burton, 1930)				+	+	
Phorbas tenacior (Topsent, 1925)	+	+	+	+	+	
Phorbas sp.		+		+	+	
Plocamionida ambigua (Bowerbank, 1866) *	+		+	+	+	+
Tedania (*Tedania*) *anhelans* (Lieberkühn, 1859)			+		+	
Mycale (*Aegogropila*) *tunicata* (Schmidt, 1862) *				+	+	
Mycale (*Paresperella*) *serrulata* Sarà & Siribelli, 1960 **, ***		+				+
Merlia normani Kirkpatrick, 1908 *			+			+
Axinella damicornis (Esper, 1794)	+	+	+	+	+	
Axinella polypoides Schmidt, 1862				+	+	
Axinella verrucosa (Esper, 1794)	+		+		+	
Phakellia sp.				+	+	
Bubaris carcisis Vacelet, 1969	+		+		+	+
Bubaris vermiculata (Bowerbank, 1866)				+	+	
Hymerhabdia oxytrunca Topsent, 1904			+		+	
Hymerhabdia typica Topsent, 1892 *			+		+	
Hymerhabdia sp.			+		+	
Halicnemia geniculata Sarà, 1958 *, **		+			+	
Halicnemia patera Bowerbank, 1864				+	+	
Acanthella acuta Schmidt, 1862	+	+	+	+	+	
Dictyonella incisa (Schmidt, 1880)	+	+	+	+	+	
Dictyonella marsilii (Topsent, 1893)			+		+	
Dictyonella pelligera (Schmidt, 1862)		+	+	+	+	
Dictyonella sp.		+			+	
Halichondria (*Halichondria*) *contorta* Sarà, 1961		+	+			+
Halichondria (*Halichondria*) cf. *convolvens* Sarà, 1960				+	+	
Halichondria (*Halichondria*) *genitrix* Schmidt, 1862		+		+		+
Halichondria (*Halichondria*) *panicea* Pallas, 1766	+		+			+
Halichondria sp.	+		+		+	
Agelas oroides Schmidt, 1864	+	+	+		+	
Dendroxea lenis (Topsent, 1892)	+		+		+	+
Haliclona (*Gellius*) *angulata* (Bowerbank, 1866)		+		+	+	+
Haliclona (*Gellius*) *marismedi* (Pulitzer-Finali, 1978) *, **		+		+	+	+
Haliclona (*Halichoclona*) *fulva* (Topsent, 1893)	+	+	+	+	+	
Haliclona (*Halichoclona*) *parietalis* (Topsent, 1893)				+	+	+
Haliclona (*Haliclona*) sp.				+	+	+
Haliclona (*Reniera*) *cinerea* Grant, 1826				+		+
Haliclona (*Reniera*) *citrina* (Topsent, 1892)				+	+	+
Haliclona (*Reniera*) sp.		+	+	+	+	
Haliclona (*Soestella*) *arenata* Griessinger, 1971				+		+
Haliclona (*Soestella*) *mucosa* (Griessinger, 1971)			+		+	
Haliclona sp.				+		+
Siphonodictyon insidiosum (Johnson, 1899)	+	+	+	+	+	+
Petrosia (*Petrosia*) *clavata* (Esper, 1794)	+		+	+	+	
Petrosia (*Petrosia*) *ficiformis* (Poiret, 1798)	+	+	+	+	+	

Ircinia variabilis (Schmidt, 1862)	+	+	+	+	+	+
Sarcotragus spinosulus Schmidt, 1862	+	+	+	+	+	+
Cacospongia mollior Schmidt, 1862	+					+
Spongia (*Spongia*) *officinalis* Linnaeus, 1759		+			+	
Spongia (*Spongia*) *virgultosa* (Schmidt, 1868)	+	+	+	+	+	+
Dysidea avara (Schmidt, 1862)	+	+		+	+	
Dysidea sp.	+					+
Pleraplysilla spinifera (Schulze, 1879)	+		+	+	+	
Aplysina cavernicola Vacelet, 1959	+				+	
Total number of species	**61**	**70**	**71**	**61**	**103**	**63**

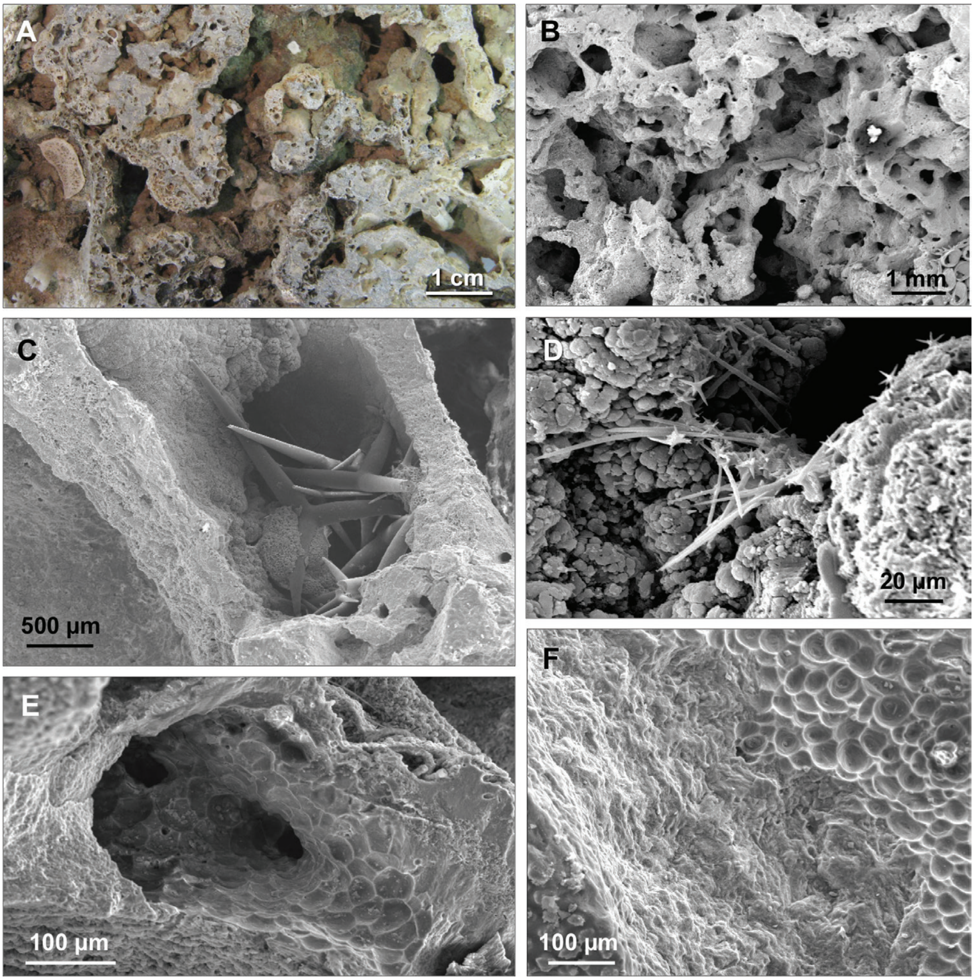

Figure 2. Porosity of the coralligenous concretion. **A** Holes and cavities of the coralligenous concretion **B** Magnification of the holes **C** Magnification of a natural hole occupied by spicules of *Pachastrella monilifera* **D** Spicules of *Jaspis johnstoni* in a natural cavity in the coralligenous concretion **E** Cavity excavated by a boring sponge with excavation marks (pits) on the wall **F** Border between the area excavated by a boring sponge (right) and the not excavated area (left).

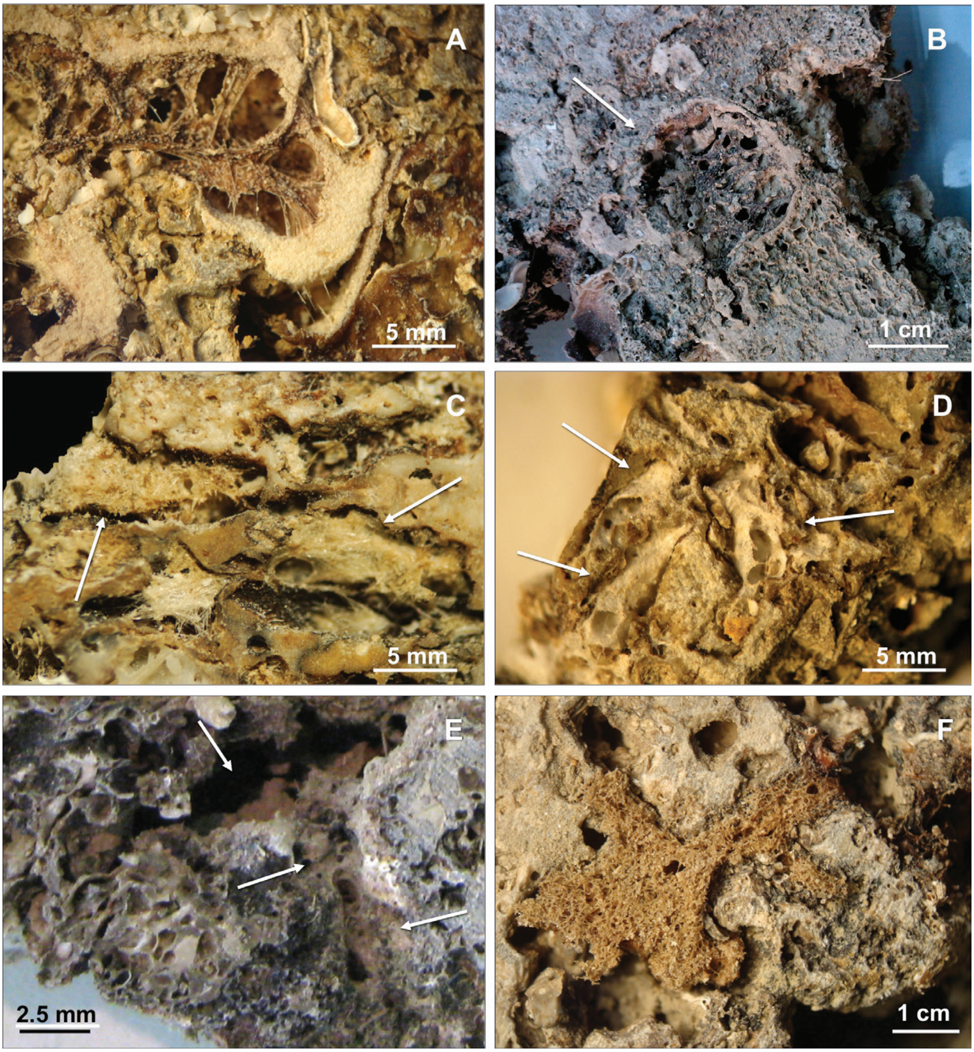

Figure 3. Insinuating sponges. **A** *Geodia cydonium* **B** *Geodia conchilega* **C** *Pachastrella monilifera* **D** *Poecillastra compressa* **E** *Paratimea oxeata* **F** *Spongia virgultosa*.

Among the 63 species recorded inside the conglomerate, 53 were insinuating and 10 boring (Table 1). From the first group six species: *Geodia cydonium* (Jameson, 1811) (Fig. 3 A), *Poecillastra compressa* (Bowerbank, 1866) (Fig. 3 D), *Stelletta grubii* Schmidt, 1862, *Paratimea oxeata* Pulitzer-Finali, 1978 (Fig. 3 E), *Hymedesmia* (*Hymedesmia*) *baculifera* (Topsent, 1901) and *Mycale* (*Paresperella*) *serrulata* (Sarà & Siribelli, 1960) were hitherto recorded encrusting or massive; four species: *Erylus discophorus* (Schmidt, 1862), *Penares euastrum* (Schmidt, 1868), *Geodia conchilega* Schmidt, 1862 (Fig. 3 B) and *Pachastrella monilifera* Schmidt, 1868 (Fig. 3 C) were generally recorded as massive but also described as insinuating by Pulitzer-Finali (1970, 1983) and Calcinai et al. (2007b).

Species descriptions

Class Demospongiae
Order Hadromerida
Family Clionaidae
Genus *Cliona*

***Cliona burtoni* Topsent, 1932**
http://species-id.net/wiki/Cliona_burtoni
Figs 4A–L

Cliona burtoni Topsent, 1932: 577.

Material examined. Specimen IG-S-BL1-F5B-spB; dry state, Gallinara Island (station 3, Sciusciaù) 44°01'34"N, 8°13'45"E, depth 30 m, collected 17-06-2009. The specimen was entirely used for spicule preparations.

Description. Boring sponge in alpha growth form, occupying a surface of 1 cm² in a section of conglomerate. Colour beige in dry state.

Skeleton. Not observed.

Spicules. Macroscleres: tylostyles to subtylostyles straight or slightly curved, 132 (225) 287 × 5 (6) 7.5 µm. Heads with a rounded or oval tyle, sometimes in terminal position but more often shifted along the shaft (Figs 4 A, B, C). Microscleres: spirasters of various shape and thickness, straight or curved, 10 (26.5) 45 × 1.25 (10) 17.5 µm. The most abundant have scattered conical spines (Figs 4 D, E, F, G, H, I, J, K) and numerous are amphiaster-like (Figs 4 H, I, K). The smaller ones are microspinated (Fig. 4 J, L).

Distribution and discussion. This is a Mediterranean endemic species (Pansini and Longo 2008) originally described from Corsica (Strait of Bonifacio), where it is known to bore into calcareous rocks and mollusc shells (Topsent 1932). This is a new record for the Ligurian Sea (Gallinara Island) and the coralligenous assemblage and the first finding after the original description.

Family Hemiasterellidae
Genus *Paratimea*

***Paratimea oxeata* Pulitzer-Finali, 1978**
http://species-id.net/wiki/Paratimea_oxeata
Figs 5A–D

Paratimea oxeata Pulitzer-Finali, 1978: 39.

Material examined. Specimen SSS-BL1-F3A-spH; alcohol and dry state; Santo Stefano Shoals (station 1), 43°49'N, 7°54'E, depth 35 m, collected 14-02-2008. The specimen was entirely used for spicule preparations.

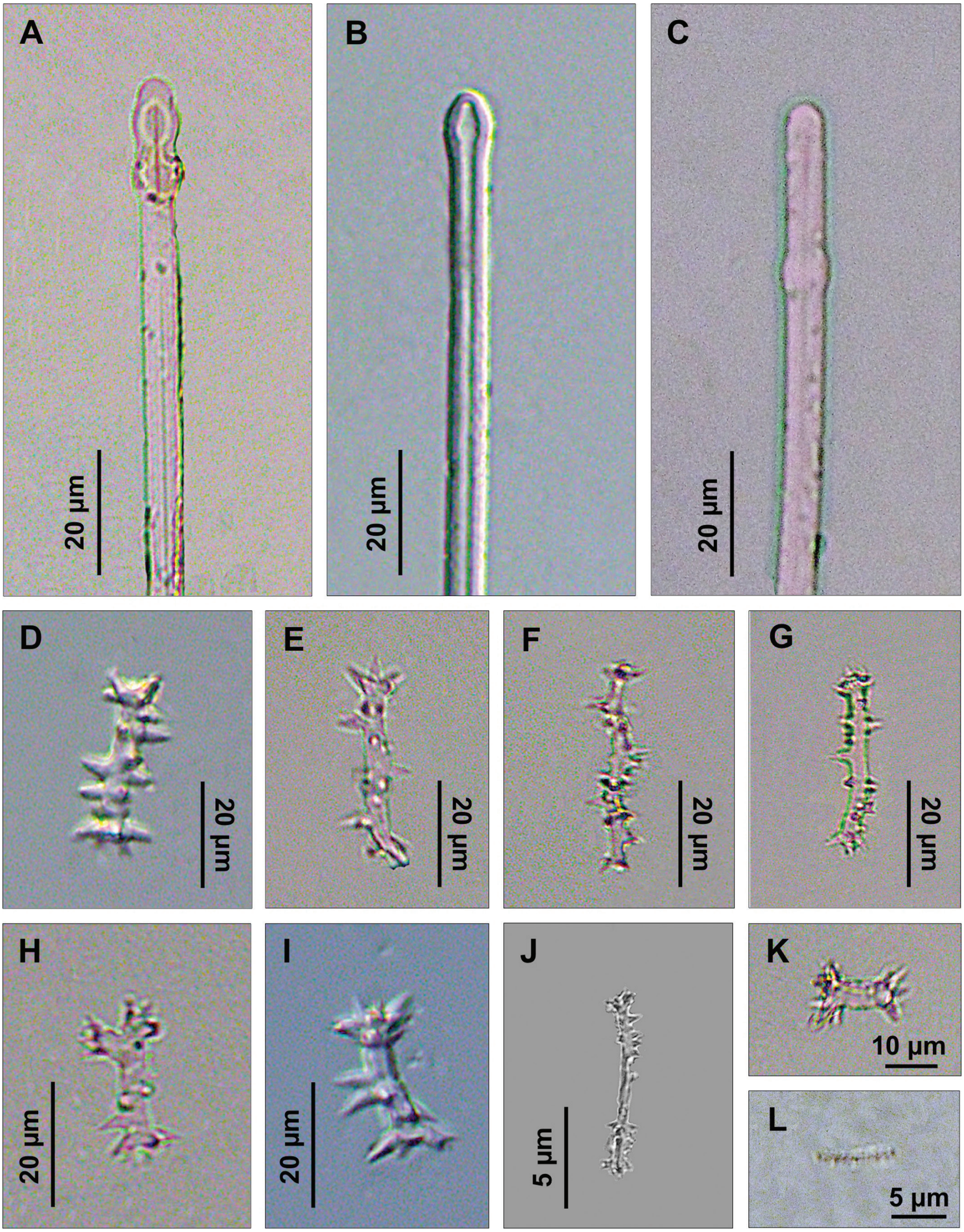

Figure 4. *Cliona burtoni.* **A–C** Tylostyle heads **D–L** Spirasters of various shape and thickness.

Description. Very small (0.5 cm^2) insinuating sponge (Fig. 5 A) detected inside a cavity of a slice of a coralligenous block. Grey coloured in dry state.

Skeleton. Not observed.

Spicules. Macroscleres: oxeas in two size categories: I) large oxeas curved, bent or flexuous, with hastate tips (Fig. 5 B), 810 (961.25) 1200 × 15 (18) 25 µm; II) small

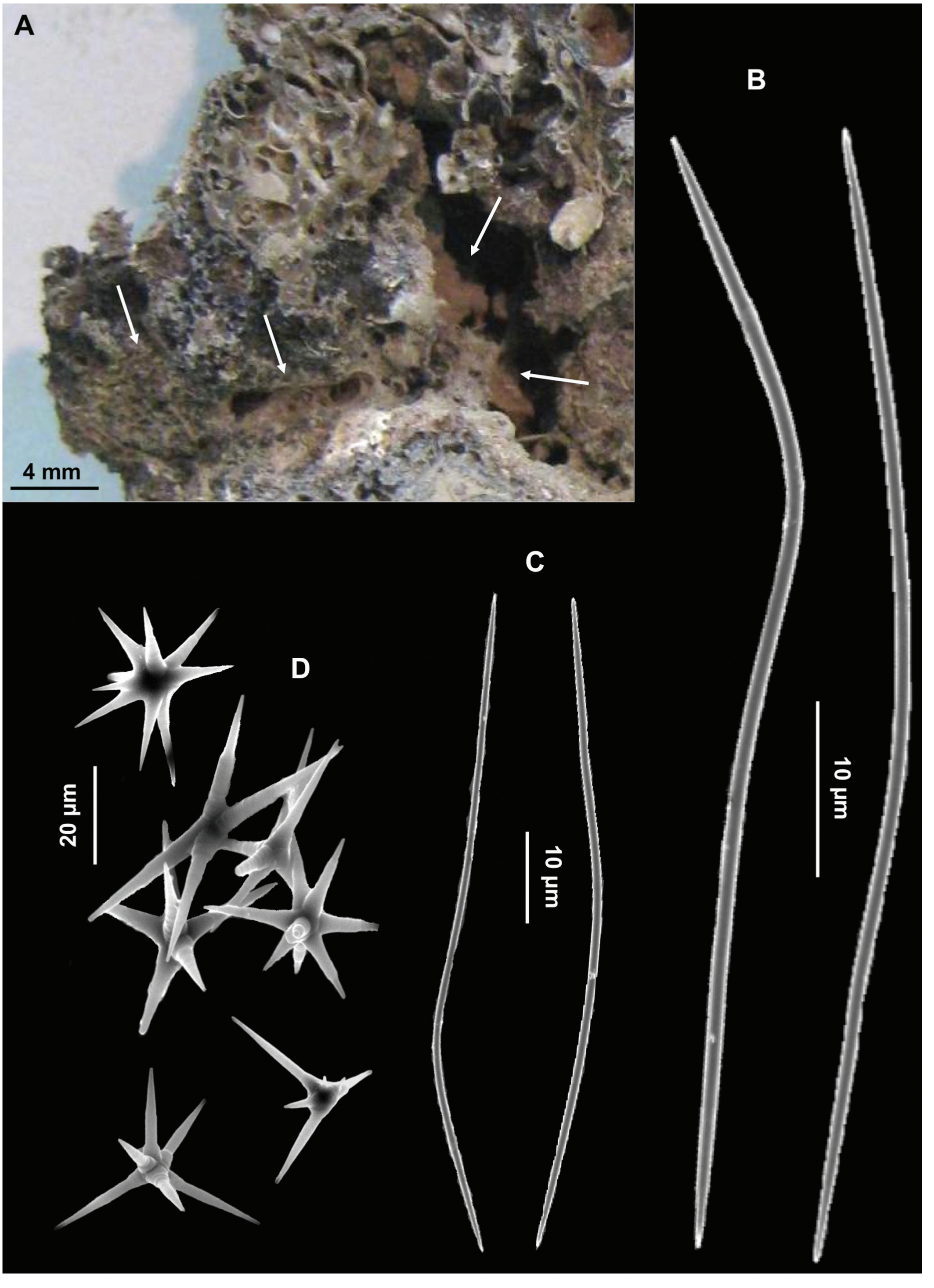

Figure 5. *Paratimea oxeata.* **A** Specimen in the coralligenous accretions (arrows) **B** Large oxeas **C** Small oxeas **D** Oxyasters.

oxeas curved or flexuous (Fig. 5 C), 300 (546.6) 700 × 2.5 (4.75) 5 µm. Microscleres: oxyasters with more or less marked centrum with 9-12 conical rays, 25 (41.5) 60 µm in diameter. In some cases the number of rays is reduced (Fig. 5 D).

Distribution and discussion. The species was described from Naples (Pulitzer-Finali 1978) where it occurred on rocky bottoms at 60-100 meter depth. This is a new record for the coralligenous assemblage and for the Ligurian Sea and it is probably endemic for the Mediterranean Sea (Pansini and Longo 2008). This is its first finding after the original description.

Order Poecilosclerida
Suborder Microcionina
Family Microcionidae
Genus *Clathria*
Subgenus *Microciona*

***Clathria* (*Microciona*) *armata* (Bowerbank, 1862)**
http://species-id.net/wiki/Clathria_armata
Figs 6A–F

Microciona armata Bowerbank, 1862; 1866: 129.

Material examined. Specimen IG-F-BL4-sp2-fot.; alcohol preserved, Gallinara Island (station 2, Falconara) 44°01'22"N, 8°13'34"E, depth 35 m, collected 31-7-2009.

Description. Thickly encrusting sponge (3-5 mm thick) covering a surface of 1.5 cm^2 on a coralligenous block (Fig. 6 A). Surface irregular, smooth. Consistency soft. The red-orange colour of the living specimen slightly fades when alcohol preserved.

Skeleton. Not observed.

Spicules. Macroscleres: acanthostyles in two size categories: I) large acanthostyles slightly curved, with obtuse spines concentrated on the head (Fig. 6 B), 220 (484.5) 830 × 3.75 (8.5) 12 µm; II) small acanthostyles, with scattered spines, but more concentrated on the head (Fig. 6 C), 100 (110) 122.5 × 3.75 (5) 6 µm; subtylostyles straight, often with slightly spined head (Fig. 6 D), 440 (503.7) 550 × 2.5 (2.9) 3.8 µm. Microscleres: palmate isochelae (Fig. 6 E), 10 (12.5) 13.5 µm long. Toxas of variable size, with more or less wide central curvature and slightly reflexed smooth points (Fig. 6 F), 80 (114.5) 210 µm long.

Distribution and discussion. This species has been recorded on rocky walls and on mollusc shells from 10 to 180 m depth (Bowerbank 1866, Arndt 1934, Pulitzer-Finali 1983, van Soest and Stone 1986). It is widely distributed in the Mediterranean Sea (Northern Adriatic Sea, Alboran Sea and Ionian Sea (Pansini and Longo 2003, 2008) and along the Atlantic coast of Europe: Arctic, Sweden, Ireland, United Kingdom, France (van Soest et al. 2013).

This specimen, like that described by van Soest and Stone (1986), differs from the type material in the toxa dimensions. Actually Bowerbank measured small toxas 50 µm long and large toxas 130 µm long dividing them in two size categories. Van Soest and Stone (1986) confirm the large variability of spicule size. The species is a new finding for the coralligenous community and the Ligurian Sea.

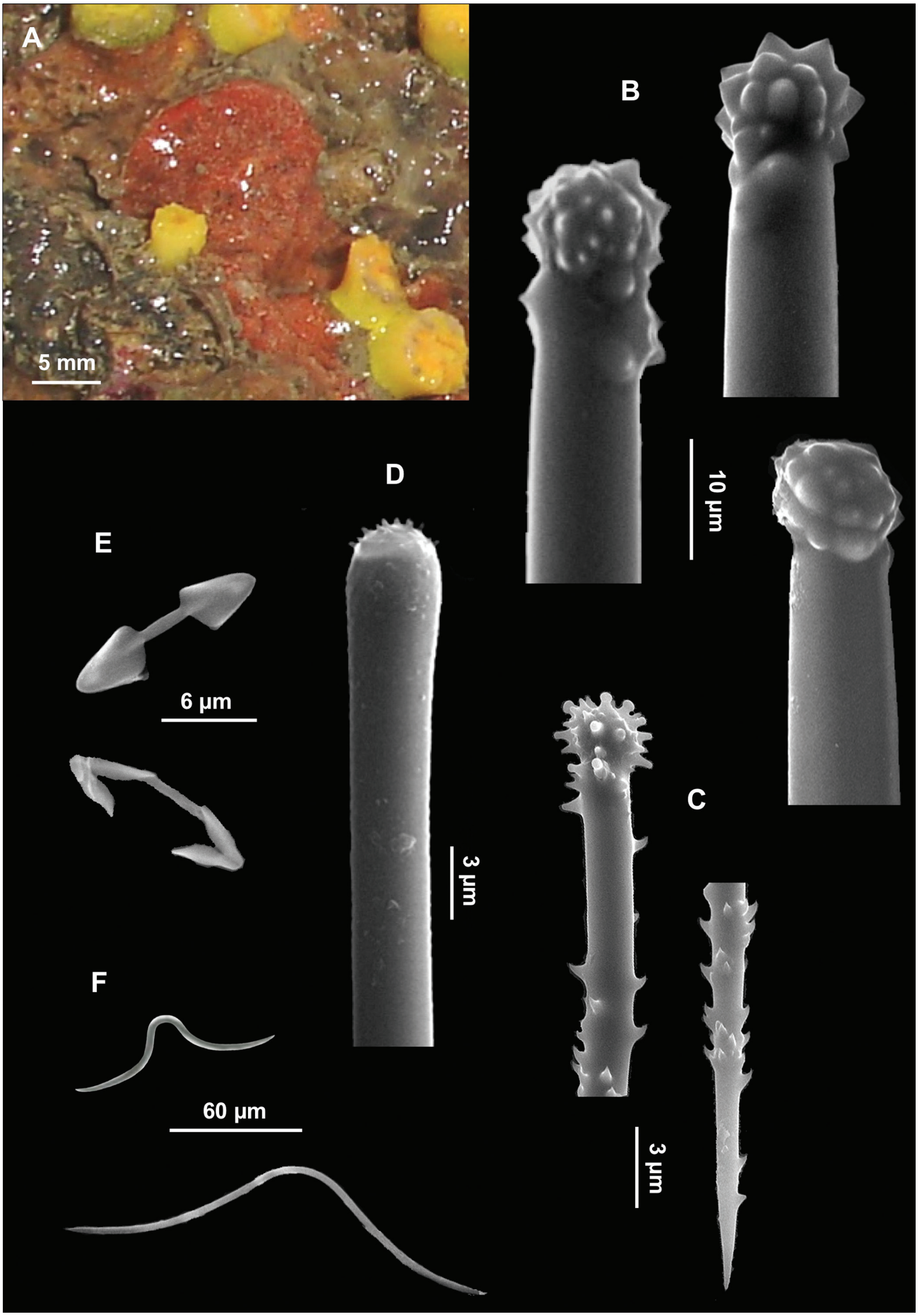

Figure 6. *Clathria* (*Microciona*) *armata.* **A** Specimen on the surface of the coralligenous block **B** Large acanthostyle heads **C** Small acanthostyle **D** Subtylostyle with spined head **E** Palmate isochelae **F** Toxas of variable size, with smooth extremities.

***Clathria* (*Microciona*) *haplotoxa* (Topsent, 1928)**
http://species-id.net/wiki/Clathria_haplotoxa
Figs 7A–F

Leptoclathria haplotoxa Topsent, 1928: 298.

Material examined. Specimen IG-F-BL3-sp5-fot.; alcohol preserved, Gallinara Island (station 2, Falconara) 44°01'22"N, 8°13'34"E, depth 35 m, collected 17-06-2009. The specimen was entirely used for spicule preparations.

Description. Encrusting sponge on the surface of a coralligenous block, 2 cm in diameter. Surface hispid. Colour brick red (Fig. 7 A).

Skeleton. Not observed.

Spicules. Macroscleres: strongyles straight, smooth, 112.5 (178) 215 × 2.5 µm (Fig. 7 B); acanthostyles straight with a characteristic constriction under the head, in two size categories: I) large acanthostyles (Fig. 7 C), 150 (175.5) 210 µm and II) small acanthostyles (Fig. 7 D), 55 (74.5) 102.5 × 2.5 (3.5) 5 µm. Microscleres: palmate isochelae with straight shaft (Fig. 7 E), 12.5 (13.8) 15 µm long; toxas thin, smooth, with wide central curvature and slightly reflexed points, 30 (32.5) 37.5 µm long (Fig. 7 F).

Distribution and discussion. Described from Porto Santo Bay (Madeira) the species extends south to the Sahelian Upwelling (Lévi 1956). In the Mediterranean Sea it was only recorded from Tunisia (Ben Mustapha et al. 2003). It is a new finding for the Italian sponge fauna and for the coralligenous community.

Family Raspailiidae
Subfamily Raspailiinae
Genus *Eurypon*

***Eurypon denisae* Vacelet, 1969**
http://species-id.net/wiki/Eurypon_denisae
Figs 8A–E

Eurypon denisae Vacelet, 1969: 188.

Material examined. Specimen IG-S-BL3 sp10-fot.; alcohol preserved, Gallinara Island (station 3, Sciusciaù) 44°01'34"N, 8°13'45"E, depth 30 m, collected 31-07-2009.

Description. Encrusting sponge covering a surface of 3 cm² on a coralligenous block. Surface hispid. Colour in life white.

Skeleton. Ectosomal skeleton absent. Choanosomal skeleton consisting of basal acanthostyles with heads embedded in a spongin layer and bundles of very long tylostyles protruding through the sponge surface which appears hispid.

Spicules. Long tylostyles, slightly curved or straight, with rather irregular heads, 1066 (1774) 2236 × 5 (8.5) 12.5 µm (Fig. 8 A); anisoxeas straight or faintly curved,

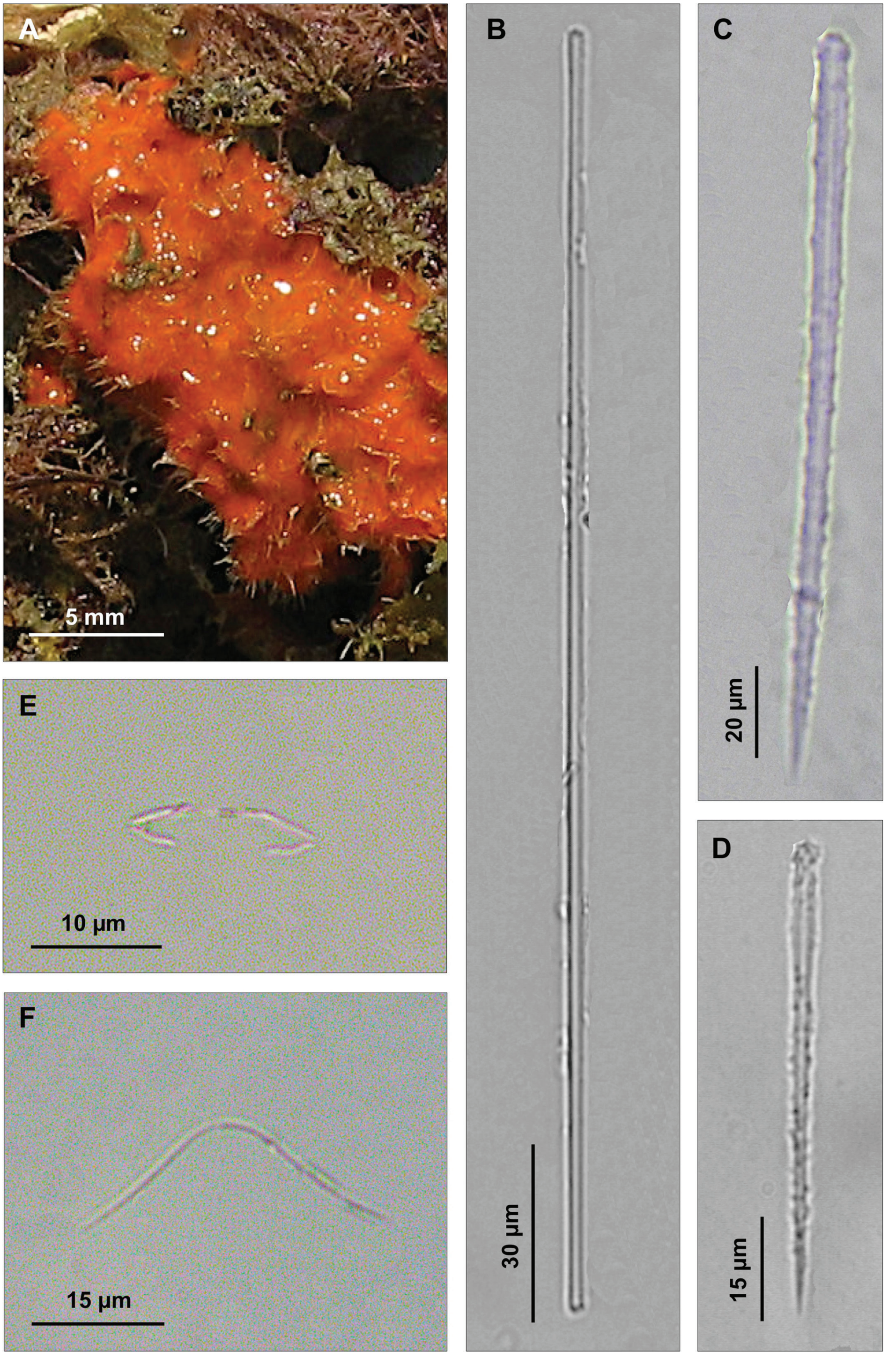

Figure 7. *Clathria* (*Microciona*) *haplotoxa*. **A** Specimen on the surface of a coralligenous block **B** Strongyle **C** Large acanthostyle **D** Small acanthostyle **E** Isochela **F** Toxa.

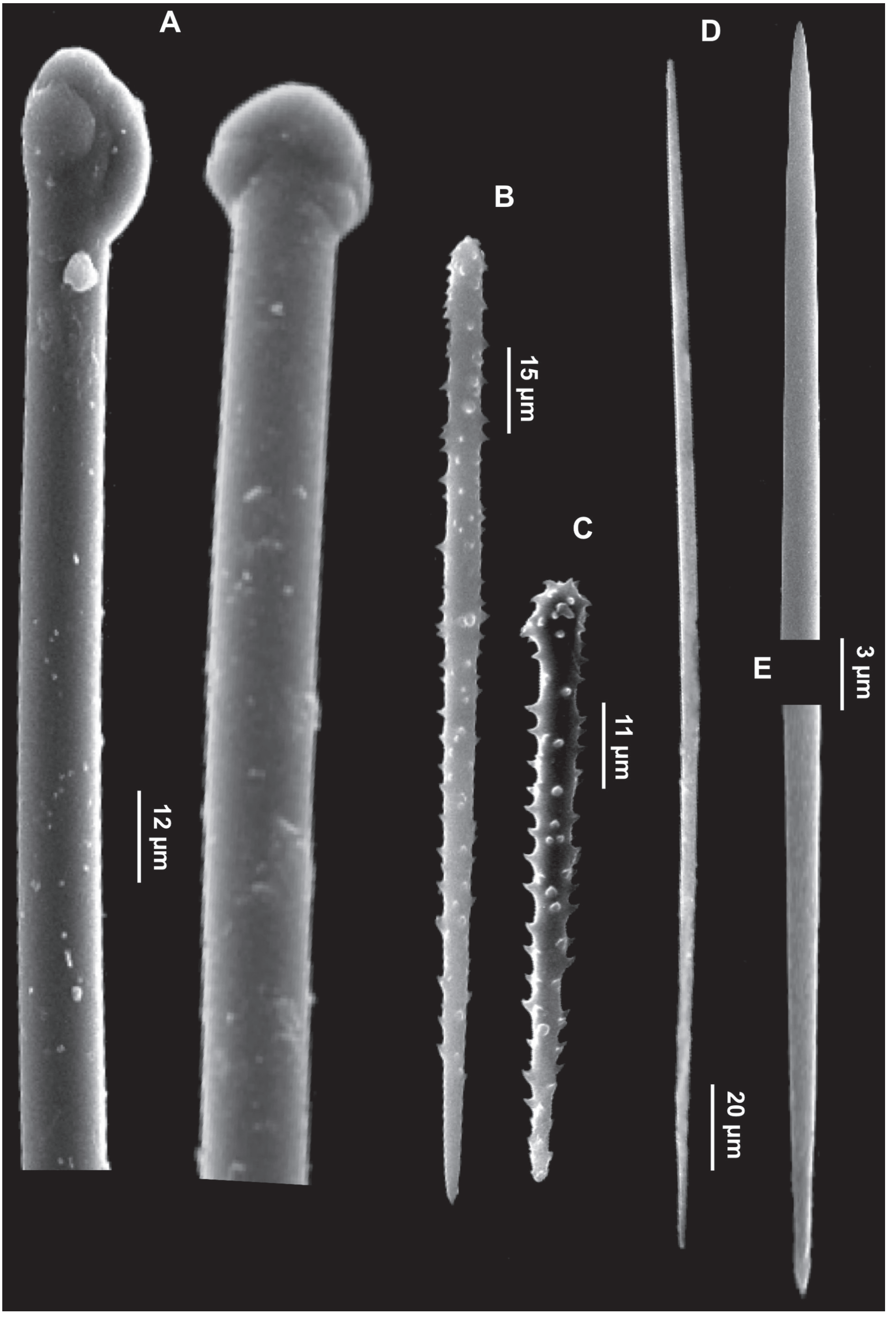

Figure 8. *Eurypon denisae.* **A** Tylostyles with variable head **B** Large acanthostyles **C** Small acanthostyles **D** Anisoxeas **E** Magnifications of the extremities of an anisoxea.

200 (220) 250 × 5 (5.5) 7 µm (Figs 8 D-E); acanthostyles in two size categories: I) large, straight acanthostyles, often with inconspicuous heads, uniformly but faintly spined, 107.7 (134.5) 170 × 7.5 (9) 12 µm (Fig. 8 B); II) small, straight acanthostyles with stouter and longer spines, 60 (68) 77.5 × 7.5 (8) 10 µm (Fig. 8 C).

Distribution and discussion. The species was originally described by Vacelet (1969) from a coral bottom in the bathyal zone (300–350 m depth) of the Gulf of Lions. This second finding is a new record for the Italian seas and the coralligenous community.

***Eurypon gracilis* Bertolino, Calcinai & Pansini, sp. n.**
http://zoobank.org/E2792BEE-BEC2-41E5-BB7E-E32969E50A1C
http://species-id.net/wiki/Eurypon_gracilis
Figs 9A–G

Material examined. Type specimen: Holotype MSNG 57017. Specimen PdF-S-BL4-sp18-sciaf., on a coralligenous concretion, depth 40 m, Stat. 4, 27-07-2009. leg. M. Bertolino, alcohol preserved.

Type locality. Italy, Ligurian Sea, Portofino Promontory (Punta del Faro) 44°17'54.20"N, 9°13'06.93"E.

Other examined material. Specimen IG-F-BL1-sp4-fot.; specimen IG-F-BL1-sp15-fot.; alcohol preserved, Gallinara Island (station 2, Falconara) 44°01'22"N 8°13'34"E, depth 35 m, collected 17-06-2009; specimen IG-S-BL3-sp6-fot.; alcohol preserved, Gallinara Island (station 3, Sciusciaù) 44°01'34"N, 8°13'45"E, depth 30 m, collected 17-06-2009; specimen PM-BL1-sp9-sciaf.; alcohol preserved, Punta Manara (station 6) 44°15'05.61"N, 9°24'09.33"E, depth 35 m, collected 13-06-2009.

Description. All the specimens were encrusting on the surface of coralligenous blocks, covering surfaces up to 2 cm². The sponge surface is corrugated, hispid. The colour in life is brick red (Fig. 9 A).

Skeleton. The skeleton consists of a basal layer of spongin in which the spicules are vertically positioned, perpendicular to the substrate. Both the categories of acanthostyles are close one another (Fig. 9 C) with the heads embedded in the basal spongin layer. Styles and oxeas–with the same vertical arrangement–are grouped in bundles which are faintly echinated, in their lower part, by the smaller acanthostyles (Fig. 9 B). Oxeas are positioned in the basal part of the bundles. The styles protrude trough the sponge surface making it hispid.

Spicules. Long styles to tylostyles, curved or flexuous (Fig. 9 D), 788 (1101) 1280 × 5 (6.8) 10 µm; oxeas thin, almost straight or with a slight curvature (Fig. 9 E), 365 (483) 650 × 2.5 µm; acanthostyles without head and uniformly spined, in two sizes categories: I) large acanthostyles, straight or slightly curved with rather small spines (Fig. 9 F), 200 (253) 320 × 5 (6) 7.7 µm; II) small acanthostyles straight, with spines more robust than in the previous category (Fig. 9 G), 90 (119.5) 160 × 2.5 (3.8) 5 µm.

Etymology. The species is named after the slenderness of all the spicule types.

Distribution. So far known only from the Ligurian Sea.

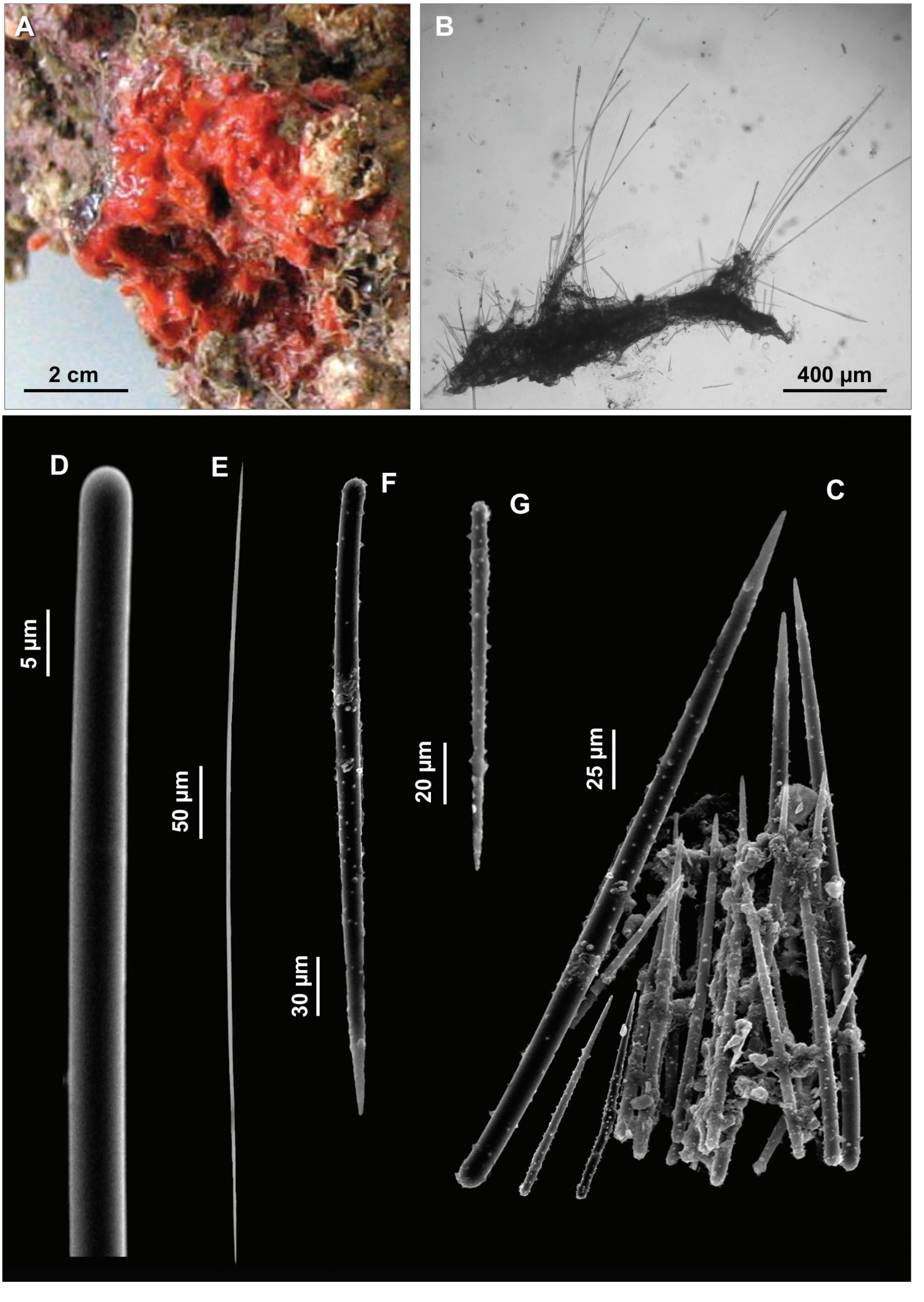

Figure 9. *Eurypon gracilis* sp. n. **A** Holotype **B** Skeleton **C** Portion of the skeleton with large and small echinating acanthostyles **D** Long style **E** Oxea **F** Large acanthostyle with scattered small spines **G** Small acanthostyle.

Ecology. It lives at 30–40 m depth on coralligenous concretion, characterized by the presence of a *Paramuricea clavata* facies.

Discussion. This species, characterized by a microcionid skeleton with a basal layer of spongin, extra-axial spicules and echinating achantostyles embedded in spongin fibres, clearly belongs to the genus *Eurypon.*

Only five, out of the numerous species of the genus *Eurypon* found in the temperate Western Atlantic have oxeas or tornotes as structural megascleres together with styles or tylostyles. All of them (*E. cinctum* Sarà, 1960*, E. denisae* Vacelet, 1969, *E. obtusum* Vacelet, 1969*, E. major* Sarà & Siribelli, 1960 and *E. lacazei* (Topsent, 1891) occur in the Mediterranean Sea. *E. cinctum* showing a lilac colour, achantostyles with discrete heads and different size in the other megascleres is not close to the new species. *E. denisae* is also different according to the description given above. *E. obtusum* is grey in colour and has smaller oxeas and acanthostyles than those of the present species, but the maximum length of its tylostyles is unknown. *E. lacazei* remarkably differs from the present species for the green colour and spicule shape and size. The closest species to the new one is *E. major* but its tylostyles are longer and stouter (1445–2210 × 10–17 µm) and differ in the shape of the heads, while the acanthostyles, in a single size category, have well formed heads. Only two other species from the temperate Atlantic: *E. lictor* (Topsent, 1904) and *E.* (*Acantheurypon*) *mucronale* (Topsent, 1928) present oxeas. However, they are both deep species (recorded deeper than 1500 m from the Azores) and they differ also in the spicule characters from *E. gracilis* sp. n. There are two other species of *Eurypon* with oxeas reported in the literature: *E. calypsoi* Lévi, 1958 from the Red Sea which is blue in colour and *E. fulvum* Lévi, 1969 from South Africa which is yellow. Both have a single size category of acanthostyles and differ in the spicule morphology. *E. gracilis* therefore has to be considered as new for science.

Suborder Myxillina
Family Coelosphaeridae
Genus *Forcepia*
Subgenus *Leptolabis*

***Forcepia* (*Leptolabis*) *brunnea* (Topsent, 1904)**
http://species-id.net/wiki/Forcepia_brunnea
Figs 10A–F

Leptolabis forcipula var. *brunnea* Topsent, 1904: 182.
Leptolabis brunnea Topsent, 1928: 278.

Material examined. Specimen PdF-NE-BL2A-sp15-sciaf.; alcohol preserved, Portofino Promontory (Punta del Faro, station 4) 44°17'55.61"N, 9°13'07.95"E, 40 m depth, collected on 27-08-2009; specimen IG-S-BL3-sp13-sciaf.; alcohol preserved, Gallinara

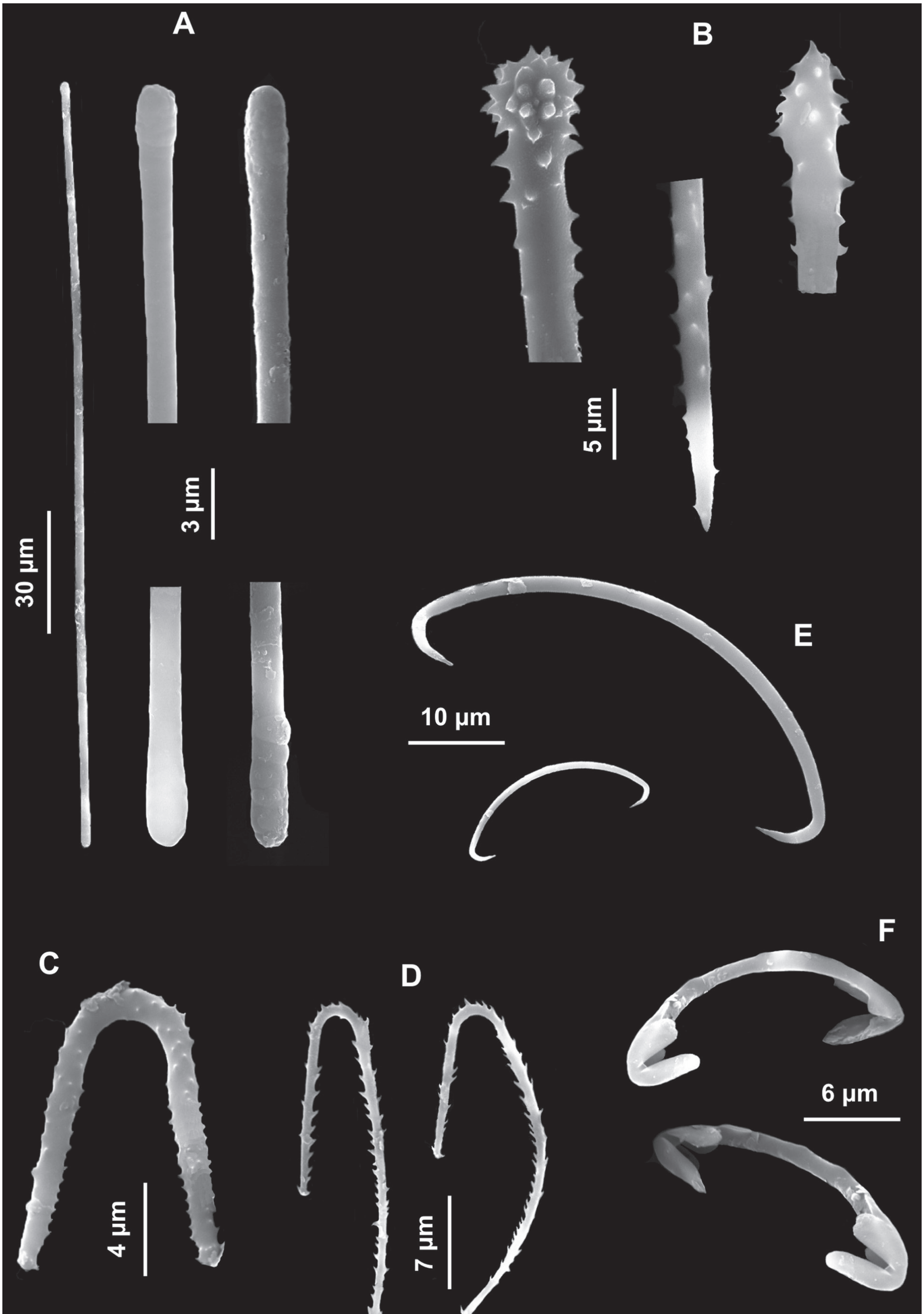

Figure 10. *Forcepia* (*Leptolabis*) *brunnea.* **A** Anisotylotes **B** Acanthostyles **C** Symmetric forceps **D** Asymmetric forceps **E** Large and small sigmas **F** Isochelae.

Island (station 3, Sciusciaù) 44°01'34"N, 8°13'45" E, depth 30 m, collected on 17-06-2009; specimen PdF-BL8-sp50-sciaf.; alcohol preserved, Portofino Promontory (Punta del Faro, station 4) 44°17'55.61"N, 9°13'07.95"E, 30 m depth, collected on 25-01-2013.

Description. Thin, small encrusting sponges (up to 0.5 cm^2) on the surface of coralligenous blocks. Colour in life yellow-orange.

Skeleton. Basal acanthostyles erect on the substrate in a hymedesmioid arrangement. Other spicule types not detectable from the skeleton.

Spicules. Megascleres: anisotylotes straight or faintly curved, with slightly different extremities and a few malformations along the shaft (Fig. 10 A), 127.5 (157.7) 280.5 × 1.25 (2.3) 2.5 µm; acanthostyles straight, conical with discrete but not swollen heads. Spines evenly distributed, slightly stouter on the spicule head (Fig. 10 B), 61.2 (92.2) 142.8 × 5.2 (7.5) 10.4 µm. Microscleres: acanthose symmetric forceps with straight legs, ending in small, button-like swellings with toothed margin (Fig. 10 C). They measure 12.5 (15.8) 17.5 × 2.5 µm in length, the distance between the legs being 5.2 (7.2) 7.5 µm. Acanthose asymmetric forceps, very thin, have unequal legs (Fig. 10 D), the longer of which is straight or curved inward, 20.4 (22.3) 25 × 1.5 µm. Sigmas in two size categories: the larger ones, “C" shaped (Fig. 10 E) or more rarely “S" shaped, 40.8 (64.3) 80 × 2.5 µm are very abundant, the smaller, 17.5–25.5 µm are rare. Palmate isochelae (Fig. 10 F), 18 (20) 20.8 µm long.

Distribution and discussion. Topsent (1904) describes three species of *Leptolabis* from the Azores: *L. forcipula* var. *brunnea*, *L. arcuata* and *L. assimilis*. The same author in 1928 states that the former three species actually belong to a single species: *Leptolabis brunnea* which shows a high variability in the large forceps shape.

L. brunnea was afterwards recorded from the Far-Oer Islands, the Azores , Spain (NW coast, Strait of Gibaltar, Castellón, Girona), France (Marseille, Monaco), Italy (Gulf of Naples), between 4 and 1360 m depth. It lives in caves, detritic bottoms, coralligenous concretions and epibiotic on other organisms (Topsent 1904, 1928, Sarà 1960, Pouliquen 1972, Carballo 1994, Cristobo 1996). This is the second finding for the Italian seas and a new finding for the Ligurian Sea.

Family Hymedesmiidae
Genus *Hymedesmia*
Subgenus *Hymedesmia*

***Hymedesmia* (*Hymedesmia*) *rissoi* Topsent, 1936**
http://species-id.net/wiki/Hymedesmia_rissoi
Figs 11A–D

Hymedesmia gracilisigma var. *rissoi* Topsent, 1936: 35.

Material examined. Specimen IG-F-BL3-F18b-spA; Specimen IG-F-BL4-sp9-sciaf.; specimen IG-F-BL4 sp11-fot.; alcohol preserved, Gallinara Island (station 2, Falcon-

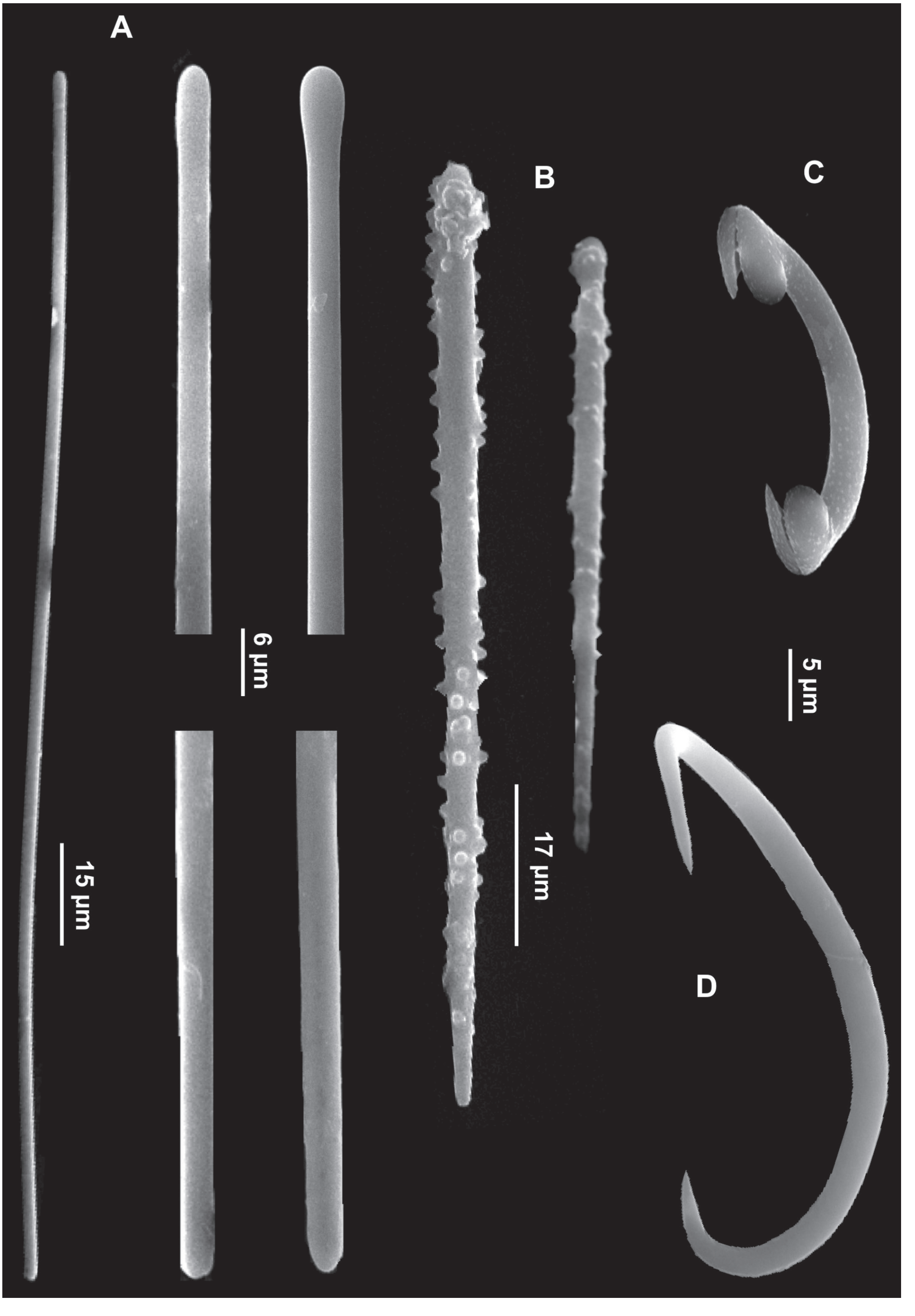

Figure 11. *Hymedesmia* (*Hymedesmia*) *rissoi*. **A** Tornote, sometimes modified into subtylotes and strongyles **B** Acanthostyles **C** Arcuate isochelae **D** Thin sigmas.

ara) 44°01'22"N, 8°13'34"E, depth 35 m, collected on 17-06-2009; specimen SSS-BL1-sp11-sciaf.; Santo Stefano Shoals, (station 1), 43°49'N, 7°54'E, depth 35 m, collected on 14-02-2008.

Description. Small (0.5 cm^2), slimy, coriaceous encrusting sponge, grey in colour after alcohol preservation, recorded both on the surface and inside the coralligenous blocks.

Skeleton. Not observed.

Spicules. Megascleres**:** straight or slightly sinuous anisotornotes, sometimes modified in anisotylotes or strongyles (Fig. 11 A), 140 (175) 177.5 × 2.5 (2.7) 3.75 µm; acanthostyles in a single size category, 67.5 (84) 105 × 2.5 (3.5) 3.75 µm, devoid of conspicuous heads. The extremities may be pointed or blunt (Figs 11 B, C). Microscleres: arcuate isochelae (Fig. 11 D), 25 (25.6) 27.5 µm long; thin sigmas "C" (Fig. 11 E) and "S" shaped, 32.5 (35) 37.5 × 1.25 µm.

Distribution and discussion. In the original description Topsent (1936) distinguished in this species two size classes of acanthostyles similar in shape: the larger were 185–265 µm in length and the smaller 75–115 µm. Subtylotes straight or sometimes slightly sinuous, 225–275 × 3.5–4.5 µm, arcuate isochelae 23–25 µm long and sigmas 40–50 µm long and less than 1 µm thick. The specimens here described match with Topsent's description apart from the presence of a single size class of acanthostyles. However, other authors (Sarà and Siribelli 1962), recorded a single class of acanthostyles as well. This is a Mediterranean endemic species (Ligurian Sea and Central Tyrrhenian Sea). It was found on *Cladocora caespitosa*, at 15–40 m depth (Topsent 1936) and on coralligenous bottom, at 40–70 m depth (Sarà and Siribelli 1962).

Suborder Mycalina
Family Mycalidae
Genus *Mycale*
Subgenus *Paresperella*

***Mycale* (*Paresperella*) *serrulata* Sarà & Siribelli, 1960**
http://species-id.net/wiki/Mycale_serrulata
Figs 12A–D

Mycale (*Paresperella*) *serrulata* Sarà & Siribelli, 1960: 51.

Material examined. Specimen IG-F-BL3-F4B-spA; specimen IG-F-BL3-F17B-spA alcohol preserved, Gallinara Island (station 2, Falconara) 44°01'22"N, 8°13'34"E, depth 35 m, collected on 31-07-2009. The specimen was entirely used for spicule preparations.

Description. Small, encrusting and insinuating sponge, beige in the dry state, occupying a small cavity (1 cm^3) in a coralligenous block.

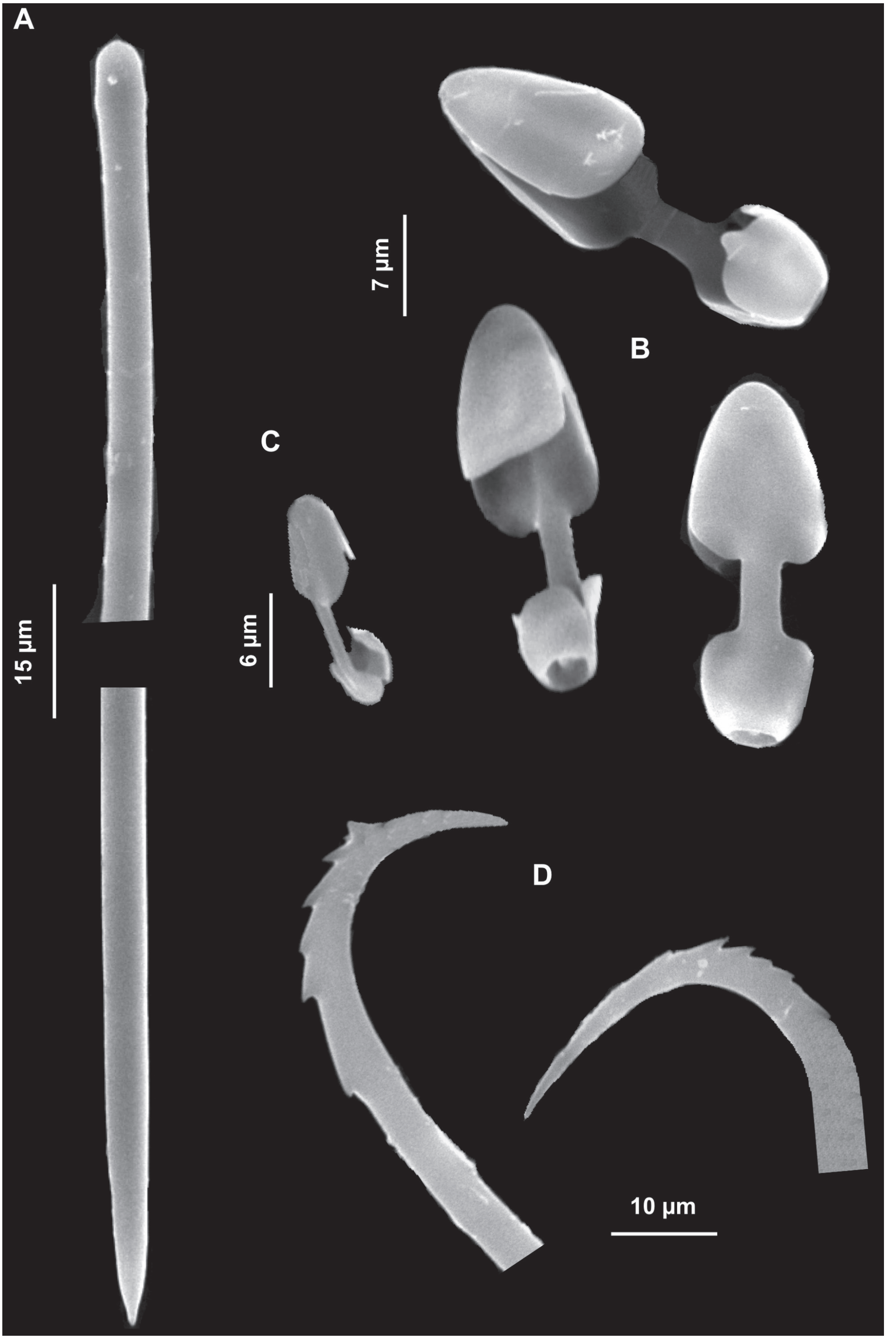

Figure 12. *Mycale* (*Paresperella*) *serrulata*. **A–B** Mycalostyles **B** Large anisochelae **C** Small anisochelae **D** Magnifications of the serrated edge of a sigma.

Skeleton. Not observed.

Spicules. Megascleres: mycalostyles straight or flexuous, with acerate tip (Fig. 12 A), 310 (325) 340 × 3.75 (5) 7.5 µm. Microscleres: anisochelae in two size categories. I) The larger ones, 25 (29.5) 35 µm, have the bigger tooth palmate and the smaller often characterized by a conspicuous point and slightly diverging outwords alae; a hole is detectable at the smaller extremity (Fig. 12 B). II) The smaller ones measure, 12.5 (13.7) 15 µm (Fig. 12 C). Sigmas "C" shaped, 64 (78) 100 × 2.5 (2.7) 5 µm, with the convex edge serrated (Fig. 12 D).

Distribution and discussion. *Mycale* (*Paresperella*) *serrulata* Sarà & Siribelli, 1960, was originally described from a detritic bottom of the Gulf of Naples at 30-40 m depth. Voultsiadou and Vafidis (2004) recorded the species encrusting on *Fasciospongia cavernosa* at 90 m depth in the Aegean Sea. *M.* (*Paresperella*) *serrulata* is a Mediterranean endemic species. Pansini and Longo (2008) recorded it for the first time for the Ligurian Sea and the coralligenous community.

Order Halichondrida
Family Eteroxyidae
Genus *Halicnemia*

***Halicnemia geniculata* Sarà, 1958**
http://species-id.net/wiki/Halicnemia_geniculata
Figs 13A–D

Halicnemia geniculata Sarà, 1958: 237.

Material examined. Specimen IG-F-BL4-sp1-sciaf.; alcohol preserved, Gallinara Island (station 2, Falconara) 44°01'22"N, 8°13'34"E, depth 35 m, collected on 17-06-2009. The specimen was entirely used for spicule preparations.

Description. Small and thin, yellow-ochre encrustation (1 cm^2) on a coralligenous block.

Skeleton. Not observed.

Spicules. Long tylostyles, 405 (1351.7) 1976 × 1.5 (2.7) 4 µm, generally straight, with terminal or subterminal swellings variable in shape; irregular and polytylote forms are to be found (Fig. 13 A). Rabdhotylostyles with heads as above, 147 (242) 705 × 1.5 (2.7) 4 µm (Fig. 13 B); oxeas long, sinuous and thin, 460 (757) 1118 × 1.5 (2.5) 5 mm (Fig. 13 C); acanthoxeas slightly curved or bent, uniformly spined, 42.5 (51.8) 62.5 × 1.5 (1.8) 2 µm (Fig. 13 D).

Distribution and discussion. This species, originally described from a superficial cave of the Gulf of Naples (Sarà 1958) was recorded at 60–70 m depth in the same area (Sarà and Siribelli 1962) and in caves close to Marseille (Pouliquen 1972). It is a Mediterranean endemic species (Pansini and Longo 2008) and a new finding for the Ligurian Sea and the coralligenous community.

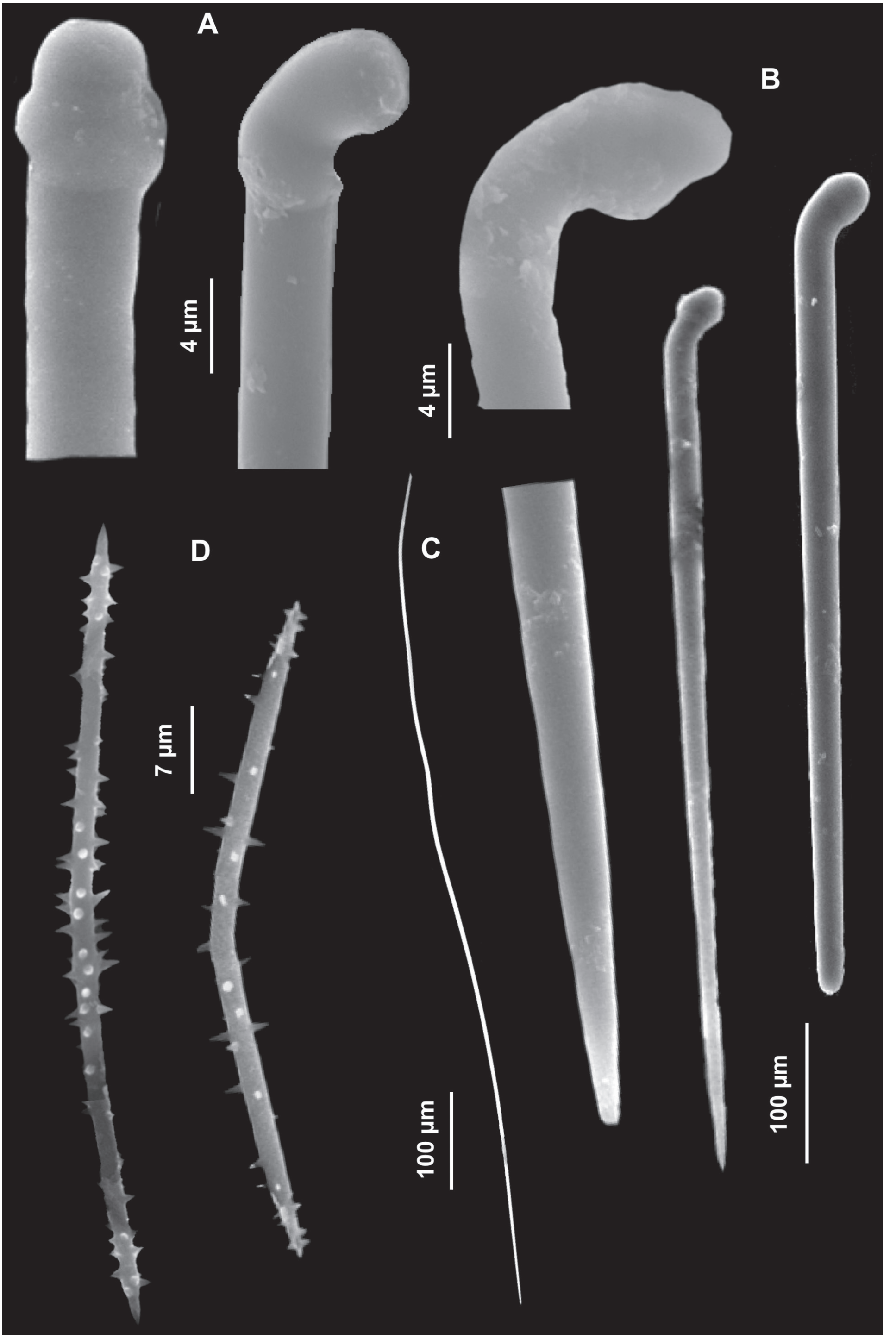

Figure 13. *Halicnemia geniculata.* **A** Magnifications of the tylostyle heads **B** Rabdhotylostyles **C** Oxeas, long, sinuous and thin **D** Acanthoxeas.

Order Haplosclerida
Suborder Haplosclerina
Family Chalinidae
Genus *Haliclona*
Subgenus *Gellius*

***Haliclona* (*Gellius*) *marismedi* (Pulitzer-Finali, 1978)**
http://species-id.net/wiki/Haliclona_marismedi
Figs 14A–F

Gellius marismedi, Pulitzer-Finali, 1978: 81.

Material examined. Specimen PM-BL1-sp7-sciaf.; specimen PM-BL1-sp8-sciaf.; specimen PM-BL2b-sp6-sciaf.; specimen PM-BL2b-sp6a-sciaf.; Punta Manara (station 6) 44°15'05.61"N, 9°24'09.33"E, depth 35 m, collected 13-07-2009; specimen IG-S-BL1-sp2-sciaf.; Gallinara Island (station 3, Sciusciaù) 44°01'34"N, 8°13'45"E, depth 30 m, collected on17-06-2009.

Description. Small (1-1.5 cm^2) encrusting and insinuating sponge, beige or brown, detected on the surface and inside a coralligenous block. Surface smooth, consistency soft (Fig. 14 A).

Skeleton. The choanosome consists of multispicular primary lines connected by unispicular secondary tracts, creating a confused reticulation.

Spicules. Oxeas gently curved with hastate extremities detectable only in the larger spicules (Fig. 14 B), 220 (245) 275 × 2.5 (4.5) 6.25 µm; toxas with more or less angulate central curvature and slightly reflexed points in two size categories: I) 27.5 (45.5) 57.5 µm (Fig. 14 C) and II) 10 (11.5) 12.5 µm (Fig. 14 D); two types of thin sigmas, "C" shaped, I) 22.5 (23.7) 25 µm and II) 10 (13.6) 17.5 µm (Figs 14 E, F).

Distribution and discussion. Pulitzer-Finali (1978) described the species from a specimen epibiothic on *Hyrtios collectrix* (Schulze, 1880) found on dead, sanded *Posidonia* beds, at 50 m depth in the Bay of Naples. The same author considered conspecific with *G. marismedi* the specimen from Banyuls-sur-Mer (rocky walls in shaded areas at 2–17 m depth and horizontal substrates at 20–40 m depth) attributed to *Gelliodes luridus* (Lundbeck, 1902) by Boury-Esnault (1971).

This is a new finding for the Ligurian Sea and the coralligenous community and the third record after the original description.

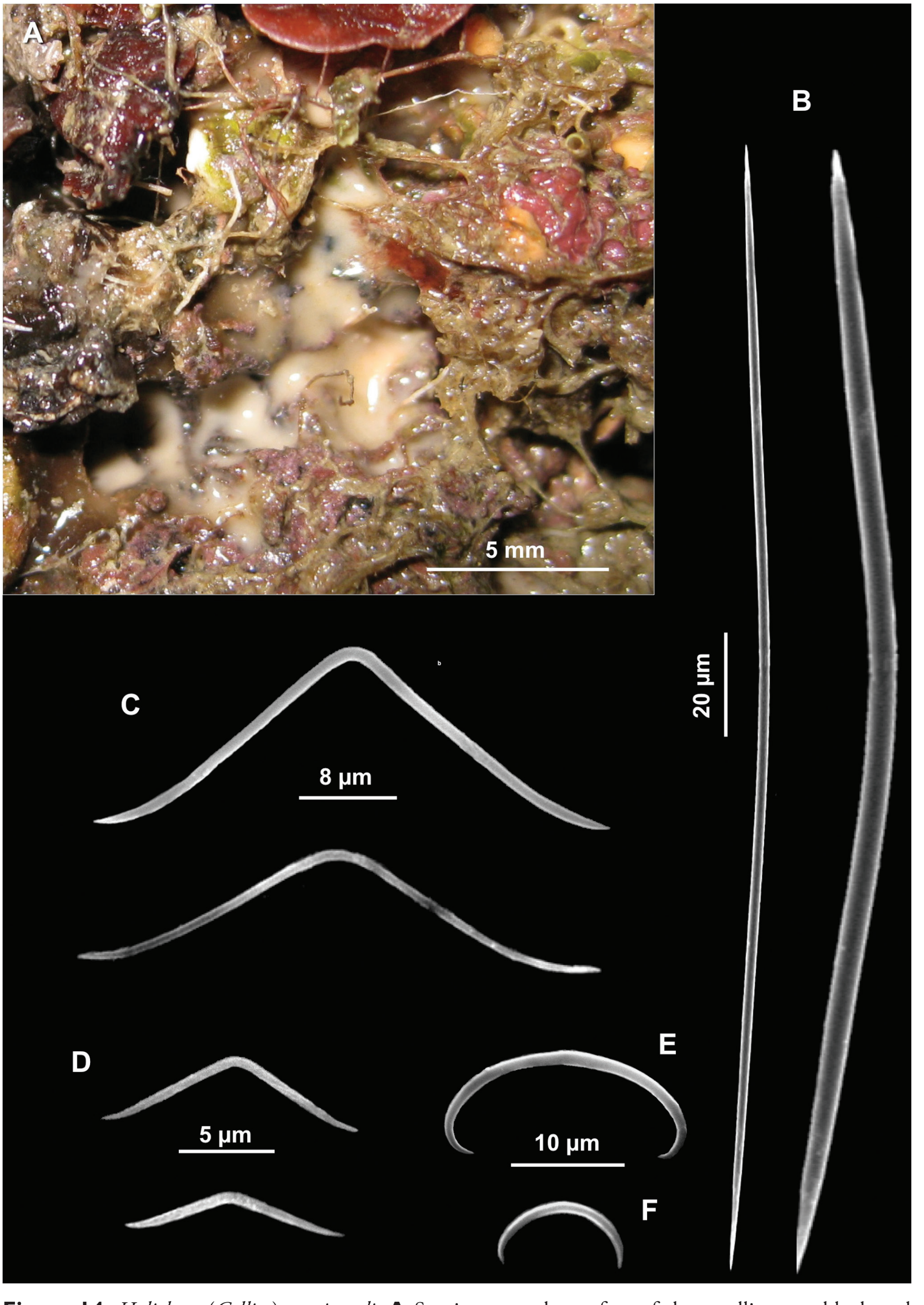

Figure 14. *Haliclona* (*Gellius*) *marismedi*. **A** Specimen on the surface of the coralligenous block and insinuating into it **B** Oxeas **C** Large toxas **D** Small toxas **E** Large sigma **F** Small sigma.

Discussion

According to the latest available revision of coralligenous biodiversity (Ballesteros 2006), 142 species of sponges have been recorded associated with this community. Adding to this list the species recorded on the coralligenous of Apulia (Sarà 1968, 1969), Liguria (Pansini and Pronzato 1973; Calcinai et al. 2007a; Calcinai et al. in prep.; Bertolino et al. 2008) and the Aegean Sea (Kefalas et al. 2003; Kefalas and Castritsi-Catharios 2012) those found associated to red coral (Melone 1965; Templado et al. 1986; Corriero et al. 1988; 1997; Maldonado 1992; Bavestrello et al. 1996; Calcinai et al. 2007b) and the data of the present study, the total number of sponge species hitherto associated to the coralligenous community increases to 273 (Table 2).

This increasing is related to the difficulty of studying the organisms inhabiting the coralligenous concretions due to the complexity of the habitat, the high diversity, and the depth where these structures are located (Kipson et al. 2011). Our study, based on the collection of blocks and their sectioning into slices, allowed the identification of species that would have been otherwise completely disregarded.

Among the insinuating species observed in the coralligenous crevices we have found several species previously recorded with a massive habitus in deeper waters. *Pachastrella monilifera* Schmidt, 1868 and *Poecillastra compressa* (Bowerbank, 1866) were the species with the highest phenotypic plasticity, since they usually appear with large, fun shaped specimens, in deep habitats (Bo et al. 2012), while in the coralligenous community they live in crevices and fissures of the concretion. Our results support the idea that environments rich in microhabitats may act as shelters essential for the dispersal of many deep water species, enlarging their distribution range (Bo et al. 2011). Therefore we can emphasize the importance of the coralligenous concretion, not only as reservoir of biodiversity, but also as an important "stepping-stone" able to facilitate the dispersal of species along vertical gradients.

As to the boring sponges, *Cliona janitrix* is indicated by Ballesteros (2006) and Calcinai et al. (2007b) as the key species in the bio-erosive processes involving *Corallium rubrum*, whereas *Cliona viridis* has the same role in the coralligenous matrix (Rosell et al. 1999). According to our data *Cliona celata* Grant, 1826, *C. schmidtii* (Ridley, 1881), *Spiroxya corallophila* (Calcinai, Cerrano & Bavestrello, 2002), *S. heteroclita* Topsent, 1896 and *Siphonodictyon insidiosum* (Johnson, 1899) may also be considered important in the bio erosive processes acting upon the coralligenous structure. SEM analyses showed that three other species: *Jaspis johnstoni* (Schmidt, 1862), *Dercitus* (*Stoeba*) *plicatus* (Schmidt, 1868), *Samus anonymus* Gray, 1867, suspected to be excavating (Carter 1880, Thomas 1973, van Soest and Hooper 2002), actually do not bore the coralligenous substratum but only occupy cavities of the porous concretion and the chambers previously excavated by boring sponges (Figs 2 E–F). *Cliona viridis*, *Jaspis johnstoni* and *Dercitus* (*Stoeba*) *plicatus*, able to penetrate 5 cm into the substrate, are the species reaching the greatest depth inside the concretion.

Table 2. List of sponge species (Demospongiae and Homoscleromorpha) hitherto recorded associated to the coralligenous community.

	Oscarellidae
1.	*Oscarella lobularis* (Schmidt, 1862)
	Plakinidae
2.	*Corticium candelabrum* Schmidt, 1862
3.	*Placinolopha moncharmonti* (Sarà, 1960)
4.	*Plakina monolopha* Schulze, 1880
5.	*Plakina dilopha* Schulze, 1880
6.	*Plakina trilopha* Schulze, 1880
7.	*Plakinastrella copiosa* Schulze, 1880
8.	*Plakinastrella mixta* Maldonado, 1992
9.	*Plakortis simplex* Schulze, 1880
	Tetillidae
10.	*Craniella cranium* (Müller, 1776)
	Samidae
11.	*Samus anonymus* Gray, 1867
	Ancorinidae
12.	*Stelletta dorsigera* Schmidt, 1862
13.	*Stelletta grubii* Schmidt, 1862
14.	*Stelletta lactea* Carter, 1871
15.	*Stelletta stellata* Topsent, 1893
16.	*Jaspis incrustans* (Topsent, 1890)
17.	*Jaspis johnstonii* (Schmidt, 1862)
18.	*Stryphnus mucronatus* (Schmidt, 1868)
19.	*Stryphnus ponderosus* (Bowerbank, 1866)
20.	*Penares candidata* (Schmidt, 1868)
21.	*Penares euastrum* (Schmidt, 1868)
22.	*Penares helleri* (Schmidt, 1864)
23.	*Holoxea furtiva* Topent, 1892
24.	*Dercitus* (*Dercitus*) *bucklandi* (Bowerbank, 1858)
25.	*Dercitus* (*Stoeba*) *plicata* (Schmidt, 1868)
	Calthropellidae
26.	*Calthropella* (*Calthropella*) *pathologica* (Schmidt, 1868)
27.	*Calthropella* (*Corticellopsis*) *stelligera* (Schmidt, 1868)
	Geodiidae
28.	*Erylus discophorus* (Schmidt, 1862)
29.	*Erylus papulifer* Pulitzer-Finali, 1983
30.	*Caminus vulcani* Schmidt, 1862
31.	*Pachymatisma johnstonia* (Bowerbank in Johnston, 1842)
32.	*Geodia anceps* (Vosmaer, 1894)
33.	*Geodia conchilega* Schmidt, 1862
34.	*Geodia cydonium* Jamenson, 1811
35.	*Caminella intuta* (Topsent, 1892)
	Pachastrellidae
36.	*Pachastrella monilifera* Schmidt, 1868
37.	*Poecillastra compressa* (Bowerbank, 1866)
38.	*Nethea amygdaloides* (Carter, 1876)
39.	*Thenea muricata* (Bowerbank, 1858)
40.	*Triptolemma simplex* (Sarà, 1959)
41.	*Vulcanella* (*Vulcanella*) *gracilis* (Sollas, 1888)
42.	*Annulastrella verrucolosa* (Pulitzer-Finali, 1983)
	Clionaidae
43.	*Cliona burtoni* Topsent, 1932
44.	*Cliona carteri* (Ridley, 1881)
45.	*Cliona celata* Grant, 1826
46.	*Cliona lobata* Hancock, 1849
47.	*Cliona janitrix* Topsent, 1932
48.	*Cliona rhodensis* Rützler & Bromley, 1981
49.	*Cliona schmidtii* (Ridley, 1881)
50.	*Cliona thoosina* Topsent, 1888
51.	*Cliona vermifera* Hancock, 1867
52.	*Cliona viridis* Schmidt, 1862
53.	*Dotona pulchella mediterranea* Rosell & Uriz, 2002
54.	*Pione vastifica* (Hancock, 1849)
55.	*Spiroxya corallophila* (Calcinai, Cerrano & Bavestrello, 2002)
56.	*Spiroxya heteroclita* Topsent, 1896
57.	*Spiroxya levispira* (Topsent, 1898)
58.	*Spiroxya sarai* (Melone, 1965)
	Thoosidae
59.	*Alectona millari* Carter, 1879
60.	*Delectona ciconiae* Bavestrello, Calcinai & Sarà, 1996
61.	*Delectona madreporica* Bavestrello et al., 1997
62.	*Thoosa armata* Topsent, 1888
63.	*Thoosa mollis* Volz, 1939
	Hemiasterellidae
64.	*Paratimea constellata* (Topsent, 1893)
65.	*Paratimea oxeata* Pulitzer-Finali, 1978
	Stelligeridae
66.	*Stelligera rigida* (Montagu, 1818)
	Polymastiidae
67.	*Polymastia inflata* Cabioch, 1968
68.	*Polymastia mamillaris* (Müller, 1806)
69.	*Polymastia polytylota* Vacelet, 1969
70.	*Quasillina brevis* (Bowerbank, 1861)

71.	*Pseudotrachya hystrix* (Topsent, 1890)
	Spirastrellidae
72.	*Diplastrella bistellata* (Schmidt, 1862)
73.	*Spirastrella cunctatrix* Schmidt, 1868
	Suberitidae
74.	*Aaptos aaptos* (Schmidt, 1864)
75.	*Prosuberites longispina* Topsent, 1893
76.	*Protosuberites ectyoninus* (Topsent, 1900)
77.	*Protosuberites epiphytum* (Lamarck, 1815)
78.	*Protosuberites rugosus* (Topsent, 1893)
79.	*Pseudosuberites hyalinus* (Ridley & Dendy, 1867)
80.	*Pseudosuberites sulphureus* (Bowerbank, 1866)
81.	*Suberites carnosus* (Johnston, 1842)
82.	*Suberites carnosus incrustans* Topsent, 1900
83.	*Suberites domuncula* (Olivi, 1792)
84.	*Suberites syringella* (Schmidt, 1868)
85.	*Terpios gelatinosa* (Bowerbank, 1866)
	Tethyidae
86.	*Tethya aurantium* (Pallas, 1766)
87.	*Tethya citrina* Sarà & Melone, 1965
	Timeidae
88.	*Timea cumana* Pulitzer-Finali, 1978
89.	*Timea fasciata* Topsent, 1934
90.	*Timea irregularis* Sarà & Siribelli, 1960
91.	*Timea stellata* (Bowerbank, 1866)
92.	*Timea stellifasciata* Sarà & Siribelli, 1960
93.	*Timea unistellata* (Topsent, 1892)
	Trachycladidae
94.	*Trachycladus minax* (Topsent, 1888)
	Chondrillidae
95.	*Chondrosia reniformis* Nardo, 1847
96.	*Chondrilla nucula* Schmidt, 1862
	Desmanthidae
97.	*Desmanthus incrustans* (Topsent, 1889)
	Acarnidae
98.	*Acarnus souriei* (Lévi, 1952)
99.	*Acarnus tortilis* Topsent, 1892
	Microcionidae
100.	*Clathria* (*Clathria*) *compressa* (Schmidt, 1862)
101.	*Clathria* (*Clathria*) *coralloides* (Olivi, 1792)
102.	*Clathria* (*Clathria*) *depressa* Sarà & Melone, 1966
103.	*Clathria* (*Clathria*) *toxivaria* (Sarà, 1959)
104.	*Clathria* (*Microciona*) *armata* (Bowerbank, 1862)
105.	*Clathria* (*Microciona*) *assimilis* Topsent & Olivier, 1943
106.	*Clathria* (*Microciona*) *gradalis* Topsent, 1925
107.	*Clathria* (*Microciona*) *haplotoxa* (Topsent, 1928)
108.	*Clathria* (*Microciona*) *spinarcus* (Carter & Hope, 1889)
109.	*Clathria* (*Microciona*) *toxistyla* (Sarà, 1959)
110.	*Antho* (*Antho*) *inconstans* (Topsent, 1925)
111.	*Antho* (*Antho*) *involvens* (Schmidt, 1864)
112.	*Antho* (*Acarnia*) *coriacea* (Bowerbank, 1874)
113.	*Antho* (*Acarnia*) cf. *novizelanica* (Ridley & Duncan, 1881)
	Raspailiidae
114.	*Raspailia* (*Raspailia*) *viminalis* Schmidt, 1862
115.	*Aulospongus spinosus* (Topsent, 1927)
116.	*Eurypon cinctum* Sarà, 1960
117.	*Eurypon clavatum* (Bowerbank, 1866)
118.	*Eurypon coronula* (Bowerbank, 1874)
119.	*Eurypon denisae* Vacelet, 1969
120.	*Eurypon gracilis* Present paper
121.	*Eurypon lacazei* (Topsent, 1891)
122.	*Eurypon major* Sarà & Siribelli, 1960
123.	*Eurypon topsenti* Pulitzer-Finali, 1983
124.	*Eurypon vesciculare* Sarà & Siribelli, 1960
125.	*Eurypon viride* (Topsent, 1889)
126.	*Raspaciona aculeata* (Johnston, 1842)
	Rhabderemiidae
127.	*Rhabderemia gallica* van Soest & Hooper, 1993
128.	*Rhabderemia indica* Dendy, 1905
129.	*Rhabderemia minutula* (Carter, 1876)
130.	*Rhabderemia* cf. *topsenti* van Soest & Hooper, 1993
	Chondropsidae
131.	*Batzella inops* (Topsent, 1891)
	Coelosphaeridae
132.	*Chaetodoryx insinuans* (Topsent, 1936)
133.	*Forcepia* (*Leptolabis*) *apuliae* (Sarà, 1969)
134.	*Forcepia* (*Leptolabilis*) *brunnea* (Topsent, 1904)
135.	*Forcepia* (*Leptolabis*) cf. *luciensis* (Topsent, 1888)
136.	*Forcepia* (*Leptolabis*) *megachela* (Maldonado, 1992)
137.	*Lissodendoryx* (*Lissodendoryx*) *isodictyalis* (Carter, 1882)
138.	*Lissodendoryx* (*Anomodoryx*) *cavernosa* (Topsent, 1892)
	Crambeidae
139.	*Crambe crambe* (Schmidt, 1862)
140.	*Crambe tuberosa* Maldonado & Benito, 1991
	Crellidae
141.	*Crella* (*Crella*) *elegans* (Schmidt, 1862)
142.	*Crella* (*Crella*) *mollior* Topsent, 1925
143.	*Crella* (*Grayella*) *pulvinar* (Schmidt, 1868)
144.	*Crella* (*Pytheas*) *fusifera* Sarà, 1969

145.	*Crella* (*Pytheas*) *sigmata* Topsent, 1925
146.	*Crella* (*Yvesia*) *rosea* (Topsent, 1892)
	Desmacididae
147.	*Desmacidon adriaticum* Sarà, 1969
148.	*Desmacidon fruticosum* (Montagu, 1818)
	Hymedesmiidae
149.	*Hemimycale columella* (Bowerbank, 1864)
150.	*Hymedesmia* (*Hymedesmia*) *baculifera* (Topsent, 1901)
151.	*Hymedesmia* (*Hymedesmia*) *paupertas* (Bowerbank, 1866)
152.	*Hymedesmia* (*Hymedesmia*) *peachi* Bowerbank, 1882
153.	*Hymedesmia* (*Hymedesmia*) *plicata* Topsent, 1928
154.	*Hymedesmia* (*Hymedesmia*) *rissoi* Topsent, 1936
155.	*Hymedesmia* (*Hymedesmia*) *versicolor* (Topsent, 1893)
156.	*Hymedesmia* (*Stylopus*) *coriacea* (Fristedt, 1885)
157.	*Phorbas dives* (Topsent, 1891)
158.	*Phorbas fibulatus* (Topsent, 1893)
159.	*Phorbas fictitius* Bowerbank, 1866
160.	*Phorbas mercator* (Schmidt, 1868)
161.	*Phorbas tenacior* (Topsent, 1925)
162.	*Plocamionida ambigua* (Bowerbank, 1866)
	Myxillidae
163.	*Myxilla* (*Myxilla*) *rosacea* (Lieberkühn,1859)
	Tedaniidae
164.	*Tedania* (*Tedania*) *anhelans* Lieberkühn, 1849
	Desmacellidae
165.	*Biemna parthenopea* Pulitzer-Finali, 1978
166.	*Biemna variantia* (Bowerbank, 1858)
167.	*Desmacella annexa* Schmidt, 1870
168.	*Desmacella inornata* (Bowerbank, 1866)
	Esperiopsidae
169.	*Ulosa stuposa* (Esper, 1794)
	Hamacanthidae
170.	*Hamacantha* (*Vomerula*) *falcula* (Bowerbank, 1874)
	Mycalidae
171.	*Mycale* (*Mycale*) *lingua* (Bowerbank, 1866)
172.	*Mycale* (*Mycale*) *massa* (Schmidt, 1862)
173.	*Mycale* (*Aegogropila*) *contarenii* (Lieberkühn, 1859)
174.	*Mycale* (*Aegogropila*) *tunicata* (Schmidt, 1862)
175.	*Mycale* (*Paresperella*) *serrulata* Sarà & Siribelli, 1960
	Merliidae
176.	*Merlia normani* Kirkpatrick, 1908
	Podospongiidae
177.	*Podospongia lovenii* Bocage, 1870
	Latrunculiidae
178.	*Latrunculia* (*Biannulata*) *citharistae* Vacelet, 1969
179.	*Sceptrella biannulata* (Topsent, 1892)
180.	*Sceptrella insignis* (Topsent, 1890)
	Axinellidae
181.	*Axinella cannabina* (Esper, 1794)
182.	*Axinella damicornis* (Esper, 1794)
183.	*Axinella rugosa* (Bowerbank, 1866)
184.	*Axinella polypoides* Schmidt, 1862
185.	*Axinella verrucosa* (Esper, 1794)
186.	*Phakellia robusta* Bowerbank, 1866
187.	*Phakellia ventilabrum* (Linnaeus, 1767)
	Bubaridae
188.	*Bubaris carcisis* Vacelet, 1969
189.	*Bubaris vermiculata* (Bowerbank, 1866)
190.	*Cerbaris curvispiculifer* (Carter, 1880)
191.	*Monocrepidion vermiculatum* Topsent, 1898
	Hymerhabdiidae
192.	*Hymerhabdia oxytrunca* Topsent, 1904
193.	*Hymerhabdia typica* Topsent, 1892
	Heteroxyidae
194.	*Halicnemia geniculata* Sarà, 1958
195.	*Halicnemia patera* Bowerbank, 1864
	Dictyonellidae
196.	*Acanthella acuta* Schmidt, 1862
197.	*Dictyonella incisa* (Schmidt, 1880)
198.	*Dictyonella marsilii* (Topsent, 1893)
199.	*Dictyonella obtusa* (Schmidt, 1862)
200.	*Dictyonella pelligera* (Schmidt, 1862)
	Halichondriidae
201.	*Axinyssa aurantiaca* (Schmidt,1864)
202.	*Halichondria* (*Halichondria*) *bowerbanki* Burton, 1930
203.	*Halichondria* (*Halichondria*) *contorta* (Sarà, 1961)
204.	*Halichondria* (*Halichondria*) *convolvens* Sarà, 1960
205.	*Halichondria* (*Halichondria*) *genitrix* (Schmidt, 1870)
206.	*Halichondria* (*Halichondria*) *panicea* (Pallas, 1766)
207.	*Halichondria* (*Halichondria*) *semitubulosa* Lieberkühn, 1859
208.	*Hymeniacidon perlevis* (Montagu, 1818)
209.	*Hymeniacidon rugosa* (Schmidt, 1868)
210.	*Laminospongia subtilis* Pulitzer-Finali, 1983
211.	*Spongosorites intricatus* (Topsent, 1892)
212.	*Spongosorites flavens* Pulitzer-Finali, 1983
213.	*Topsentia glabra* (Topsent, 1898)
214.	*Topsentia vaceleti* Kefalas & Castritsi–Catharios, 2012

	Agelasidae
215.	*Agelas oroides* Schmidt, 1864
	Callyspongiidae
216.	*Callyspongia subcornea* Griessinger, 1971
	Chalinidae
217.	*Dendroxea lenis* (Topsent, 1892)
218.	*Haliclona* (*Gellius*) *angulata* (Bowerbank, 1866)
219.	*Haliclona* (*Gellius*) *dubia* (Babic, 1922)
220.	*Haliclona* (*Gellius*) *flagellifer* (Ridley & Dendy, 1866)
221.	*Haliclona* (*Gellius*) *lacazei* (Topsent, 1893)
222.	*Haliclona* (*Gellius*) *marismedi* (Pulitzer-Finali, 1978)
223.	*Haliclona* (*Gellius*) *tenuisigma* (Sarà & Siribelli, 1960)
224.	*Haliclona* (*Halichoclona*) *fulva* (Topsent, 1893)
225.	*Haliclona* (*Haliclona*) *simulans* (Johnston, 1842)
226.	*Haliclona* (*Reniera*) *aquaeductus* (Schmidt, 1862)
227.	*Haliclona* (*Reniera*) *citrina* (Topsent, 1892)
228.	*Haliclona* (*Reniera*) *cratera* (Schmidt, 1862)
229.	*Haliclona* (*Reniera*) *mediterranea* Griessinger, 1971
230.	*Haliclona* (*Rhizoniera*) *rosea* (Bowerbank, 1866)
231.	*Haliclona* (*Rhizoniera*) *sarai* (Pulitzer-Finali, 1969)
232.	*Haliclona* (*Soestella*) *arenata* Griessinger, 1971
233.	*Haliclona* (*Soestella*) *implexa* (Schmidt, 1868)
234.	*Haliclona* (*Soestella*) *mamillata* (Griessinger, 1971)
235.	*Haliclona* (*Soestella*) *mucosa* (Griessinger, 1971)
236.	*Haliclona* (*Soestella*) *valliculata* (Griessinger, 1971)
237.	*Haliclona elegans* (Lendenfeld, 1887)
	Phloeodictyidae
238.	*Siphonodictyon coralliirubri* (Calcinai et al., 2007)
239.	*Siphonodictyon insidiosum* (Johnson, 1899)
240.	*Calyx nicaeensis* (Risso, 1826)
	Petrosiidae
241.	*Petrosia* (*Petrosia*) *clavata* (Esper, 1794)
242.	*Petrosia* (*Petrosia*) *ficiformis* (Poiret, 1798)
	Irciniidae
243.	*Ircinia dendroides* (Schmidt, 1862)
244.	*Ircinia oros* (Schmidt, 1864)
245.	*Ircinia variabilis* (Pallas, 1766)
246.	*Sarcotragus fasciculatus* (Pallas, 1766)
247.	*Sarcotragus foetidus* Schmidt, 1862
248.	*Sarcotragus pipetta* (Schmidt, 1868)
249.	*Sarcotragus spinosulus* Schmidt, 1862
	Thorectidae
250.	*Cacospongia mollior* Schmidt, 1862
251.	*Cacospongia scalaris* Schmidt, 1862
252.	*Hyrtios collectrix* (Schulze, 1880)
253.	*Fasciospongia cavernosa* (Schmidt, 1862)
	Spongiidae
254.	*Spongia* (*Spongia*) *agaricina* Pallas, 1766
255.	*Spongia* (*Spongia*) *nitens* (Schmidt, 1862)
256.	*Spongia* (*Spongia*) *officinalis* Linnaeus, 1759
257.	*Spongia* (*Spongia*) *virgultosa* (Schmidt, 1868)
258.	*Spongia* (*Spongia*) *zimocca* Schmidt, 1862
259.	*Hippospongia communis* (Lamarck, 1814)
	Dysideidae
260.	*Dysidea avara* (Schmidt, 1862)
261.	*Dysidea fragilis* (Montagu, 1818)
262.	*Dysidea tupha* (Martens, 1824)
263.	*Pleraplysilla spinifera* (Schulze, 1879)
	Darwinellidae
264.	*Aplysilla rosea* (Barrois, 1876)
265.	*Aplysilla sulfurea* Schulze, 1878
266.	*Chelonaplysilla noevus* (Carter, 1876)
	Dictyodendrillidae
267.	*Spongionella gracilis* (Vosmaer, 1883)
268.	*Spongionella pulchella* (Sowerby, 1804)
	Halisarcidae
269.	*Halisarca dujardini* Johnston, 1842
	Aplysinidae
270.	*Aplysina aerophoba* Nardo, 1843
271.	*Aplysina cavernicola* Vacelet, 1959
	Ianthellidae
272.	*Hexadella pruvoti* Topsent, 1896
273.	*Hexadella racovitzai* Topsent, 1896

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RESEARCH ARTICLE

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A peculiar new species of the genus *Tetrasticta* Kraatz (Coleoptera, Staphylinidae, Aleocharinae) from Peninsular Malaysia

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Abstract

Tetrasticta gnatha **sp. n.**, collected under the bark of a rotten fallen tree in Peninsular Malaysia, is described. A habitus photograph, line drawings of diagnostic characters, and a diagnosis are provided. The new species is readily distinguished from all known congeners by having long mandibles, and long, curved maxillary palpi.

Keywords

Aleocharini, description, Oriental region, taxonomy, under bark

Introduction

The staphylinid genus *Tetrasticta* Kraatz, 1857 (Aleocharinae: Aleocharini) is a small genus that currently contains ten species from the Oriental and Afrotropical regions (Maruyama and Sugaya 2002; Maruyama 2004; Pace 2008). *Tetrasticta* is distinguished from the other genera of the tribe Aleocharini Fleming, 1821 by having large eyes, thick antennae, a broad pronotum, short elytra, and a long, broad intercoxal-process of the metaventrite (see, Maruyama 2004). The life histories of most species are unknown, but some species, e.g., *T. polita* Kraatz, 1857 and *T. laeta* Maruyama & Sugaya, 2002, are presumed to be weakly integrated termitophiles (Kraatz 1857; Cameron 1939; Maruyama et al. 2013). A morphology-based phylogeny by Kanao et al. (2011) suggested that the termitophilous subtribe Compactopediina Kistner, 1970 of the Aleocharini evolved termitophily within the *Tetrasticta* genus group (sensu Maruyama 2004).

Previously, three species of *Tetrasticta* were known from Malaysia (Cameron 1943; Maruyama 2004; Pace 2008), one of which was recorded from Peninsular Malaysia (Maruyama 2004).

Materials and methods

The technical procedures, terminology, and other methods used here are given in detail in Maruyama (2006) and Yamamoto and Maruyama (2012). In the descriptions, the numbers of macrosetae are those on one side of the body. The macrosetae on tergite VIII and sternite VIII are illustrated only on one side of the segments. All measurements in the paper are given in millimetres as follows: minimum length–maximum length (mean±SD). Most of the type specimens including the holotype are preserved at the Kyushu University Museum, Fukuoka, Japan.

Taxonomy

Genus *Tetrasticta* Kraatz

Tetrasticta Kraatz, 1857: 54 [original description]. See Maruyama (2004) for synonymic list.

Tetrasticta gnatha sp. n.

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http://species-id.net/wiki/Tetrasticta_gnatha
Figs 1–12

Type material. Holotype: male, "Nr. Kenyir Lake / Kuala Terengganu St. / W. MALAYSIA / 1-III-2002 / Tomoyuki TSURU leg.". Paratypes: 1 male, 1 female, 9 unsexed specimens, same data as the holotype.

Description. Body: broad, somewhat flattened, shining (Fig. 1). **Color:** reddish brown; abdomen paler, with darker tergites V–VII; antennal segments I–IV, mouthparts, and legs reddish yellow; antennal segments V–XI brown. **Head:** large, as broad as pronotum, somewhat pentangular, moderately convex above, slightly wider than long;

Figure 1. Habitus of *Tetrasticta gnatha* sp. n., female, dorsal view.

apical margin of clypeus rounded; frons produced, V-shaped; surface sparsely covered with minute, yellow setae; eyes prominent, length 0.64 times that of head. Antennae slightly longer than combined length of head and pronotum; segment I long, as long as combined length of segments II–V; segment II small, less than one-third of I; segment III small, shorter than II; segment IV extremely short, much wider than long, about half as long as III; segment V slightly wider than long; segments VI–X wider than long; segment XI oval, longer than wide; relative length of segments from base to apex: 31: 7: 6: 3.5: 9.5: 10: 10: 10: 10: 10: 22 (Fig. 2). **Mouthparts:** labrum much wider than long (W/L = 1.9), anterior margin widely emarginate. Mandibles slightly asymmetric, strongly curved, pointed apically (Fig. 3). Maxilla with a long and strongly curved maxillary palpus (Fig. 4). Mentum somewhat semicircular, much wider than long (W/L = 2.3); surface with 4 setae, and dozens of pores antero-medially. **Pronotum:** much wider than long, semicircular; disc with three pairs of small depressions (two pairs medially, one pair laterally); surface sparsely covered with yellow setae, and with approximately five bristles along lateral margin; each depression bearing a small bristle. **Elytra:** wider than long, subparallel-sided, rounded posterolaterally; surface moderately punctured and covered with yellow setae, and with four bristles laterally. **Legs:** rather short in length; relative lengths of tarsomeres from base to apex: 7: 5: 5: 6: 10.5 in foretarsus; 10: 6: 7: 7: 11 in midtarsus; 11: 11: 11: 11: 19 in hindtarsus. **Abdomen:** flattened, subpararell-sided, widest around segments IV and V; tergites III–VII sparsely covered with small setae.

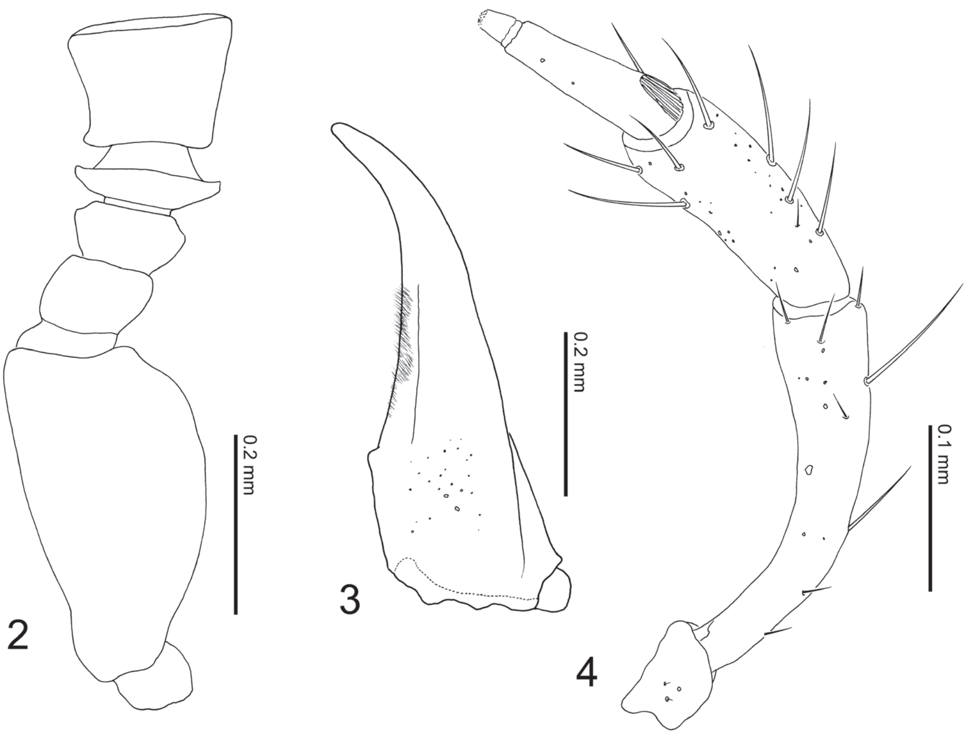
Male: tergite VIII generalized in shape; surface smooth, with approximately 5–6 macrosetae (Fig. 5). Sternite VIII generalized in shape, semicircular in dorsal view, with approximately 9–10 macrosetae (Fig. 7). Median lobe of aedeagus slightly narrowed apically in lateral view; inner sac with flagellum of copulatory piece not coiled (Figs 9–10); apical lobe of paramerite long, slightly dilated apically with four setae (Fig. 11).

Female: tergite VIII generalized as in male, with approximately 7–9 macrosetae (Fig. 6). Sternite VIII generalized as in male, with approximately 9–10 macrosetae (Fig. 7). Spermatheca: moderately curved; border between basal and apical portions narrowly membranous; basal portion dilated apically, longer than apical portion, with prominent opening of spermathecal gland; apical portion oval, inner wall of apical part three-quarters to four-fifths densely striate (Fig. 12).

Measurements. BL, ca. 3.7–5.6 (4.4±0.5); HL, 0.70–0.91 (0.79±0.06); HW, 0.99–1.15 (1.07±0.06); AL, 1.68–1.97 (1.84±0.09); PL, 0.71–0.84 (0.77±0.05); PW, 1.12–1.36 (1.25±0.07); EL, 0.61–0.78 (0.70±0.05); EW, 1.22–1.56 (1.38±0.09); FTL, 0.64–0.81 (0.72±0.05); MTL, 0.78–0.97 (0.89±0.06); HTL, 0.89–1.16 (1.04±0.07); HW/HL, 1.22–1.52 (1.34±0.09); PW/PL, 1.58–1.68 (1.63±0.03). $N = 12$.

Diagnosis. This new species is easily distinguished from other *Tetrasticta* species by having a large head, which is as wide as pronotum, flattened body with unique mouthparts (i.e., strongly curved maxillary palpi, especially segment II, and curved, sharply pointed mandibles). Furthermore, the species lacks a coiled flagellum inside the median lobe of the male aedeagus.

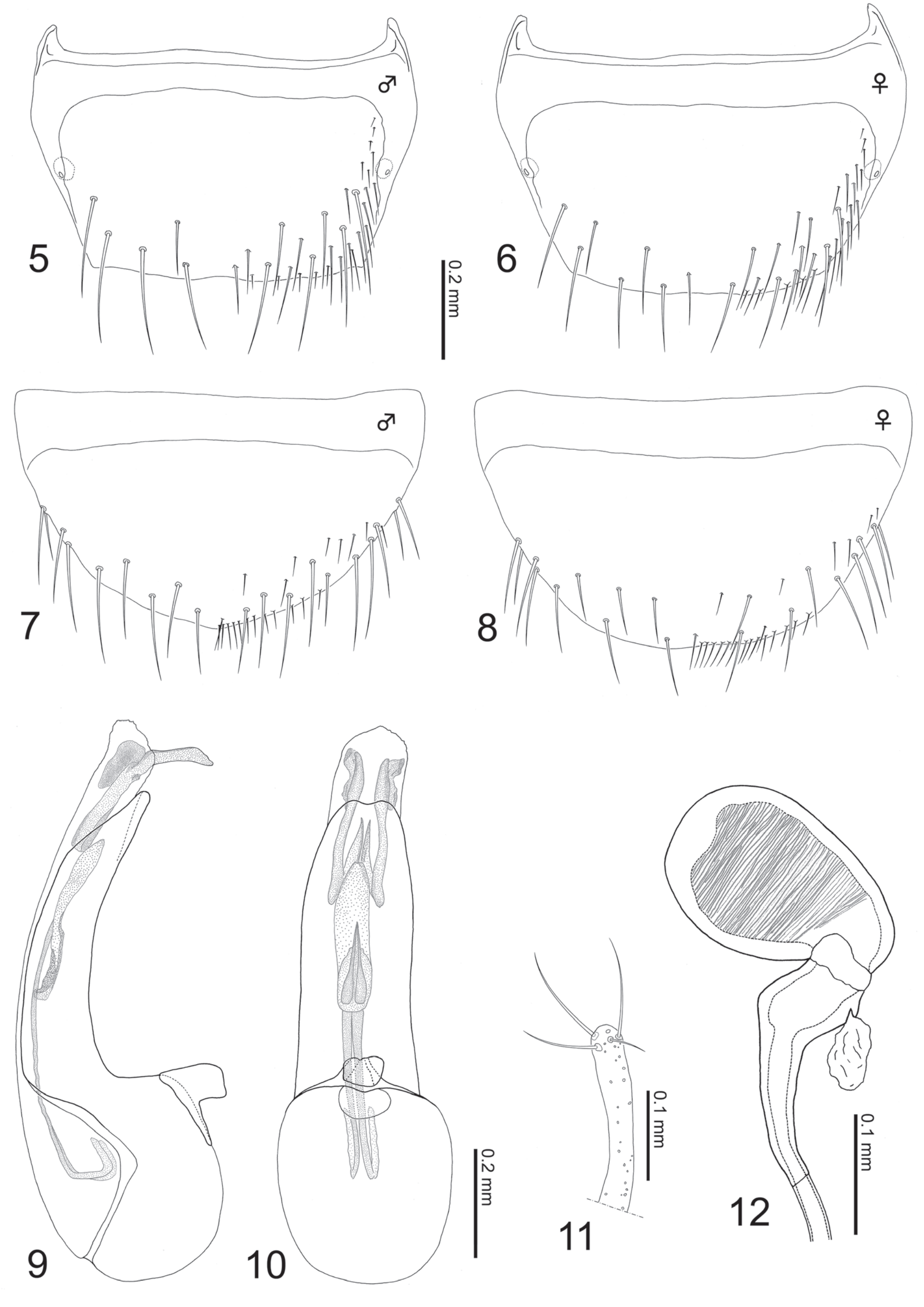
Bionomics. Dr. T. Tsuru collected all the specimens from a rotten log about 50 cm in diameter lying in the rainforest.



Figures 2–4. *Tetrasticta gnatha* sp. n. **2** antennal segments I–V (right, dorsolateral view) **3** right mandible, male, dorsal view (hairs along inner side are those of prostheca) **4** right maxillary palpus, male, ventral view.

Distribution. Malaysia (Peninsula).

Remarks. *Tetrasticta* belongs to the *Tetrasticta* genus group, which comprises the genera *Creochara* Cameron, 1931, *Cratoacrochara* Pace, 1986, *Ilarochara* Pace, 1993, *Aleonictus* Kistner, 1997, *Formicaenictus* Kistner, 1997, and *Myrmecosticta* Maruyama, 2011 (Maruyama 2004; Maruyama et al. 2011). Pace (2010) synonymized *Creochara* with *Tetrasticta*, but did not provide an appropriate explanation; we do not follow this concept here. *Tetrasticta gnatha* is well characterized by the following character states: 1) long mandibles; 2) long, 3) curved segment II of the maxillary palpus; and 4) short, 5) simple flagellum of the median lobe of the aedeagus. Of these, states 2) and 3) are probably correlated with long mandibles, as also observed in the other aleocharines with long mandibles (e.g., some Lomechusini species). All other known species of *Tetrasticta* share a long, coiled flagellum of the median lobe of the aedeagus. The other character states fully coincide with those of *Tetrasticta*. A short, simple flagellum is also observed in *Aleonictus* and *Formicaenictus* in the same genus group, which are closely allied to *Tetrasticta*, but this state is apparently plesiomorphic, and cannot support a relationship between *T. gnatha* and these genera. Although *T. gnatha* is unique within the *Tetrasticta* genus group at first glance, we do not erect a genus for it. All of the type specimens of *T. gnatha* were found under



Figures 5–12. *Tetrasticta gnatha* sp. n. **5** male tergite VIII, dorsal view **6** female tergite VIII, dorsal view **7** male sternite VIII, ventral view **8** female sternite VIII, ventral view **9** median lobe of aedeagus, lateral view **10** ditto, ventral view **11** apical lobe of paramerite **12** spermatheca.

bark. Since no behavioral observations were made, termitophily of *T. gnatha* remain uncertain. The long mandibles in both sexes and the flattened body suggest a predatory life under bark.

Etymology. The Greek *gnathos* means jaw, for the exceptionally long mandibles.

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RESEARCH ARTICLE

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First record of leaf-hole shelters used and modified by leaf beetles (Coleoptera, Chrysomelidae), with descriptions of two new *Orthaltica* Crotch species from southern India

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Abstract

Behavioural novelties observed in adult leaf beetles of two new *Orthaltica* Crotch species include: 1) the use of low cost leaf-hole shelters, either in pre-formed holes produced by larger beetles that fed on the same leaf, or artificially created holes as part of an experiment; and 2) the use of faeces to partition the hole. Two new southern Indian species of the genus *Orthaltica* are described and illustrated: *O. syzygium* and *O. terminalia*. Host plants are identified for both species. A key to the Indian species of *Orthaltica* is provided.

Keywords
Leaf-hole shelter, faeces, leaf beetles, new species, host plant

Introduction

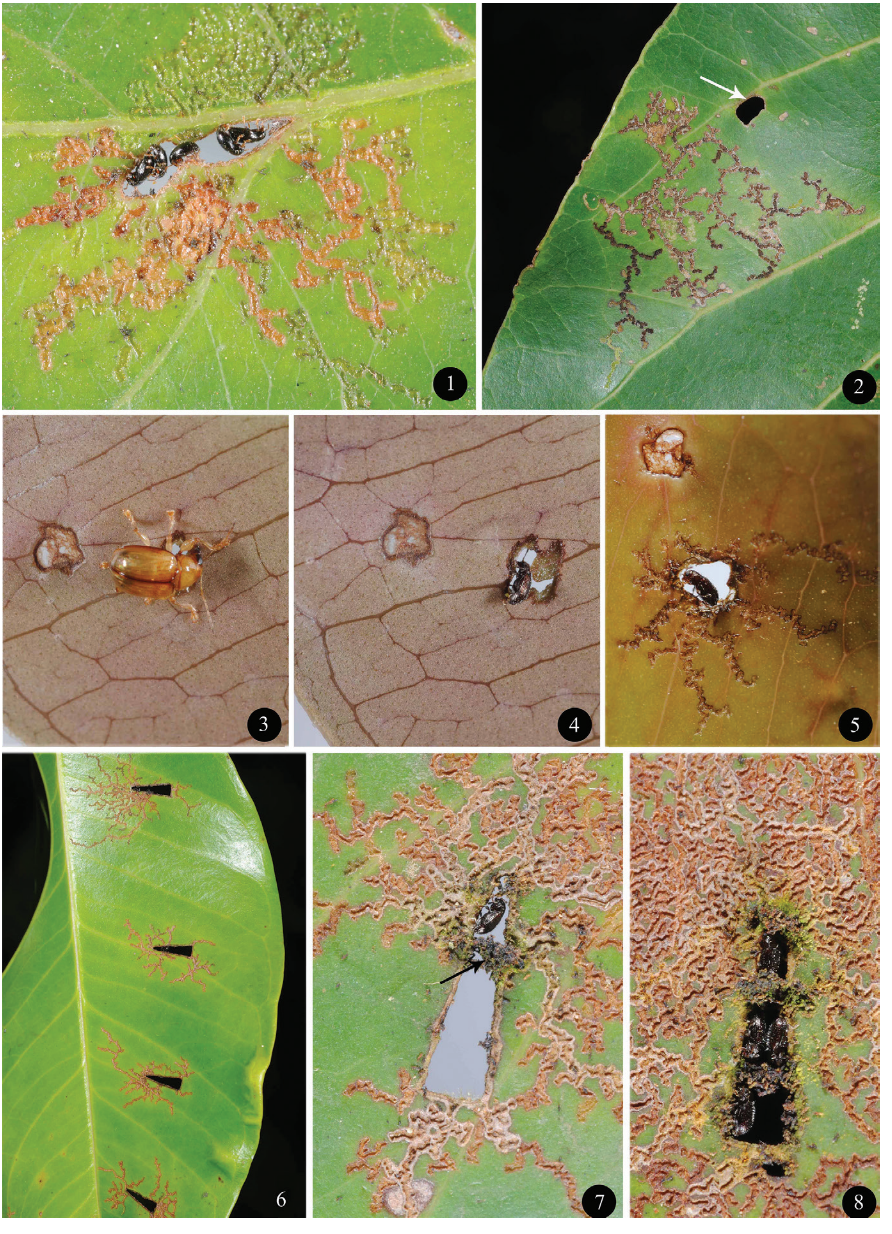
Animal architecture reflects the biology of its builder. Three broad categories of animal constructions have been recognized: homes, traps and displays (Hansell 2005; 2007). Homes or shelters protect their builders from external physical and possible biological hostilities. They provide protection by means of their architecture, effecting avoidance of detection and the prevention of invasion after detection has occurred (Hansell 2005).

In architecture birds, spiders, termites, ants, bees and wasps are prodigies. Beetles exhibit the most numerous radiation within the animalia, but there are very few architects amongst them. In leaf beetles (Chrysomelidae) (about 50, 000 species) larval defensive structures, built of faeces and exuvial skin, are known (Chaboo et al. 2007, Chaboo et al. 2008, Prathapan and Chaboo 2011). Larvae of several leaf beetles are known to use faeces for defense, and nearly 20% of the described chrysomelid species have a form of faecal covering or faeces-associated structure at some point in their lifecycle (Vencl et al. 1999; Weiss 2006).

Two genera in the Cassidinae, namely *Imatidium* Fabricius (Gilbert et al. 2001) and *Leptispa* Baly (Maulik 1919; Voronova and Zaitsev 1982; Prathapan et al. 2009), have the only leaf beetles known to build leaf shelters. Larvae of nearly all of about 4500 species of Camptosomata (Cryptocephalinae and Lamprosomatinae) build cases from their own faeces (Chaboo et al. 2008).

Builders invest considerable resources and time making constructions. Hence, natural selection favours building behaviour which reduces the cost of building, whilst maximizing the benefits it offers. Nesting in existing cavities produced by primary cavity nesters, as in woodpeckers, is a common method of cost reduction used by birds. Low cost shelters of *Leptispa pygmaea* Baly larvae are formed by feeding alone—no cutting, bending or secretion of silk or glue is required (Prathapan et al. 2009). A type of low cost shelter, named a leaf-hole shelter, is here reported for the first time for two species of *Orthaltica* Crotch, a genus of minute leaf beetles (Figs 1, 4–8).

The genus *Orthaltica* is distributed in the Afrotropical, Australian, Nearctic and Oriental Regions (Seeno and Wilcox 1982; Reid 1990) and contains 44 named species, of which the majority (32 species) are distributed in the Oriental Region. The taxonomy of *Orthaltica* is complex, currently including eight generic synonyms. *Crioceris copalina* (F.), the type species, occurs in the Nearctic Region. In India the genus is represented by at least ten species level taxa, of which only six have been formally named and described: *O. assamensis* (Scherer, 1971), *O. bengalensis* (Basu & Sengupta, 1978), *O. coomani* (Laboissiére, 1933 in Basu and Sengupta 1978), *O. dakshina* (Basu & Sengupta, 1978), *O. minuta indica* (Medvedev, 1998) and *O. purba* (Basu & Sengupta,



Figures 1–8. *Orthaltica* species and their low cost leaf-hole shelters. **1** Leaf-hole shelter of *Orthaltica terminalia* on *Terminalia paniculata*. Note the feeding trenches radiating from the leaf-hole shelter **2** Feeding trenches of non-shelter forming species on an unidentified plant from the Combretaceae. Note the unoccupied leaf-hole nearby **3** Eumolpine beetle (*Basilepta* sp.) feeding holes on the abaxial side of the leaf of *Syzygium caryophyllatum* **4** *Orthaltica syzygium* occupying the leaf-hole made by the eumolpine beetle in Fig. 3 **5** Leaf-hole shelter of *Orthaltica* in Fig. 3 as seen on the second day, viewed from adaxial side of leaf. Note the feeding trenches radiating from the leaf-hole **6** Triangular-shaped artificial leaf-holes on *Syzygium travancoricum* used as shelter by *Orthaltica syzygium* - note feeding trenches radiating from holes **7** Single occupancy - note the first partition **8** Multiple occupancy with multiple partitions.

1985). We here describe two species that utilise leaf-hole shelters. However, a revisionary study of the genus is necessary, at least in Asia, to clarify both species boundaries and the relationships between species groups currently placed in *Orthaltica*.

Material and methods

Five species of *Orthaltica* were collected from various localities in southern India, along with their host plants, forming part of our long term study of the leaf beetles of India. Species from this genus are known to feed on plants from the Combretaceae, Melastomataceae and Myrtaceae. Leaf-hole sheltering, described below, was observed in two species feeding on *Syzygium* (Myrtaceae) and *Terminalia* (Combretaceae) species respectively. The *Orthaltica* species feeding on *Syzygium* (Gaertn.) is here described as *Orthaltica syzygium* new species, and the species on *Terminalia* L. as *Orthaltica terminalia* new species. *Orthaltica syzygium* was collected from various localities in the states of Karnataka (Kottigehara, Kudremukha) and Kerala (Arippa, Kumarakom, Vattavada) on *Syzygium cumini* (L.) Skeels, *S. caryophyllatum* Alston and *S. travancoricum* Gamble. *Orthalitca terminalia* was also collected in the states of Karnataka (Kudremukha) and Kerala (Calicut University Campus, Kallar, Trichur), but on *Terminalia cuneata* Roth and *T. paniculata* Roth. The leaf-hole shelters on *T. paniculata* were initially formed by a *Tricliona* sp. (Eumolpinae). Natural populations of all the *Orthaltica* species were carefully observed in the field for feeding and shelter seeking behaviour. Leaf-hole shelters of *O. syzygium* were observed at the Kudremukha National Park on *S. caryophyllatum*, but were initially formed by a *Basilepta* sp. (Eumolpinae) (Fig. 3). Other leaf feeding beetles, but particularly Eumolpinae, were observed for their feeding activity on the hosts of *Orthaltica*. Artificial leaf holes were presented to the beetles on leaf laminae of *S. travancoricum*. Holes were made with a punch, generally used for making the card points on which small leaf beetles are mounted. The punch created elongate, triangular holes of 7 mm in length and a width of 2 mm at the base. About 60 leaves were provided to adults of *Orthaltica syzygium* on 20th April, 2013, each with six holes punched on the lamina. Occupation of the holes by these beetles was observed on 20th May, 2013 and 20th August, 2013 and could easily be determined by checking for the presence or absence of feeding trenches radiating from the hole (Fig. 6).

Descriptive terminology follows Konstantinov (1998). Holotypes of the new species are deposited in the National Museum of Natural History, Smithsonian Institution, Washington, DC, USA (USNM). Paratypes will be deposited in the National Pusa Collection, Indian Agricultural Research Institute, New Delhi, India (NPC); University of Agricultural Sciences, Bangalore, India (UASB); Natural History Museum, London, United Kingdom (BMNH); and in the personal collection of the first author (PKDC). Plant vouchers with accession numbers are deposited in the Calicut University Herbarium, Calicut, India. Different labels on specimens are denoted by numbers and separated by ";".

Results

Orthaltica syzygium **Prathapan & Konstantinov, sp. n.**
http://zoobank.org/B1CFE822-AA5E-498C-8000-F64A0A5791F2
http://species-id.net/wiki/Orthaltica_syzygium
Figs 4–15

Description. Body length 1.30–1.60 mm, width 0.67–0.81 mm. Body dark brown (Figs 9, 10). Basal antennomeres and tarsi paler and yellowish-brown. Vertex with 8 long and more than 10 short setae. Supracallinal sulci straight; orbital sulci short, poorly developed; and suprafrontal and suprantennal sulci poorly developed. Antennal calli narrow and elongate (Fig. 11), relatively widely connected, with two large setiferous pores. Frontal ridge parallel-sided, ending before reaching anterofrontal ridge. Anterofrontal ridge of uniform height, but sloping abruptly towards clypeus. Labrum as wide as distance between outer edges of antennal sockets. Setiferous pores on dorsal surface of labrum small, not possible to count. Antennomere 3 slightly shorter than 4 and 5 separately.

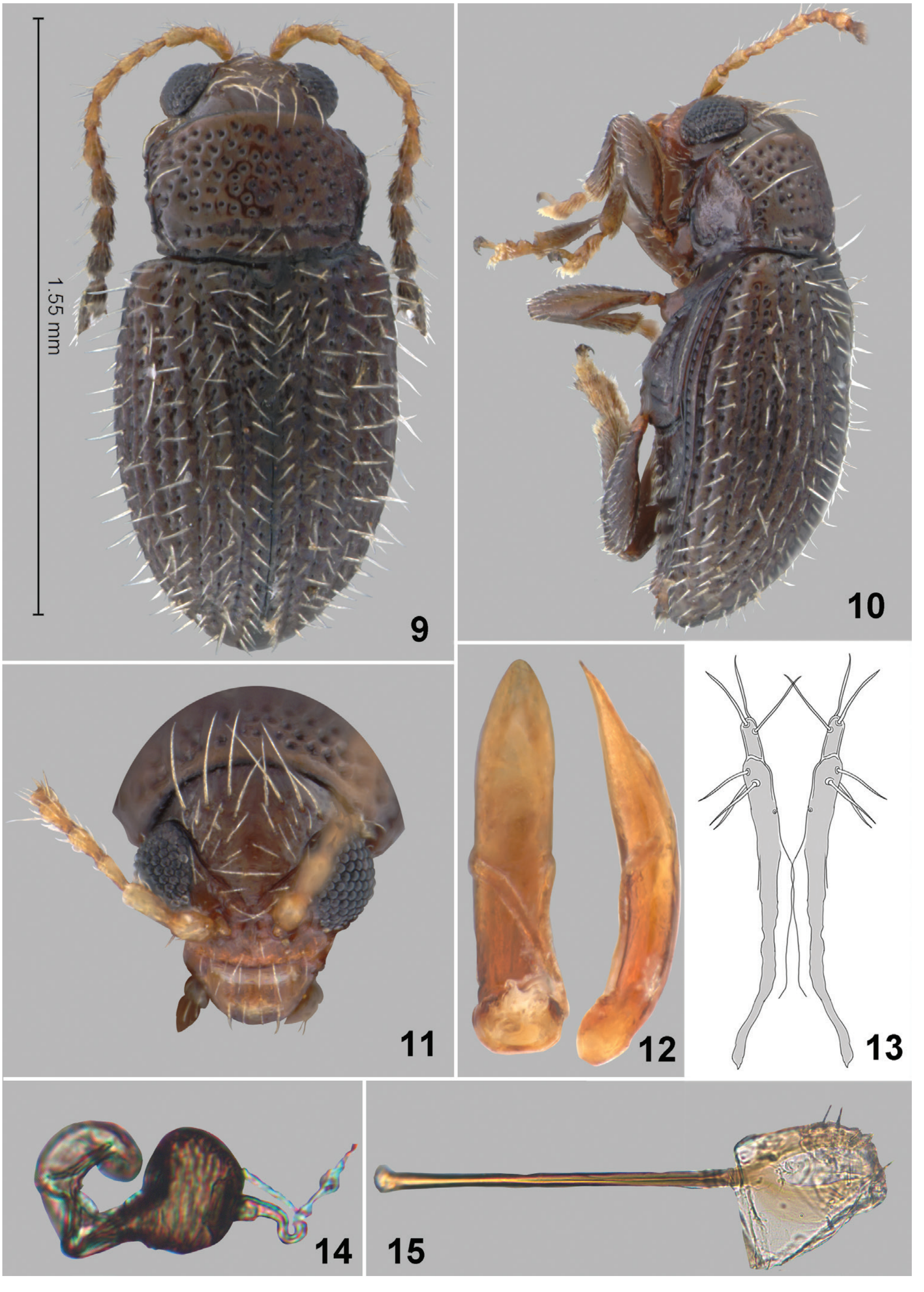
Pronotum widening towards apex and narrowing abruptly after reaching anterolateral callosity. Lateral margins slightly uneven with a prominent submedial denticle, and two long setae (Fig. 10). Antebasal transverse impression distinct (Fig. 9). Pronotal surface densely covered with large punctures, their diameter larger than the distance between punctures.

Elytra densely and evenly pubescent (Figs 9, 10), with erect setae on interstices. Elytral punctures arranged in striae located in relatively deep grooves. Humeral calli distinct. Pro- and middle tibiae lacking spurs. Claws appendiculate.

Apex of aedeagus narrowing gradually (Fig. 12), base above basal opening as wide as medial width, and apex slightly down-curved in lateral view.

Spermatheca with short thick pump (Fig. 14), distinctly separated from receptacle. Tignum straight, widening abruptly anteriorly (Fig. 15). Apical abdominal segment attached near middle of vaginal palpi (Fig. 13).

Type material. Holotype, male. 1) India: Kerala, Arippa, N8°50'11", E77°1'46", 30.xi.2011, 236m. D. Prathapan & K. Shameem Coll.; 2) H:396 *Syzygium travancoricum*; 3) *Orthaltica* sp. 1 KD Prathapan det 2012; 4) Holotype *Orthaltica syzygium* n. sp. Prathapan & Konstantinov 2012 (USNM). **Paratypes**: 13 specimens, the same labels as holotype; 8 specimens, the same labels as holotype except for the date 23.iii.2012. 29 specimens. 1) India Kerala, Kumarakom, 2.vii.2010 Prathapan Coll.; 2) 157 *Syzygium caryophyllatum;* 3) Paratype *Orthaltica syzygium* n. sp. Prathapan & Konstantinov 2012. 16 specimens. 1) India Karnataka, Kottigehara, N13°7'7.7", E75°30'37.9", 8.v.2011, 938m. D. Prathapan & K. Shameen Coll. 2) Host *Syzygium cumini* 3) Paratype *Orthaltica syzygium* n. sp. Prathapan & Konstantinov 2012. 19 specimens. 1) India Karnataka, Kudremukha N. P., N13°14'42", E75°6'44", 12.v.2011, 110m. D. Prathapan & K. Shameem Coll. *Syzygium caryophyllatum*; 2) Paratype *Orthaltica*



Figures 9–15. *Orthaltica syzygium* Prathapan & Konstantinov, sp. n. **9** Dorsal habitus **10** Lateral habitus **11** Head frontal view **12** Aedeagus, ventral and lateral view **13** Vaginal palpi **14** Spermatheca **15** Tignum.

syzygium n. sp. Prathapan & Konstantinov 2012 (5 – BMNH, 64 – NPC, 5 – PKDC, 5 – UASB, 9 – USNM).

Etymology. The specific epithet is a noun in apposition, based on the host plant name.

Host plants. *Syzygium cumini* (L.) Skeels (Accession no. 6516), *S. caryophyllatum* Alston (Accession no. 6626) and *S. travancoricum* Gamble (Accession no. 6693) (Myrtaceae).

Remarks. *Orthaltica syzygium* can easily be distinguished from all known Indian *Orthaltica* species using the key provided below. *Orthaltica terminalia* can be distinguished from the most similar species using the following characters: body dark brown (Fig. 9); vertex with eight long and more than 10 short setae (Fig. 11); elytra densely pubescent (Figs 9–10); apex of aedeagus narrowing gradually (Fig. 12); and spermatheca with short thick pump (Fig. 14).

Orthaltica terminalia Prathapan & Konstantinov, sp. n.

http://zoobank.org/040BDB2D-61C5-4E47-83DF-E15A898C06CC
http://species-id.net/wiki/Orthaltica_terminalia
Figs 1, 16–22

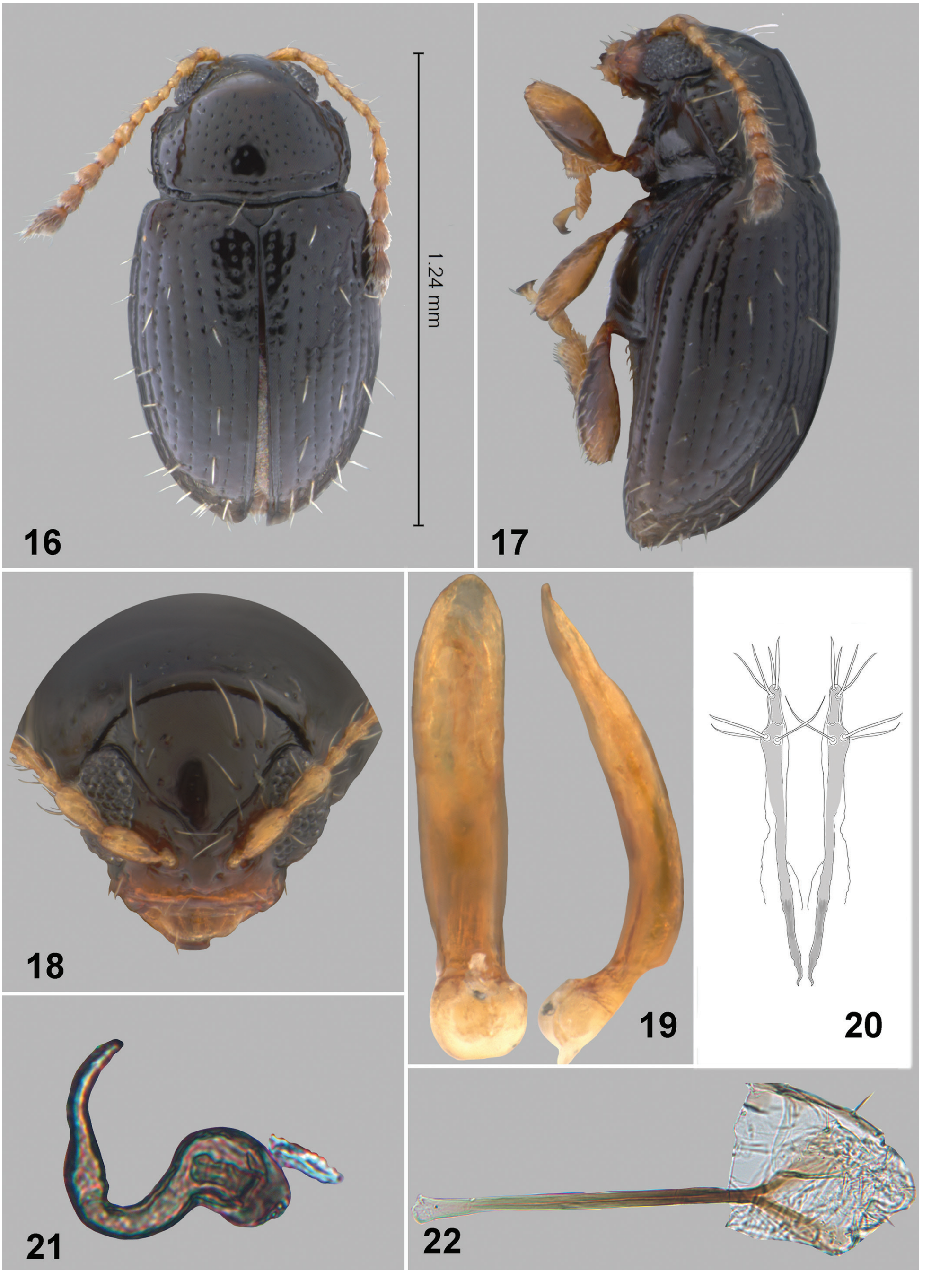
Description. Body length 1.20 – 1.50 mm, width 0.75 – 0.84 mm. Body shiny brownish-black (Figs 16, 17). Antennomeres (except most apical) and legs (except base of some femora) yellowish-brown. Vertex with 4 long and 6 short setae. Supracallinal sulci slightly curved; orbital sulci absent; suprafrontal sulcus poorly developed; and suprantennal sulcus shallow. Antennal calli narrow and elongate (Fig. 18), relatively widely connected, with two large setiferous pores. Frontal ridge parallel-sided, ending before reaching anterofrontal ridge. Anterofrontal ridge of uniform height, but sloping abruptly towards clypeus. Labrum as wide as distance between outer edges of antennal sockets. Setiferous pores on dorsal surface of labrum small, more than two, but not possible to count. Antennomere 3 slightly shorter than 4 and 5 separately.

Pronotum about as wide basally as apically, with sides evenly curved. Lateral margins slightly uneven and lacking a prominent denticle; bearing two long setae (Fig. 17). Antebasal transverse impression distinct (Fig. 16). Pronotal surface sparsely covered with slightly elongate punctures, their diameter smaller than distance between punctures.

Elytra sparsely pubescent (Figs 16, 17), with erect setae mainly near apices. Elytral punctures arranged in striae located in relatively deep grooves. Humeral calli distinct. Pro- and middle tibiae lacking spurs. Claws appendiculate.

Apex of aedeagus narrowing abruptly (Fig. 19), base above basal opening narrower than medial width, and apex slightly up-curved in lateral view.

Spermatheca with long thin pump (Fig. 21) which is not distinctly separated from receptacle. Tignum straight widening gradually anteriorly (Fig. 22). Apical abdominal segment attached to basal third of vaginal palpus (Fig. 20).



Figures 16–22. *Orthaltica terminalia* Prathapan & Konstantinov, sp. n. **16** Dorsal habitus **17** Lateral habitus **18** Head frontal view **19** Aedeagus, ventral and lateral view **20** Vaginal palpi **21** Spermatheca **22** Tignum.

Type material. Holotype, male. 1) India Karnataka, Kudremukha N. P., N13°14'42", E75°6'44", 12.v.2011, 110m. D. Prathapan & K. Shameem Coll. *Terminalia paniculata*; 2) Holotype *Orthaltica terminalia* n. sp. Prathapan & Konstantinov 2012 (USNM). **Paratypes**: 45 specimens, the same labels as holotype. 1 specimen 1) India Karnataka, Guddayanadoddi, N12°43.233', E077°33.576', 29.vii.2011 905m; 2) *Terminalia arjuna;* 3) *Orthaltica* sp. 2 K D Prathapan det. 2012; 4) Paratype *Orthaltica terminalia* n. sp. Prathapan & Konstantinov 2012. 12 specimens 1) India Kerala, Calicut Univ. Campus, 3.vii.2012, Shameem K. Coll. Ex *Terminalia paniculata;* 2) Paratype *Orthaltica terminalia* n. sp. Prathapan & Konstantinov 2012. 8 specimens 1) India Kerala, Trichur VellaniPacha, 27.x.2010, Prathapan K. D. Coll; 2) 230 *Terminalia arjuna;* 3) *Orthaltica* sp. 2 K D Prathapan det. 2012; 4) Paratype *Orthaltica terminalia* n. sp. Prathapan & Konstantinov 2012. 1 specimen 1) India Kerala, Aathirappilly, N10°18'44.7", E076°42'19.6", 26.x.2010, 570m; 3) *Orthaltica* sp. 2 K D Prathapan det. 2012;4) Paratype *Orthaltica terminalia* n. sp. Prathapan & Konstantinov 2012. 9 specimens 1) India Kerala, Kallar, 17.viii.2010, Prathapan Coll.; 2) *Terminalia paniculata;* 3) *Orthaltica* sp. 2 K D Prathapan det. 2012; 4) Paratype *Orthaltica terminalia* n. sp. Prathapan & Konstantinov 2012. (5 – BMNH, 53 – NPC, 5 – PKDC, 5 – UASB, 9 – USNM).

Etymology. The specific epithet is a noun in apposition, based on the host plant name.

Host plants. *Terminalia cuneata* Roth (Accession no. 6576) and *T. paniculata* Roth (Accession no. 6484) (Combretaceae).

Remarks. *Orthaltica terminalia* can be easily distinguished from all known Indian *Orthaltica* species using the key below. *Orthaltica syzygium* can be distinguished from the most similar species using the following characters: body shiny black (Fig. 16); vertex with four long and six short setae (Fig. 18); elytra sparsely pubescent (Figs 16 & 17); apex of aedeagus narrowing abruptly (Fig. 19); spermatheca with thin elongate pump (Fig. 21). *Orthaltica minuta indica* (Medevedev) is not included in the key as there is no character to separate it from *O. dakshina* (Basu & Sengupta). Both species are from the same locality (Doddabetta in Tamil Nadu) and further research may prove them to be synonymous.

Key to the Indian species of *Orthaltica*

1 Length 2.4 mm; vertex with a pair of long widely separated setae at posterior .... ***O. purba* Basu & Sengupta**

– Length 1.6 mm or less; vertex with a row of at least four long setae at posterior **2**

2(1) Elytral interstices, between the eighth and ninth row of punctures, sharply carinated; transverse antebasal impression on pronotum sinuate .... ***O. assamensis* (Scherer)**

– Elytral interstices, between eighth and ninth row of punctures, not carinate; transverse antebasal impression on pronotum straight................................ **3**

3(2) Anterofrontal ridge low, merging gradually with clypeus ....***O. bengalensis* (Basu & Sengupta)**
– Anterofrontal ridge high; sloping abruptly towards clypeus **4**
4(3) General body colour reddish-brown.......... ***O. dakshina* (Basu & Sengupta)**
– General body colour dark brown to black..**5**
5(4) Frontal ridge merging gradually with anterofrontal ridge, together forming a triangular ridge .... ***O. coomani* (Laboissiere)**
– Anterofrontal ridge evenly raised and transverse, abruptly joining frontal ridge to form an inverted T-shaped ridge...**6**
6(5) Body shiny brownish-black (Fig. 16). Vertex with 4 long and 6 short setae (Fig. 18). Elytra sparsely pubescent (Fig. 16 & 17). Apex of aedeagus narrowing abruptly (Fig. 19). Spermatheca with thin elongate pump (Fig. 21)..***O. terminalia* sp. n.**
– Body dark brown (Fig. 9). Vertex with 8 long and more than 10 short setae (Fig. 11). Elytra densely pubescent (Fig. 9 & 10). Apex of aedeagus narrowing gradually (Fig. 12). Spermatheca with short thick pump (Fig. 14) .... ***O. syzygium* sp. n.**

Discussion

Besides *Orthaltica*, species of *Terminalia* and *Syzygium* also support other leaf feeding beetles belonging to the family Chrysomelidae, as well as to the family Curculionidae. These beetles, being much larger (length 2.2 – 4.5 mm) than *Orthaltica* (length 1.2 – 1.6 mm), feed by cutting holes in the laminae. The adults of *Orthaltica* are extremely small and incapable of cutting holes in the laminae, but rather produce elongate feeding trenches on their adaxial surface. Adults of *O. syzygium* and *O. terminalia* utilise holes previously made by larger herbivores, in the leaves of their respective hosts, as shelter. They then create feeding trenches which radiate from the leaf hole which is their shelter (Fig. 1). Beetles could be seen inside holes during most of the day when they were not feeding. They came out of their leaf-hole shelters to feed, forming irregular trenches radiating from the hole. When threatened by means of a finger or a stick, beetles in holes immediately shifted their position to the reverse side of laminae, thus making themselves invisible to the enemy on the opposite side. It was observed that whenever an ant appeared on one side of the lamina, the occupant of a leaf-hole shelter also shifted its position to the reverse side.

Leaf beetles of the subfamily Eumolpinae are the most common primary hole makers on *Syzygium* and *Terminalia* species. At Kudremukha National Park it was observed that a *Basilepta* sp. (Eumolpinae) leaf beetle chewed holes in the laminae of *Syzygium caryophyllatum* (Fig. 3). *Orthaltica syzygium* released on the leaf readily occupied the leaf-hole as a shelter (Fig. 4). By the second day feeding trenches were observed radiating from the leaf-hole shelter (Fig. 5).

The triangular artificial holes, made in the laminae of *S. travancoricum* with a punch, were accepted as shelters (Fig. 6). It was observed that the shape and size of the holes were not exactly what the beetles required. Holes were then resized by partitioning—walls were constructed using faecal pellets (Fig. 7). A single occupant was observed in a hole in most cases. However, when high population densities occurred, several beetles could be seen in a single hole that was large enough to accommodate them (Figs 1, 8).

In the case of the triangular artificial leaf-holes, beetles had a distinct preference for the narrow vertex of the triangle, above its wider base (Fig. 7). This may be because their size allowed them to easily fit inside the narrow apical angle. On 20^{th} May it was found that, of the 316 triangular holes examined on 53 leaves after a month, 235 were occupied. Similarly on 20th August, after a period of four months, of the 319 triangular holes on 58 leaves, 240 were occupied.

Even when suitable leaf-holes were available on leaf laminae, non-shelter forming species never occupied such holes (Fig. 2). *Orthaltica syzygium* confined on leaves without holes fed normally on the adaxial surface of the laminae.

Leaf-hole shelters provide a roosting site that offers a certain degree of camouflage as well as protection. In the field it was observed that on sensing the presence of an enemy on one side of the leaf the occupant of a leaf-hole shelter could easily shift to the other side, making itself invisible to the intruder. It may also be presumed that larger predators cannot pass through the hole in pursuit of the occupant. The leaf-hole, as well as the surrounding area with feeding trenches, turn dark brown and provide a dark background from which the beetle cannot be easily differentiated by a potential predator. On the other hand, the leaf-hole shelter can also provide sufficient cues for a specialist enemy that only needs to learn to locate the leaf-hole shelter to get the inmate. This is the case where insect collectors are concerned—it is easy for them to locate leaf-hole shelter and collect the beetles utilising them.

Leaf-hole shelters were observed in two of the five *Orthaltica* species found in southern India. This is certainly a behavioural novelty of evolutionary significance. It can be seen as an example of Lorenz's (1937) discovery that a behaviour pattern can be treated as an anatomical organ, which Dawkins (1982) further synthesized and developed into the hypothesis of "the extended phenotype". It is likely that this extracorporeal adaptation evolved in two lineages of *Orthaltica* in response to interactions with other leaf feeding beetles. Further investigation into the prevalence and diversity of herbivorous beetles on the host plants of *Orthaltica,* and their interactions with each other, might provide the answer.

Adult chrysomelids, unlike their larvae, never carry their faeces in the form of defensive shields. However, females of many species are known to defecate on their eggs after oviposition. Adults are also known to defecate when seized (Müller and Hilker 2004). The use of excreta for the construction of defensive structures or retreats was, until now, not known for adult leaf beetles.

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Franco Mason[1,2]

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Abstract

An updated checklist for Stratiomyidae of Italy is presented. Previous knowledge and information are put together in a comprehensive way, integrated also with results obtained by sampling with Malaise traps in some of the test areas of the LIFE+ project ManFor C.BD.

At the time of writing, with 91 known species, the Italian fauna of Stratiomyidae is the richest in Europe. *Neopachygaster meromelas* (Dufour, 1841) and *Zabrachia minutissima* (Zetterstedt, 1838) are new to the Italian fauna. A comprehensive key to the European species of *Chorisops* Rondani 1856 is given.

Keywords

Italy, identification keys, faunistic, checklist, forest, Life Project

Introduction

In the recent decades, stimulated by the monograph of Rozkošný (1982, 1983), faunistic research on Stratiomyidae has received a remarkable stimulus throughout Europe. In Italy the latest studies are reported in the following contributions: Adamo (2008), Mason (1988a), Mason (1988b), Mason (1989), Biondi et al. (1991), Troiano (1995), Troiano and Toscano (1995), Mason and Rozkošný (2003), Mason (2003), Mason (2004), Mason (2005), Mason et al. (2006), Mason and Rozkošný (2008), Whitmore et al. (2008), Stuke (2008) and Mason et al. (2009). The faunistic data collected in this paper (see Appendix) are preliminary to the biodiversity studies in the framework of the project LIFE09 ENV/IT/000078 ManFor C.BD., "Managing forests for multiple purposes: carbon, biodiversity and socio–economic wellbeing" and were partly integrated by sampling with Malaise traps in some of the project test areas. The Italian species are listed in Table 1, according to the criteria of the "Checklist of the Italian Fauna" (Minelli et al. 1995; Mason and Krivosheina 1995). The identifications were made using Rozkošný (1982, 1983), Troiano (1995), Troiano and Toscano (1995) and Krivosheina and Rozkošný (1990). The nomenclature and the list of the species known to Italy follows "Fauna Europaea" (Rozkošný 2012). Abbreviations of the collections: FMCV (Franco Mason, Verona, Italy); MCSNG (Museo Civico di Storia Naturale, Genova, Italy) CNBFVR (Centro Nazionale Biodiversità Forestale "Bosco Fontana" Verona, Italy).

Short notes on the species new to the Italian fauna

Neopachygaster meromelas (Dufour, 1841)

The larva of *Neopachygaster meromelas* has been described in detail by Rozkošný (1983) and by Stubbs and Drake (2001). The material examined was collected in Latium, Roma at "Tenuta della Cervelletta" 41°54'41.55"N, 12°34'57.15"E. Nine larvae were collected on 7.ii.2005 under decaying bark of a trunk of *Populus* sp. partially submerged in water; 3 ♂♂ and 6 ♀♀ emerged from reared larvae on v–vi/2005, M. Mei leg. (FMCV). *Neopachygaster meromelas* is a European species, known from Fennoscandia to the Pyrenees and North Caucasus (Rozkošný 1983), and has been recorded from the following countries: Belarus, Belgium, British Islands, Corsica, Czech Republic, Finland, France (mainland), Germany, Hungary, Poland, Russia (North and Northwest), Slovakia, Spain (mainland), Sweden (Rozkošný 2012) and Italy (this paper). In Italy *Neopachygaster meromelas* is known only in central Italy at "Tenuta della Cervelletta", a small natural area (about 44 ha) located in the Northeast suburbs of Rome which is a relict wetland (Mason and Mei 2002). This site represents the southernmost European record of the species (cf. Rozkošný 1983).

Zabrachia minutissima (Zetterstedt, 1838)

Venetia Region: Rovigo province, Porto Caleri, loc. Bosco Giardino, 45°05'N, 12°19'E, 12.viii–8.ix.2004, Malaise Trap, 2 ♀♀, D. Sommaggio leg. (FMCV); Emilia–Romagna, Ferrara province, Isola Bianca, LIPU Oasi, Retro Duna, 44°53'N, 11°38'E, 4.vii–1.viii.2004, Malaise Trap, 1 ♀, D. Sommaggio leg. (FMCV); Rovigo province, Porto Caleri, Bosco intermedio, 45°06'N, 12°19'E, 8.ix–1.x.2004, Malaise Trap, 1 ♀, D. Sommaggio leg. (FMCV); same data, but 20.vii–12.vii.2004, 1 ♀, (FMCV). Regione Veneto, Belluno province, Cellarda, Vincheto di Cellarda [State

Table 1. Updated Italian checklist of Stratiomyidae. Abbreviations: Italian administrative regions (cf. Minelli et al. 1995). N = Northern Italy: Em = Emilia-Romagna, FVG = Friuli-Venezia Giulia, Li = Liguria, Lo = Lombardy, Pi = Piedmont, TAA = Trentino-Alto Adige, V = Venetia, VA = Val d'Aosta. S = Peninisular Italy: Abr = Abruzzo, Ba = Basilicata, Ca = Calabria, Cp = Campania, La = Latium, Ma = Marches, Mo = Molise, Pu = Apulia, To = Tuscany, Um = Umbria. Si = Sicily and small circum-Sicilian islands, Sa = Sardinia and small circum-Sardinian islands.

Taxa		N								S										Sa	Si
		Em	FVG	Li	Lo	Pi	TAA	VA	V	Abr	Ba	Ca	Cp	La	Ma	Mo	Pu	To	Um	Sa	Si
1.	*Actina chalybea* Meigen, 1804		•			•	•		•	•	•										
2.	*Adoxomyia dahlii* (Meigen, 1830)			•		•								•			•				•
3.	*Adoxomyia lindneri* Dušek & Rozkošný,1963			•										•							
4.	*Alliocera graeca* Saunders, 1845		•																		
5.	*Beris chalybata* (Forster, 1771)	•					•		•	•								•			
6.	*Beris clavipes* (Linnaeus, 1767)	•				•	•		•							•					
7.	*Beris fuscipes* Meigen, 1820					•				•											
8.	*Beris geniculata* Curtis, 1830					•	•			•											
9.	*Beris morrisii* Dale, 1841	•		•		•	•		•	•								•			
10.	*Beris strobli* Dušek & Rozkošný, 1968						•				•										
11.	*Beris vallata* (Forster, 1771)					•	•			•				•							
12.	*Chloromyia formosa* (Scopoli, 1763)	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•
13.	*Chloromyia speciosa* (Macquart, 1834)		•			•	•			•	•			•							
14.	*Chorisops caroli* Troiano, 1995			•								•		•				•		•	
15.	*Chorisops masoni* Troiano & Toscano, 1995			•	•									•						•	•
16.	*Chorisops nagatomii* Rozkošný, 1979	•			•	•				•		•		•				•			
17.	*Chorisops tibialis* (Meigen, 1820)				•		•		•					•	•						
18.	*Chorisops tunisiae* (Becker, 1915)																			•	
19.	*Clitellaria ephippium* (Fabricius, 1775)	•	•		•	•	•	•	•	•				•	•			•	•		
20.	*Eupachygaster tarsalis* (Zetterstedt, 1842)	•				•			•					•				•			•
21.	*Hermetia illucens* (Linnaeus, 1758)			•	•	•			•		•	•		•			•	•		•	
22.	*Lasiopa calva* (Meigen, 1822)																				•
23.	*Lasiopa krkensis* Lindner, 1938		•																		

Taxa		N								S										Sa	Si
		Em	FVG	Li	Lo	Pi	TAA	VA	V	Abr	Ba	Ca	Cp	La	Ma	Mo	Pu	To	Um	Sa	Si
24.	*Lasiopa pseudovillosa* Rozkošný, 1983	•								•	•	•		•	•		•	•		•	•
25.	*Lasiopa tsacasi* Dušek & Rozkošný, 1970					•				•	•			•							
26.	*Lasiopa villosa* (Fabricius, 1794)	•	•	•		•				•				•			•				•
27.	*Microchrysa flavicornis* (Meigen, 1822)					•	•							•				•			
28.	*Microchrysa polita* (Linnaeus, 1822)					•	•		•					•				•		•	
29.	*Nemotelus* (*Camptopelta*) *nigrinus* Fallén, 1817																				
30.	*Nemotelus* (*Nemotelus*) *anchora* Loew, 1846	•																		•	
31.	*Nemotelus* (*Nemotelus*) *argentifer* Loew, 1846										•						•				
32.	*Nemotelus* (*Nemotelus*) *crenatus* Egger, 1859	•							•												
33.	*Nemotelus* (*Nemotelus*) *cylindricornis* Rozkošný, 1977																				•
34.	*Nemotelus* (*Nemotelus*) *lasiops* Loew, 1846																			•	•
35.	*Nemotelus* (*Nemotelus*) *latiusculus* Loew, 1871	•							•						•			•	•		
36.	*Nemotelus* (*Nemotelus*) *longirostris* Wiedemann, 1824																				•
37.	*Nemotelus* (*Nemotelus*) *maculiventris* Bigot, 1861																				•
38.	*Nemotelus* (*Nemotelus*) *nigrifrons* Loew, 1846																			•	•
39.	*Nemotelus* (*Nemotelus*) *niloticus* Olivier, 1811																			•	
40.	*Nemotelus* (*Nemotelus*) *notatus* Zetterstedt, 1842	•							•					•			•			•	
41.	*Nemotelus* (*Nemotelus*) *pantherinus* (Linnaeus, 1758)	•	•	•		•	•			•		•		•			•	•		•	
42.	*Nemotelus* (*Nemotelus*) *proboscideus* Loew, 1846																				•
43.	*Neopachygaster meromelas* (Dufour, 1841)													•							
44.	*Odontomyia angulata* (Panzer, 1798)	•	•		•	•			•				•	•			•	•		•	•
45.	*Odontomyia annulata* (Meigen, 1822)	•	•							•			•	•	•					•	
46.	*Odontomyia argentata* (Fabricius, 1794)						•														
47.	*Odontomyia cephalonica* Strobl, 1898																				•
48.	*Odontomyia discolor* Loew, 1846													•				•		•	•
49.	*Odontomyia flavissima* (Rossi, 1790)	•										•		•	•				•		•
50.	*Odontomyia hydroleon* (Linnaeus, 1758)	•	•		•	•	•	•	•	•				•				•			

Taxa		N								S										Sa	Si
		Em	FVG	Li	Lo	Pi	TAA	VA	V	Abr	Ba	Ca	Cp	La	Ma	Mo	Pu	To	Um	Sa	Si
51.	*Odontomyia ornata* (Meigen, 1822)	•			•	•			•					•				•		•	•
52.	*Odontomyia tigrina* (Fabricius, 1775)	•		•	•				•												
53.	*Oplodontha viridula* (Fabricius, 1775)	•	•		•	•	•	•	•	•				•			•	•		•	
54.	*Oxycera analis* Wiedemann *in* Meigen, 1822					•			•	•									•		
55.	*Oxycera fallenii* Stæger, 1844																				
56.	*Oxycera germanica* (Szilády, 1932)			•			•											•			
57.	*Oxycera leonina* (Panzer, 1798)		•	•	•	•	•		•									•			
58.	*Oxycera locuples* Loew, 1857				•	•	•	•										•			
59.	*Oxycera marginata* Loew, 1859											•		•							•
60.	*Oxycera meigenii* Stæger, 1844	•		•		•	•			•											
61.	*Oxycera morrisii* Curtis, 1833		•				•							•							•
62.	*Oxycera muscaria* (Fabricius, 1794)						•														
63.	*Oxycera nigricornis* Olivier, 1812	•			•	•	•		•	•				•			•			•	
64.	*Oxycera pardalina* Meigen, 1822	•		•		•	•	•	•					•				•			
65.	*Oxycera pseudoamoena* Dušek & Rozkošný, 1974			•			•														
66.	*Oxycera pygmaea* (Fallén, 1817)				•	•						•									
67.	*Oxycera rara* (Scopoli, 1763)	•		•		•	•											•		•	
68.	*Oxycera terminata* Meigen, 1822	•		•					•												
69.	*Oxycera trilineata* (Linnaeus, 1767)																			•	
70.	*Oxycera varipes* Loew in Heyden, 1870			•			•	•													
71.	*Pachygaster atra* (Panzer, 1798)	•	•	•	•	•	•		•	•				•	•			•	•		•
72.	*Pachygaster leachii* Curtis, 1824			•	•				•	•				•				•		•	
73.	*Sargus albibarbus* Loew, 1855			•					•			•		•							
74.	*Sargus bipunctatus* (Scopoli, 1763)	•	•	•	•	•			•	•				•						•	•
75.	*Sargus cuprarius* (Linnaeus, 1758)	•		•	•		•			•				•							•
76.	*Sargus flavipes* Meigen, 1822	•		•	•	•	•		•	•		•		•				•			
77.	*Sargus harderseni* Mason & Rozkošný, 2008				•				•												

Taxa	N								S										Sa	Si
	Em	FVG	Li	Lo	Pi	TAA	VA	V	Abr	Ba	Ca	Cp	La	Ma	Mo	Pu	To	Um	Sa	Si
78. *Sargus iridatus* (Scopoli, 1763)	•		•	•	•	•	•		•			•	•	•		•				•
79. *Sargus rufipes* Wahlberg, 1854					•	•					•									
80. *Stratiomys cenisia* Meigen, 1822	•		•	•	•		•		•			•	•	•		•				•
81. *Stratiomys chamaeleon* (Linnaeus, 1758)			•	•	•	•	•		•				•						•	
82. *Stratiomys concinna* Meigen, 1822					•	•							•							
83. *Stratiomys equestris* Meigen, 1835						•			•											
84. *Stratiomys hispanica* (Pleske, 1901)																				•
85. *Stratiomys longicornis* (Scopoli, 1763)	•	•							•		•	•	•						•	•
86. *Stratiomys potamida* Meigen, 1822	•	•	•	•		•		•	•				•							
87. *Stratiomys rubricornis* (Bezzi, 1896)	•								•	•				•						
88. *Stratiomys singularior* (Harris, 1776)	•	•	•					•								•				•
89. *Vanoyia tenuicornis* (Macquart, 1834)													•							
90. *Zabrachia minutissima* (Zetterstedt, 1838)	•					•		•												
91. *Zabrachia tenella* (Jaennicke, 1866)						•													•	
Total	**37**	**19**	**29**	**25**	**38**	**39**	**10**	**32**	**32**	**9**	**14**	**6**	**44**	**10**	**2**	**14**	**26**	**6**	**26**	**28**

Nature Reserve], 230 m, UTM Latitude: 46°0'43"N, 11°58'32"E, 1–15.viii.2007, Window Trap T5 (cf. Audisio et al. 2008), G. Gatti & M. Dal Cortivo leg. (FMCV).

Distribution. *Zabrachia minutissima* is a Eurasian species (Rozkošný 1983): Czech Republic, Denmark (mainland), Finland, France (mainland), Germany, Greece (mainland), Hungary, Norway (mainland), Poland, Russia, Spain (mainland), Sweden, Switzerland, Ukraine, East Palaeartic and Near East (Rozkošný 2012).

Other records new to the regions

Hermetia illucens is new to Calabria (Reggio Calabria, Pellaro, 19.ix.2011, photo by Francesco D'Aleo (2012)). *Stratiomys cenisia* is new to Sicily (Trapani 20.v.2009), and *Clitellaria ephippium* is new to Marche (12.vii.2010, photo by Marco Paglialunga). All these data were posted in the "Forum Entomologi italiani" [Forum of Italian Entomologists] www.entomologiitaliani.net/forum (last accessed 16 April 2012).

Notes and key to European species of *Chorisops* Rondani 1856: 173

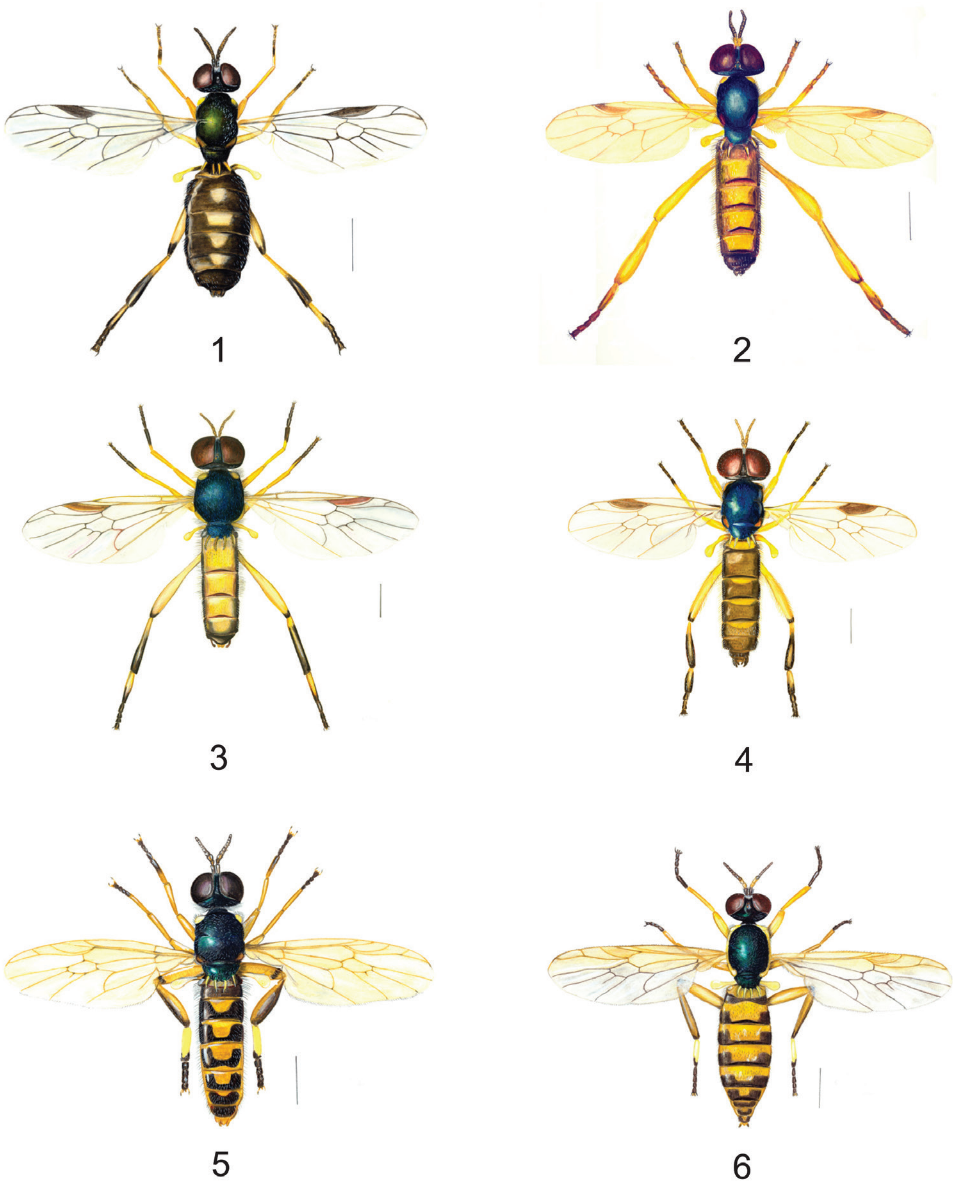
The nomenclatorial history of the name *Chorisops* Rondani has been recently clarified by O'Hara et al. (2011).

In Europe, at the present time, five species of *Chorisops* are known: *C. caroli* Troiano, 1995, *C. masoni* Troiano & Toscano, 1995, *C. nagatomii* Rozkošný, 1979, *C. tibialis* (Meigen, 1820) and *C. tunisiae* (Becker, 1915). Two of these, *C. caroli* and *C. masoni*, are probably endemic to Italy (Troiano 1995; Mason et al. 2006; Mason et al. 2009) (Figs 2–6).

As in other Beridinae (Woodley 2001) three subspherical spermathecae are present in the females of *Chorisops* (Figs 7, 8). The sensory pits on the external side of the first flagellomere, are up to four different types: finger-like (A), sunken finger-like in a pit (B), subconical (C) and stick-like inside a pit (D) (cf. Figs 9, 10). The males of *C. nagatomii* (cf. also Stubbs and Drake 2001), were observed in a swarm over a shrub in a grassland and on flowers of *Hedera helix* L., in a floodplain forest (D. Birtele, pers. comm. 2012). In Italy, the peak of the flight period of *C. nagatomii* and *C. masoni* is generally between the second half of August and the first half of September (cf. Mason 2004), about one month later than the flight period of *C. tibialis.* A new record is here reported for Piedmont for *C. nagatomii*: 1 ♂ Alessandria province, Piovera, 44°57'43"N, 8°44'5"E, x.1933, G. C. Doria (in MCSNG).

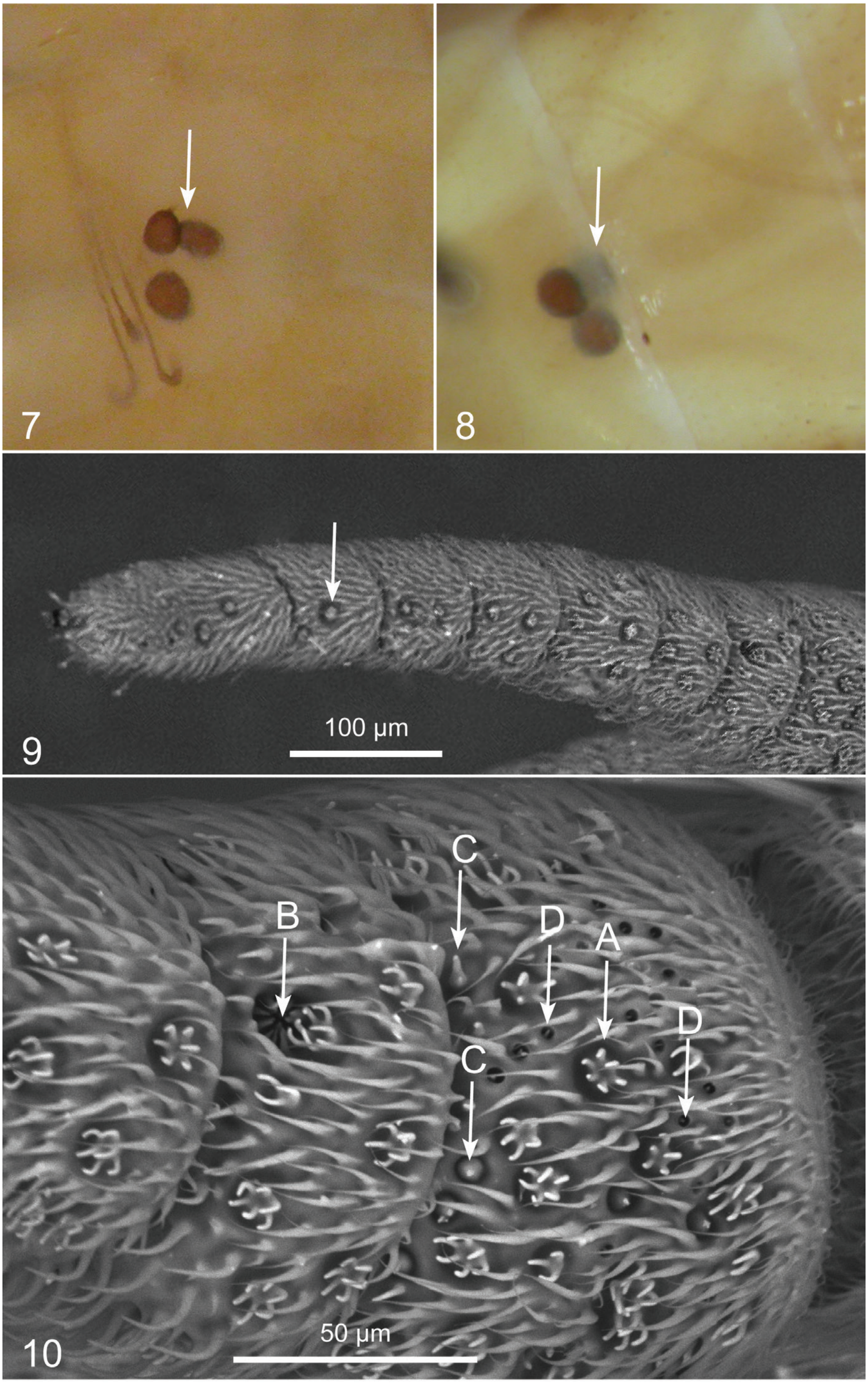
Key to the European species of *Chorisops*

Despite the availability of a relatively large amount of newly collected material of *Chorisops*, I have not been able to find any reliable external character of diagnostic

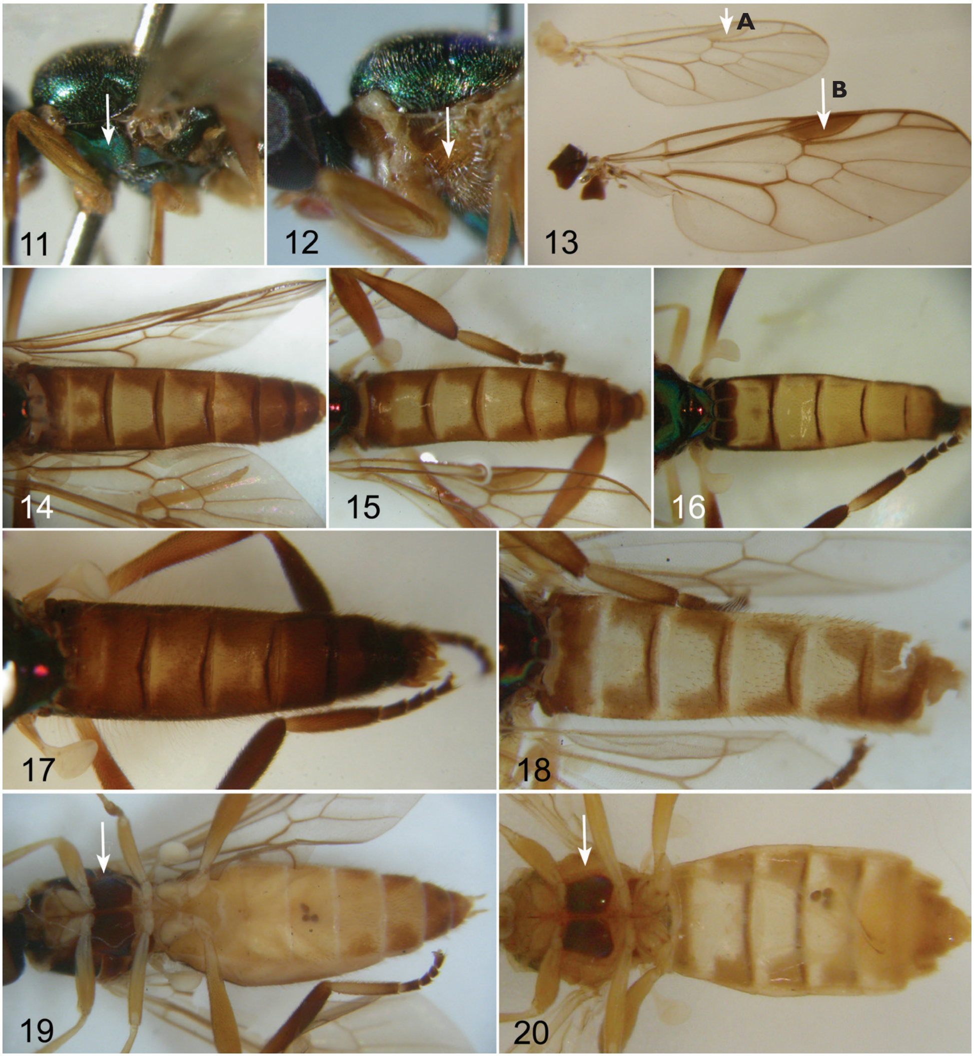


Figures 1–6. *Chorisops,* habitus: **1** *C. caroli* Troiano, 1995 ♂ **2** *C. masoni* Troiano & Toscano, 1995 ♂ **3** *C. nagatomii* Rozkošný, 1979 ♂ **4** *C. tibialis* (Meigen, 1820) ♂ **5** *Chorisops tunisiae* (Becker, 1915) ♂ **6** *Chorisops tunisiae* ♀, (drawns by Mason F). Scale bar = 1 mm.

value, except for the different colouring of the anepisternum and postpronotal callus (cf. Figs 11 and 12) and in the relative darkening of the wing pterostigma (Figs 13A, 13B). A reliable identification is possible only by examining the genitalia of both sexes.



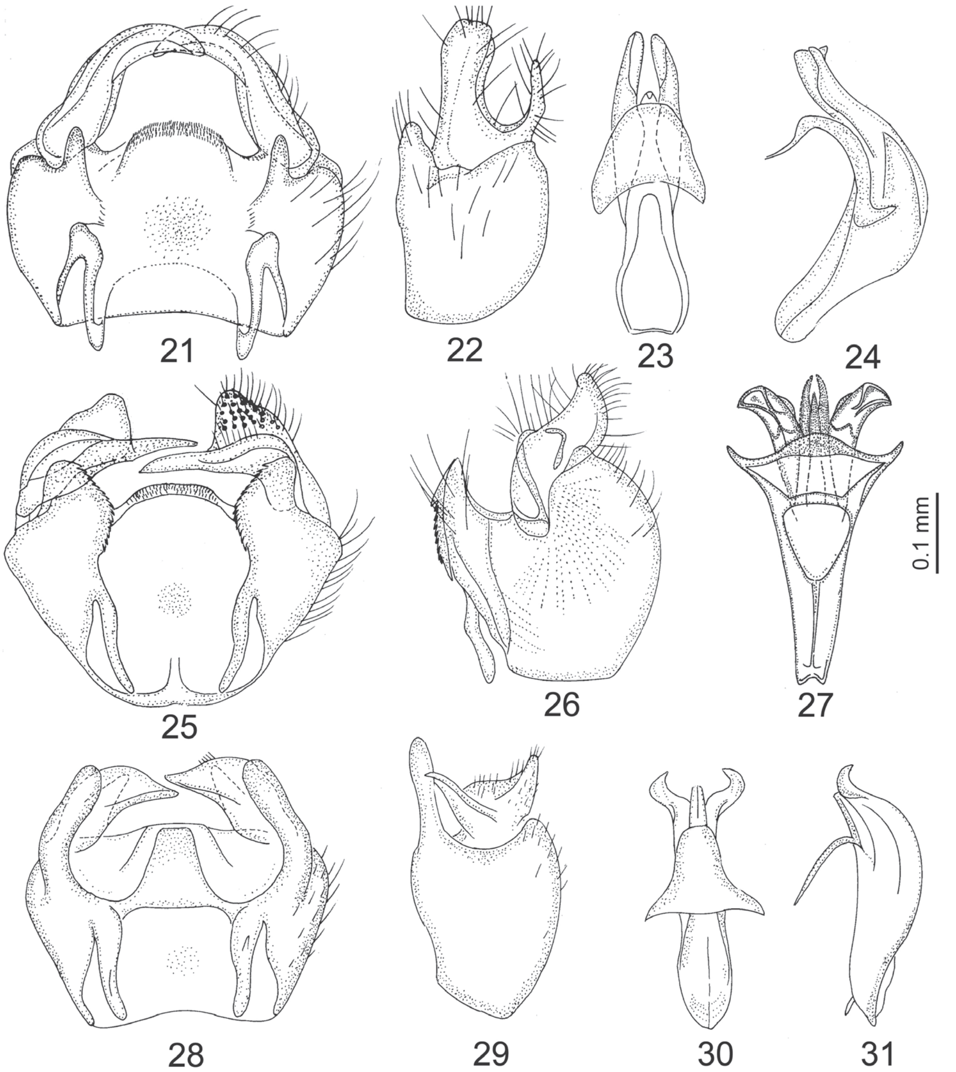
Figures 7–10. 7 Spermathecae of *Chorisops tunisiae* (Becker) **8** Spermathecae of *Chorisops tibialis* (Meigen) **9** Antenna of *Chorisops tunisia*e (Becker) **10** External side of the first (basal) flagellomere of *Chorisops tunisiae* (Becker). Antennal sensilla: **A** finger-like **B** sunken finger-like **C** subconical **D** stick-like.



Figures 11–20. 11 Thorax in lateral view of *Chorisops nagatomii* Rozkošný **12** Thorax in lateral view of *Chorisops tunisiae* (Becker) **13** Wing pterostigma: **A** *Chorisops tunisiae* (Becker) **B** *C. tibialis* (Meigen) **14–18** Male abdomen (dorsal view) of: **14** *C. caroli* Troiano **15** *C. masoni* Troiano & Toscano **16** *C. nagatomii* Rozkošný **17** *C. tibialis* (Meigen) **18** *C. tunisiae* (Becker) **19–20** Male abdomen (ventral view) of: **19** *C. tibialis* (Meigen) **20** *C. tunisiae* (Becker).

Key to males

1	Pterostigma light yellow (Fig. 13A)	***C. tunisiae* (Becker)**
–	Pterostigma usually darker (Fig. 13B)	**2**
2	Abdominal tergites mainly brown (Figs 5, 17)	***C. tibialis* (Meigen)**
–	Tergites with more extensive yellow pattern (Figs 2, 3, 4, 6)	**3**



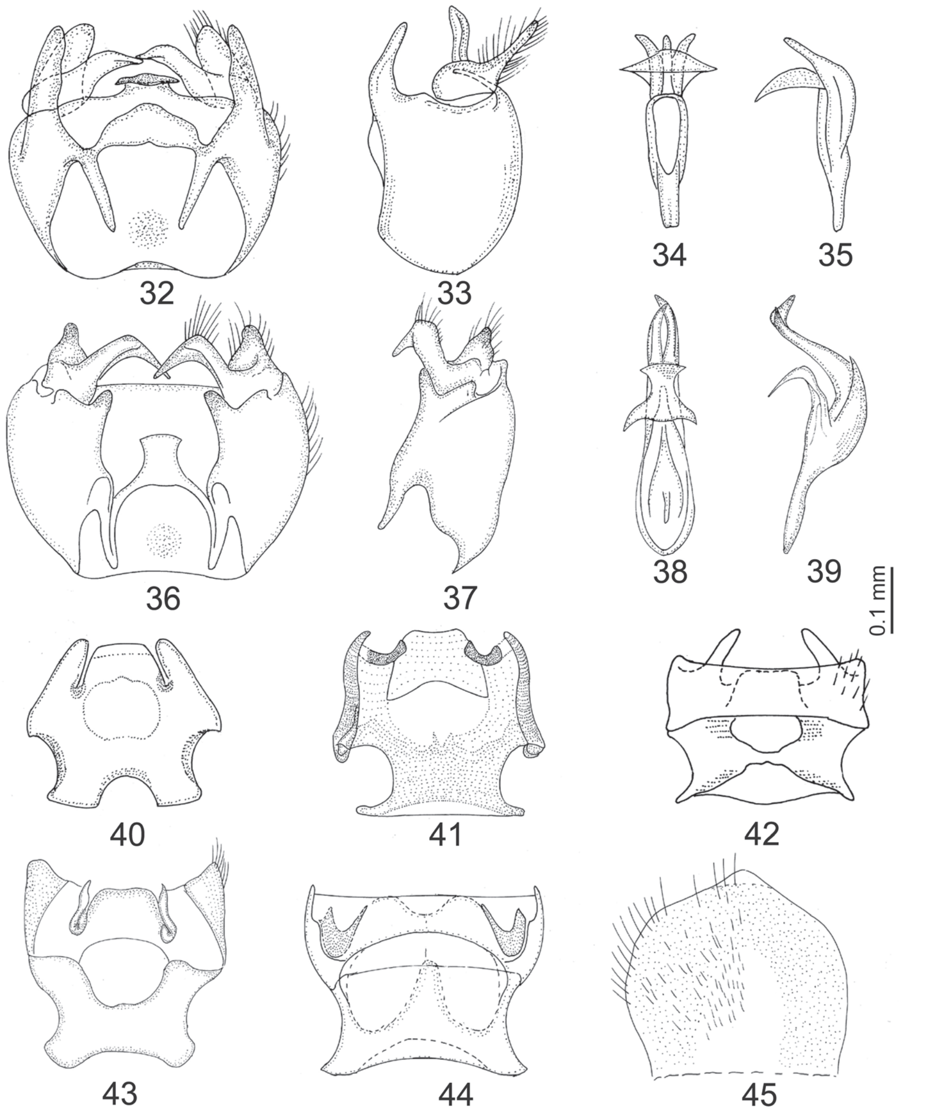
Figures 21–31. *Chorisops caroli*: **21** Genital capsule **22** Genital capsule (lateral view) **23** Aedeagal complex **24** Aedeagal complex (lateral view) **25–27** *C. masoni*: **25** Genital capsule **26** Genital capsule (lateral view) **27** Aedeagal complex (ventral view) **28–31** *C. nagatomii*: **28** Genital capsule **29** Genital capsule (lateral view) **30** Aedeagal complex (ventral view) **31** Aedeagal complex (lateral view); (redrawn from Rozkošný (1982) Troiano (1995) and Troiano and Toscano (1995).

3 Tergites with only a narrow brown preapical grooves (Figs 4, 16); genitalia as in Figs 32–35...***C. nagatomii* Rozkošný**

– Tergites with different colour pattern (Figs 2, 3, 14, 15)............................4

4 Scutum shining green; genitalia as in Figs 25–27 .... ***C. masoni* Troiano & Toscano**

– Scutum shining blue; genitalia as in Figs 21–24...............***C. caroli* Troiano**



Figures 32–45. *Chorisops tibialis*: **32** Genital capsule **33** Genital capsule (lateral view) **34** Aedeagal complex **35** Aedeagal complex (lateral view) **36–39** *C. tunisiae*: **36** Genital capsule **37** Genital capsule (lateral lateral view) **38** Aedeagal complex **39** Aedeagal complex (lateral view) **40–44** Genital furca of: **40** *C. caroli* **41** *C. masoni* **42** *C. nagatomii* **43** *C. tibialis* **44** *C. tunisiae* **45** Sugenital plate of *C. tunisiae*; (redrawn from Rozkošný (1982) Troiano (1995) and Troiano and Toscano (1995).

Key to females

1 Pterostigma light yellow (Fig. 13A), anepisternum and postronotal callus yellow (Fig. 12), pleural sclerites bright yellow, except for the contrastingly black katepisternum (Fig. 20) .... ***C. tunisiae* (Becker)**

Figure 46. Habitus of *Sargus harderseni* Mason & Rozkošný, 2008 (♂), (drawn by Mason F).

–	Pterostigma darker (Fig. 13B), anepisternum shining green (Fig. 11), pleural sclerites always dark (Fig. 19)	**2**
2	Genital furca with rounded corners (Figs 40, 42)	**3**
–	Genital furca with pointed corners (Figs 41, 43)	**4**
3	Genital furca massive, laterally enlarged, with a rounded median aperture (Fig. 40)	***C. caroli* Troiano**
–	Genital furca with a relatively wide transverse median aperture (Fig. 42)	***C. nagatomii* Rozkošný**
4	Genital furca with developed lateral wings (Fig. 41)	***C. masoni* Troiano**
–	Genital furca without developed lateral wings (Fig. 43)	***C. tibialis* (Meigen)**

Short faunistic notes

With newly recorded *Eupachygaster meromelas* and *Zabrachia minutissima*, the Italian fauna includes at the present time 91 species. The species probably endemic to Italy are: *Chorisops caroli*, *C. masoni* and *Sargus harderseni* (Fig. 46), the last recently described (Mason and Rozkošný 2008). The unique Italian record of *Vanoya tenuicornis* (Macquart, 1834), (Mason and Mei 2002) represents the southernmost European distribution of this species. The different regional distributions (cf. Tab. 1, Fig. 1), are evidently dependent on the intensity of the faunistic investigations. From the point of view of conservation, in Italy the most threatened species of soldier flies are those that have larvae which live in springs and in coastal salt marshes, because of water pollution and the progressive fragmentation and destruction of such habitats. Their conservation should start with (cf. Rozkošný 2005) building a European red list of endangered species, according to the IUCN categories (IUCN 2008; Farkač et al. 2005) as recently achieved for the saproxylic Coleoptera (Nieto and Alexander 2010).

Figure 47. Number of species of the Stratiomyidae in the Italian administrative regions. N = Northern Italy: Em = Emilia-Romagna, FVG = Friuli-Venezia Giulia, Li = Liguria, Lo = Lombardy, Pi = Piedmont, TAA = Trentino-Alto Adige, V = Venetia, Va = Val Val d'Aosta. S = Peninsular Italy: Abr = Abruzzo, Ba = Basilicata, Ca = Calabria, Cp = Campania, La = Latium, Ma = Marches, Mo = Molise, Pu = Apulia, To = Tuscany, Um = Umbria. Si = Sicily and small circum-Sicilian islands. Sa = Sardinia and small circum-Sardinian islands.

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www.manfor.eu LIFE_09_ENV_IT_0000078

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Appendix

Diptera Stratiomyidae, identified by Mason F. 2012 and 2013. (doi: 10.3897/zookeys.336.6016.app) File format: Microsoft Excel file (xls).

Explanation note: Diptera Stratiomyidae collected by Malaise trap in the framework of the Project LIFE_09_ENV_IT_0000078.

Citation: Mason F (2013) Updated Italian checklist of Soldier Flies (Diptera, Stratiomyidae). ZooKeys 336: 61–78. doi: 10.3897/zookeys.336.6016 Diptera Stratiomyidae, identified by Mason F, 2012 and 2013. doi: 10.3897/zookeys.336.6016.app

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doi: 10.3897/zookeys.336.5719
www.zookeys.org

RESEARCH ARTICLE

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Taxonomic studies on the ant genus *Cerapachys* Smith (Hymenoptera, Formicidae) from India

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http://zoobank.org/ABA31400-F058-4AF7-9279-A3D7D81D946F

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Abstract

The Indian species of the ant genus *Cerapachys* Smith are keyed. Twelve species are recognized of which 6 are described as new. The species are: *C. aitkenii* Forel, *C. alii* **sp. n.**, *C. anokha* **sp. n.**, *C. besucheti* Brown, *C. biroi* Forel, *C. indicus* Brown, *C. longitarsus* (Mayr), *C. nayana* **sp. n.**, *C. schoedli* **sp. n.**, *C. seema* **sp. n.**, *C. sulcinodis* Emery and *C. wighti* **sp. n.** Geographic distribution and group affinities of the new species are discussed. A revised key to the Indian species is provided. The rare ergatoid queens of *C. nayana, C. schoedli* and *C. seema* are reported. Formed in response to selective pressures these ergatoid queens have a significant role in dispersal strategies and contribute much to our understanding of the biology of these ants.

Keywords

Ants, Cerapachyinae, ergatoid queens, new species, myrmecophagy, India, Formicidae, *Cerapachys*, key, taxonomy

Introduction

The ant genus *Cerapachys* includes mainly myrmecophagous ants which raid the nests of other ants for prey (Wilson 1959). The genus is distributed widely throughout the tropical and subtropical regions of the world, with the majority of species known from the Indo-Australian region (Brown 1975). *Cerapachys* is the largest genus in the tribe Cerapachyini and is represented by 153 species globally (Bolton 2013). The tribe was comprehensively covered by Brown (1975), with treatment of 137 described species. Other significant contributions to the genus from South-east Asia include those of Ogata (1983) who described a new species from China; Terayama et al. (1988) provided notes on the Taiwanese species, with the rediscovery of *Cerapachys sauteri* Forel, 1913 from Taiwan; Morisita et al. (1989) contributed a guide to identification of Japanese species; Radchenko (1993) described the queen of *Cerapachys sauteri* from Vietnam; Wu and Wang (1995) reviewed the Chinese species; Terayama (1996, 2009) respectively provided keys in addition to descriptions of three new species from Taiwan and Borowiec (2009) discussed the status of the spurious genus *Yunodorylus* Xu, and described three new species related to *Cerapachys sexspinus* (Xu, 2000).

Cerapachys in India is currently represented by 6 species (Bharti 2011). The present study reports 6 further new species; *C. alii* sp. n., *C. anokha* sp. n., *C. nayana* sp. n., *C. schoedli* sp. n., *C. seema* sp. n., and *C. wighti* sp. n. from the southwest of the country. *Cerapachys* is thus now represented by 12 Indian species, a revised key to which is provided here. The present study aims to describe and catalogue the diversity of *Cerapachys* species from India and to discuss group affinities based upon available data.

Materials and methods

The specimens were collected by hand and Winkler extraction. Taxonomic analysis was conducted using a Nikon SMZ 1500 stereo zoom microscope. For digital images, an MP evolution digital camera was used on the same microscope with Auto-Montage (Syncroscopy, Division of Synoptics, Ltd.) software. Later, images were cleaned as per requirement with Adobe Photoshop CS6. Description style and morphological terminology for measurements and indices follow Brown (1975) and Borowiec (2009) and include: HL = Head length; maximum length of head in dorsal view, measured in a straight line from the anterior-most point of the nasal (clypeal) flank to the midpoint of the frontovertextal margin (Fig. 1C); HW = Head width; maximum width of head in dorsal view (Fig. 1C); EL = Eye length; maximum length of eye as measured normally in oblique view of the head to show full surface of eye (Fig. 1A); SL = Scape length; maximum length of the scape excluding the basal neck and condyle (Fig. 1C);WL = Weber's length measured from

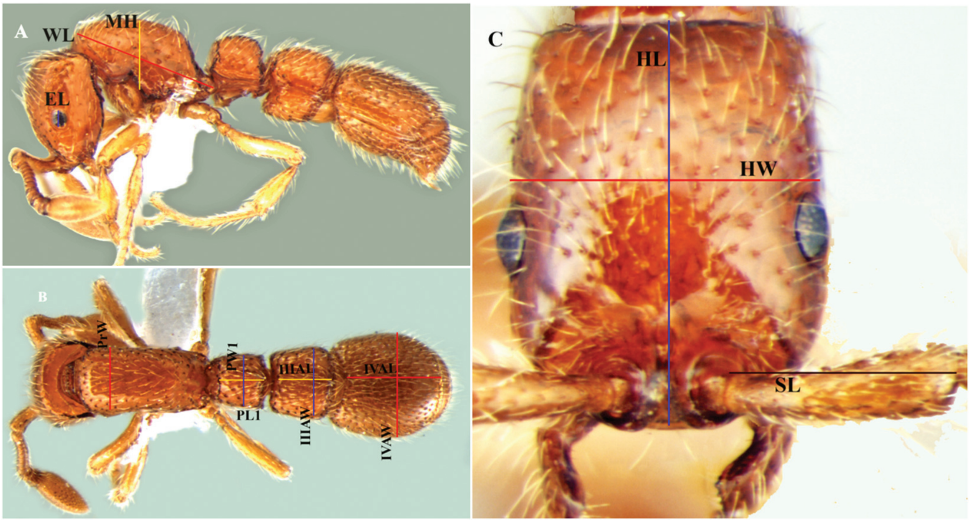


Figure 1. Images illustrating the measurements used. **A** body in lateral view with measuring lines for EL, MH, and WL **B** body in dorsal view with measuring lines for PrW, PL1, PW1, IIIAW, IIIAL, IVAW and IVAL **C** head in full-face view with measuring lines for HL, HW and SL.

the anterior surface of the pronotum proper (excluding the collar) to the posterior extension of the propodeal lobes (Fig. 1A); MH = Mesosoma height; in the side view, maximum height measured from the lowermost point of the mesopleuron (in front of middle coxa) to the dorsal edge of the mesosoma (Fig. 1A); PrW = Pronotal width; maximum width in dorsal view (Fig. 1B); PL1 = Petiole length; maximum length of the petiole in dorsal view (Fig. 1B); PW1 = Petiole width; maximum width of the petiole in dorsal view (Fig. 1B); IIIAL = Third abdominal tergite length; Maximum length in dorsal view, measuring only the length of the Posttergite (excluding pretergite, III, helcium) (Fig. 1B); IIIAW = Third abdominal tergite width; Maximum width in dorsal view (Fig. 1B); IVAW = Fourth abdominal tergite width; Maximum width in dorsal view (Fig. 1B); IVAL = Fourth abdominal tergite length; Maximum length in dorsal view, excluding pretergite (Fig. 1B); CI = Cephalic index: HW/HL × 100; SI = Scape index: SL/HW × 100; PI = Petiolar index: PW1/PL1 × 100.

Acronyms of depositories

BMNH Natural History Museum, London, U.K.

PUAC Punjabi University Patiala, Ant Collection at Department of Zoology and Environmental Sciences, Punjabi University, Patiala, Punjab, India.

Key to the species of genus *Cerapachys* from India based on worker caste (modified after Brown 1975)

1	Antenna 9 segmented	**2**
–	Antenna 11 or 12 segmented	**3**
2	Larger species (HW 0.46–0.49 mm). Sculpture predominantly punctuate (Fig. 2A)	***C. biroi* Forel**
–	Smaller species (HW 0.37–0.39 mm). Sculpture predominantly foveate (Fig. 2B)	***C. alii* sp. n.**

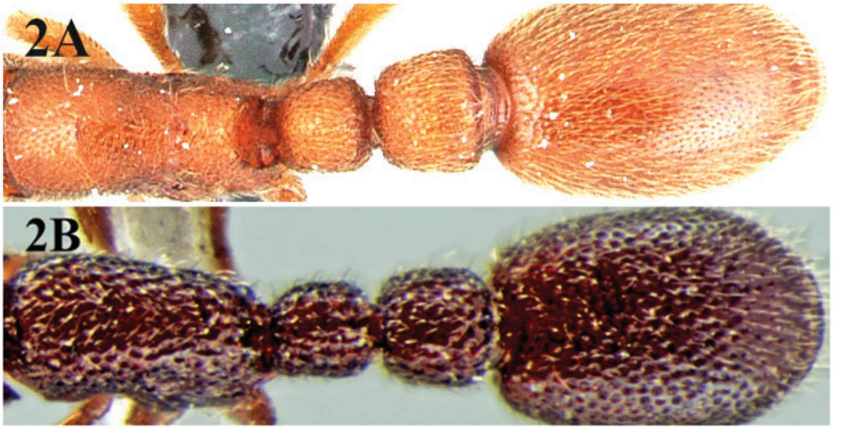


Figure 2. A dorsal surface of *C. biroi* with conspicuous punctate sculpture **B** dorsal surface of *C. alii* with foveate sculpture.

3	Antenna 11 segmented	***C. besucheti* Brown**
–	Antenna 12 segmented	**4**
4	Petiole with dorsum rounding into sides; dorsolateral margins absent or vestigial (Fig. 3A)	**6**
–	Petiole with strong overhanging dorsolateral margins (Fig. 3B)	**5**

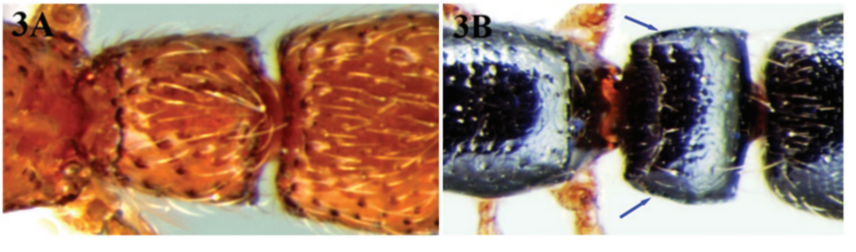


Figure 3. A petiole of *C. schoedli* with dorsum rounding into sides without overhanging dorsolateral margins **B** petiole of *C. nayana* with strong overhanging dorsolateral margins.

5 Head brown, trunk red or brown, petiole and postpetiole light to dark reddish, gaster brown or black. Dorsal surface of body shiny, with widely scattered, indistinct punctures, throughout the body (Fig. 4A) ..... ***C. longitarsus* (Mayr)**

– Head, trunk, petiole and postpetiole black coloured. Dorsal surface of body shiny, with widely scattered, indistinct punctures, mostly confined to postpetiole (Fig. 4B) .... ***C. nayana* sp. n.**

Figure 4. A. body of *C. longitarsus* in lateral view illustrating the characteristic bicolouration **B** uniformly coloured body of *C. nayana* in lateral view.

6 Dorsal surface of petiolar node with a smooth, median area (Fig. 5A)........... .... ***C. sulcinodis* Emery**

– Dorsal surface of petiolar node rounded and punctuate, without a differentiated median smooth area (Fig. 5B) 7

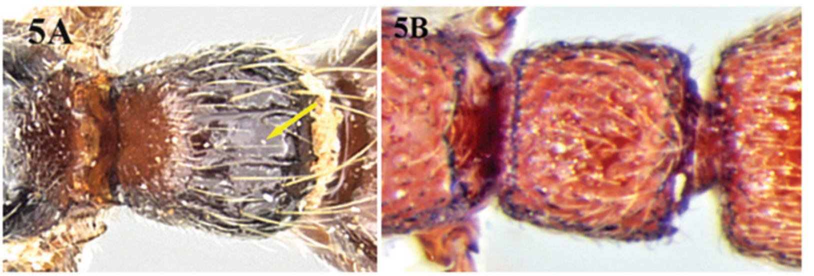


Figure 5. A petiolar node of *C. sulcinodis* with smooth median area **B** petiolar node of *C. wighti* without any median smooth area.

7 Punctures on dorsum of head relatively small, their diameter smaller than the average distance separating them (Fig. 6A)..**8**

– Punctures on head dorsum large, foveiform, dense, their diameter as large, or larger than, the average distance separating them, and in some cases these are contiguous (Fig. 6B) **10**

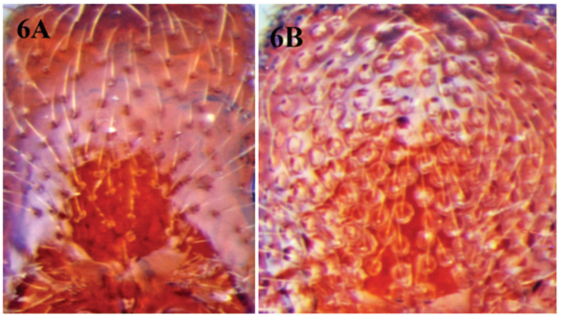


Figure 6. A cephalic dorsum of *C. schoedli* illustrating small punctures with diameter less than the average distance separating them **B** cephalic dorsum of *C. wighti* showing large punctures with diameter greater than space separating them.

8 Declivity of propodeum with distinct cariniform margins, continuous across the dorsum; petiolar dorsum flat; colour other than black (Fig. 7A)............**9**

– Declivity of propodeum without distinct cariniform margins, petiolar dorsum strongly convex; colour black (Fig. 7B)....................... ***C. anokha* sp. n.**

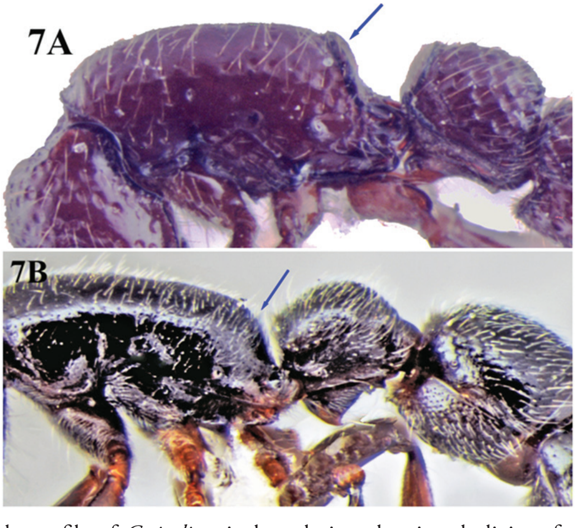


Figure 7. A body profile of *C. indicus* in lateral view showing declivity of propodeum with distinct cariniform margins **B** body profile of *C. anokha* in lateral view with propodeal declivity lacking distinct cariniform margins.

9 Shiny species; body sculpture reduced; eyes breaking the lateral margins of head; colour varies from light orange to dark red (Fig. 8A) .... ***C. schoedli* sp. n.**
– Dull coloured species; body sculpture prominent; eyes not breaking the lateral margins of head; colour brown to dark brown (Fig. 8B) .... ***C. seema* sp. n.**

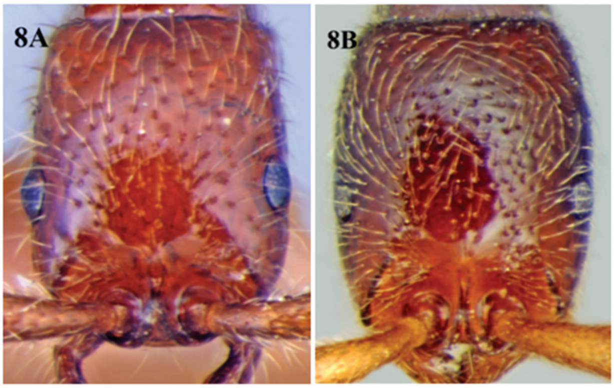


Figure 8. A shining cephalic dorsum of *C. schoedli* with reduced sculpture and eyes not breaking the lateral margins of head **B** dull cephalic dorsum of *C. seema* with prominent sculpture and eyes breaking the lateral margins of head.

10 Eyes reduced (EL< 0.1mm; Fig. 9A) .... ***C. wighti* sp. n.**
– Eyes large (EL >0.2mm; Fig. 9B) **11**

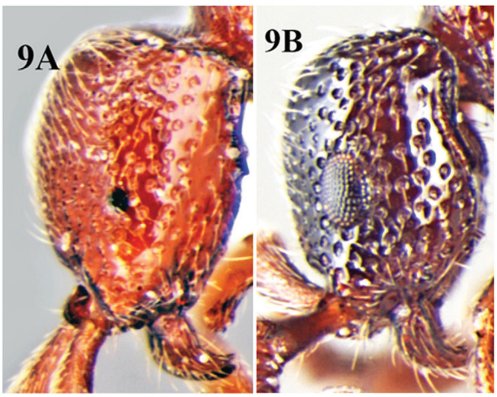


Figure 9. A head of *C. wighti* in lateral view illustrating smaller eyes **B** head of *C. aitkenii* in lateral view illustrating larger eyes.

11 Head reddish brown or red; trunk and both nodes red; gaster black or dark brown; dorsal surface of mesosoma densely and finely sculptured; foveate or rugo-reticulate (Fig. 10A) .... ***C. aitkenii*** **Forel**

– Body unicolorous, lighter brownish red; dorsal surface of mesosoma mostly smooth with few scattered punctures along sides (Fig. 10B).... ***C. indicus*** **Brown**

Figures 10. A body profile of *C. aitkenii* in lateral view illustrating the characteristic bicolouration and prominent foveate sculpture **B** body profile of *C. indicus* in lateral view illustrating unicolorous body colouration and with reduced punctuate sculpture.

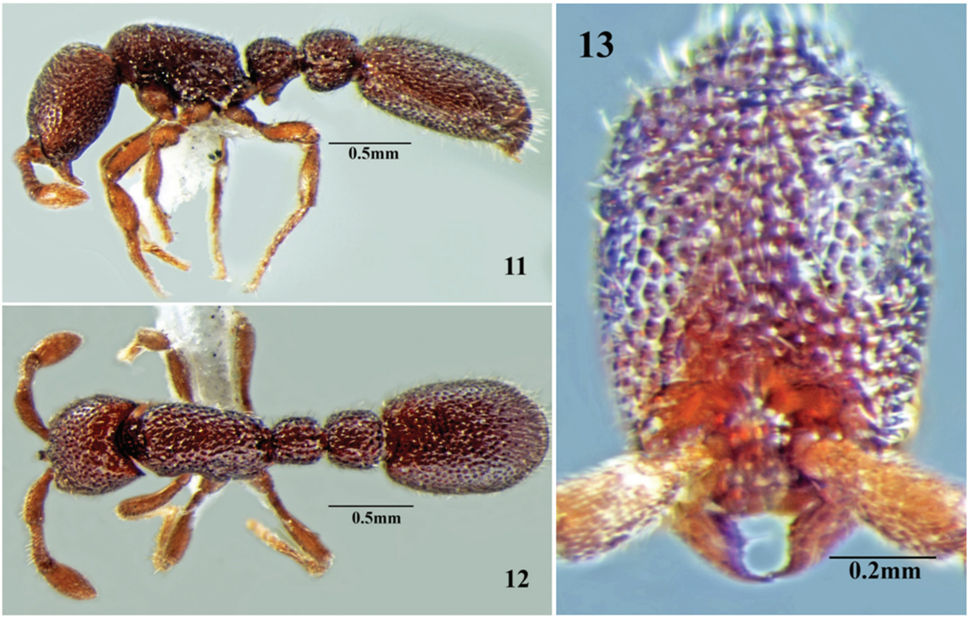
Results

Descriptions of new species

Cerapachys alii **sp. n.**
http://zoobank.org/52540038-860B-4EA4-BA1E-40217FF6D555
http://species-id.net/wiki/Cerapachys_alii
Figures 2B, 11, 12, 13, Table 1

Type material. Holotype and 6 paratypes (worker): India, Kerala, Salim Ali Bird Sanctuary, 10°45'N, 76°44'E, 118m a.s.l., 10.x.2011, Winkler method (coll. Shahid A. Akbar); Holotype in PUAC and paratype in BMNH.

Worker description. Measurements (holotype in brackets): HL 0.46–0.51(0.48); HW 0.37–0.39(0.38); WL 0.47–0.49(0.49); MH 0.28–0.31(0.31); PrW 0.25–0.29(0.25); PL1 0.16–0.20(0.17); PW1 0.16–0.19(0.18); IIIAL 0.20–0.22(0.22);



Figures 11–13. *Cerapachys alii* sp. n. **11** body in profile **12** body in dorsal view **13** head in full-face view.

IIIAW 0.22–0.27(0.23); SL 0.21–0.22(0.22); IVAL 0.43–0.49(0.49); IVAW 0.39–0.41(0.41). Indices: CI 76–80(79); SI 56–57(57); PI 95–105(105) (n=5).

Head. Rectangular, longer than broad, sides converge anteriorly; vertexal margin concave, posterior lateral corners rounded. Parafrontal ridges prominent, raised. Eyes absent. Mandibles dentate; narrow, with strongly incurved apical tooth; anterior clypeal margin entire and projects forward as a low rounded transparent lobe or apron. Lateroclypeal teeth reduced. Antennae 9 segmented; scapes short, clavate, each falling short of posterior margin of head by 1/3rd of its length.

Mesosoma. Stout, wider anteriorly; dorsal surface slightly convex, almost flat, the dorsal surface gently rounded along sides without any distinct margin. Declivous face of propodeum with cariniform margins across the top and along lateral margins.

Metasoma. Petiole as long as broad, without overhanging dorsolateral margins. Anterior face transverse and posterior face shallowly convex. Subpetiolar process prominent, acute, posteriorly directed; no fenestra present. Postpetiole slightly longer than broad, lateral angles uniformly rounded. Gaster elongate; base of cinctus of first gastral tergite with cross ribs; sting exerted.

Sculpture. Mandibles punctured. Head strongly foveate. Mesosoma, petiole and postpetiole with similar prominent foveate sculpture.

Vestiture. Body with reduced white pilosity; moderate, decumbent or subdecumbent hairs distributed evenly throughout. Apical funicular segments and legs with small standing hairs.

Colour. Dark red with mandibles, antennae and legs castaneous.

Etymology. The species is named in honor of Dr. Salim Ali, renowned Indian Ornithologist.

Differential diagnosis. With its 9 segmented antennae *C. alii* can be easily separated from other species known from India. Only eight other known species of *Cerapachys* are reported to have 9 segmented antennae. These eight species are placed in the *typhlus* group and include; *C. biroi* Forel, 1907; *C. cryptus* Mann, 1921; *C. edentatus* Forel, 1900; *C. fuscior* Mann, 1921; *C. papuanus* Emery, 1897; *C. pawa* Mann, 1919; *C. pusillus* Emery, 1897 and *C. typhlus* Roger, 1861. The new species can be easily separated from all of them. *C. cryptus* and *C. fuscior* are larger species (HW> 0.70 mm) while *C. alii* is a smaller species (HW< 0.40 mm). *C. typhlus* has the postpetiole more than half as long as the succeeding gastric segment while in *C. alii* it is less than half as long as the succeeding gastric segment. *C. papuanus, C. pawa* and *C. pusillus* have the anterolateral shoulders of the first gastric segment abruptly rounded, accentuating the medium concavity that receives the postpetiole while in *C. alii* the anterolateral shoulders of the first gastric segments as seen from above broadly rounded and gradually widening caudad. *C. biroi* and *C. edentatus* predominantly have punctuate body sculpture while *C. alii* has predominantly foveate body sculpture. *C. alii* can also be confused with *C. fragosus* Roger, 1862 and *C. coecus* Mayr, 1897 which has similar prominent foveate body sculpture, however these two species are characterized by 11 segmented antennae while as *C. alii* has 9 segmented antennae.

Ecology. This subterranean species seems to be of rare occurrence as it was encountered only once during the extensive surveys in the region. The specimens were collected from a leaf litter sample taken from Salim Ali bird Sanctuary. A low-land evergreen forest area, located between the branches of Periyar river. The region is considered as the richest bird habitat on peninsular India.

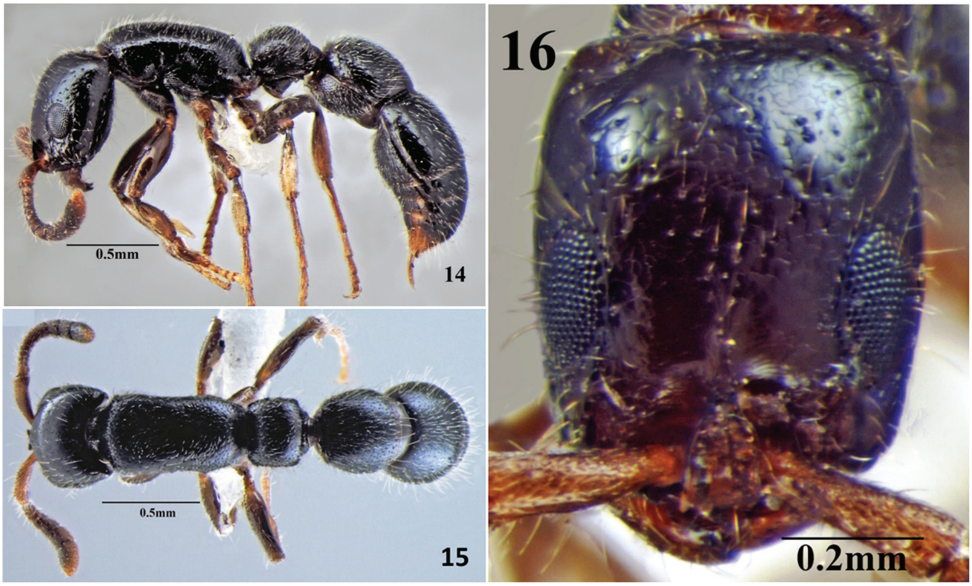
Cerapachys anokha sp. n.

http://zoobank.org/2A8BE8D2-BED1-4DAC-A73F-E9AC2189FE23
http://species-id.net/wiki/Cerapachys_anokha
Figures 7B, 14, 15, 16, Table 1

Type material. Holotype and 3 paratypes (worker): India: Kerala, Periyar tiger reserve, Thanikkudy, 9°.30'N, 77°.16'E, 1003m a.s.l., 15.x.2011, hand picking method (coll. Shahid A. Akbar). Holotype in PUAC and paratype in BMNH.

Worker description. Measurements (holotype in brackets): HL 0.69–0.73(0.72); HW 0.60–0.63 (0.63); EL 0.20–0.22(0.22); WL 0.72–0.80(0.80); MH 0.33–0.38(0.38); PrW 0.42–0.47(0.47); PL1 0.29–0.33(0.33); PW1 0.38–0.41(0.41); IIIAL 0.38–0.45(0.41); IIIAW 0.44–0.55(0.52); SL 0.29–0.32 (0.32); IVAL 0.85–0.92(0.92); IVAW 0.57–0.64(0.64). Indices: CI 86–87(87); SI 48–51(51); PI 124–131(124) (n=4).

Head. Rectangular, longer than broad, widest at about mid-length; sides parallel; vertexal margin slightly concave, posterior lateral corners are weakly acute to rounded.



Figures 14–16. *Cerapachys anokha* sp. n. **14** body in profile **15** body in dorsal view. **16**. head in full-face view.

Parafrontal ridges present. Eyes prominent, placed below midline of head. Mandible triangular with acute apices and sharp concave, edentate, masticatory margins; anterior clypeal margin with small apron shaped transparent structure. Lateroclypeal teeth small, blunt and projecting slightly inwards. Antennae 12 segmented; scape short and clavate, reaching up to 1/3rd of posterior margin of head.

Mesosoma. Stout, rectangular in dorsal view; dorsal surface convex, the dorsal surface gently rounded along sides without any distinct margin. Declivous face of propodeum lacking cariniform margins across the top and along sides.

Metasoma. Petiole highly convex, broader than long, with traces of reduced dorsolateral margins, anterior and posterior faces continuous with dorsum. Subpetiolar process prominent, wedge like, with apex directed backward; no fenestra present. Postpetiole wider than long, uniformly rounded. Gaster elongate; base of cinctus of first gastral tergite with cross ribs; sting exerted.

Sculpture. Mandibles smooth and shining. Head with few small punctures. Sculpture on dorsal surface of mesosoma, petiole and postpetiole consist of very small, uniform punctures, distributed throughout the surface. Gaster mostly smooth, with few scattered punctures. Cinctus of 1st gastral, with few cross ribs.

Vestiture. Body covered with decumbent or subdecumbent hairs. Longer hairs are also present on postpetiole and gaster. Head also consists of few long hairs; apical funicular segments and legs with standing hairs.

Colour. Black with mandibles, antennae and legs castaneous.

Etymology. The species epithet is Hindi for "unique", in reference to its unique nature of propodeal declivity.

Differential diagnosis. This species is unique in having the declivous face of the propodeum lacking cariniform margins across the top and along the sides, features unique in described workers of the Cerapachyinae. The new species show interesting variation in the form of the petiole. The petiolar node has the inferior as well as the superior posterolateral angles produced, but not sharply angular. The sides of the petiole could not be considered either immarginate (*Cerapachys* lineage) or marginate (*Phyracaces* lineage). This makes the placement of this species somewhat transitional between the two lineages and easily distinguishes it from other reported species of the genus. When using Brown`s (1975) key *C. anokha* comes close to *singaporensis* Viehmeyer, 1916. The two species however can be easily separated. *C. singaporensis* has the body arrayed with long pale hairs; and copiously pubescent, and the dorsal sides of the petiole strongly marginate, while *C. anokha* has only decumbent or subdecumbent body hairs, little pubescence and the dorsolateral sides of petiole are not marginate. *C. anokha* could also be confused with *C. nayana* which has similar habitat preferences and body colouration; however the two species can be easily separated: *C. nayana* has larger eyes (EL 0.24–0.27 mm), the declivous face of the propodeum has cariniform margins across the top, and the petiole has marginate dorsolateral sides; while *C. anokha* has smaller eyes (EL 0.20–0.22 mm), the declivous face of its propodeum lacks cariniform margins across the top, and the petiole is without marginate dorsolateral sides.

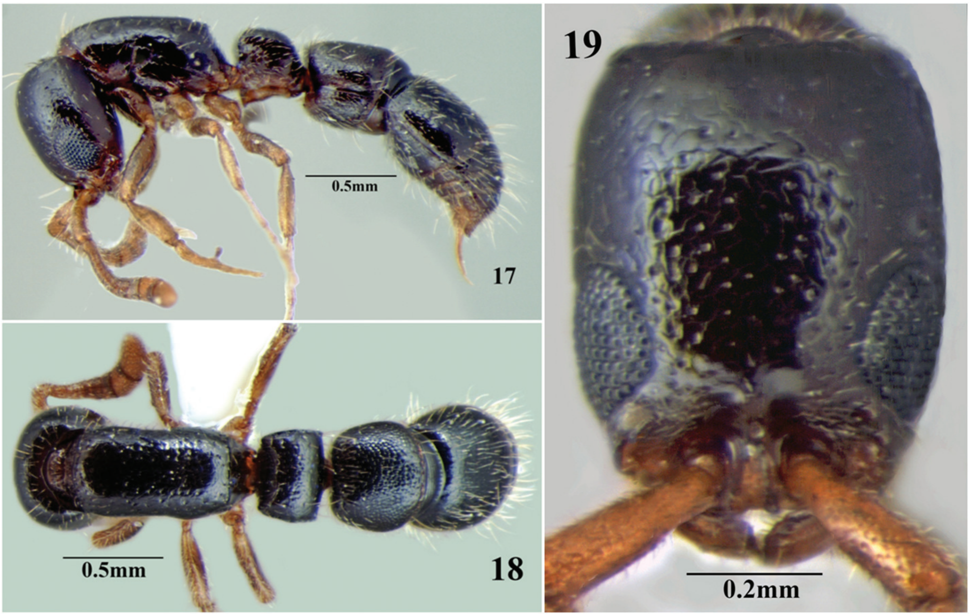
Ecology. This species seems to be infrequent. It is from the Western Ghats. Four specimens were collected by handpicking from the Thanikkudy region of the Periyar tiger reserve. Which is a primary, undisturbed tropical moist evergreen forest. The area is situated at 1003 meters elevation. It is a shady place with little sunlight penetration.

***Cerapachys nayana* sp. n.**

http://zoobank.org/46F8FF78-D753-4BEF-8FCB-7A83D4149E8D
http://species-id.net/wiki/Cerapachys_nayana
Figures 3B, 4B, 17, 18, 19, 20, 21, 22, Table 1

Type material. Holotype worker: India: Kerala, Silent valley national park, 11°5'N, 76°26'E, 897m a.s.l., 25.ix.2011, hand picking. Paratypes: 2 workers and 1 ergatoid queen with same data as holotype; 6 workers and 2 ergatoid queens, India, Karnataka, Gundlupet 11°8'N, 76°68'E, 800m a.s.l., 27.ix.2010, hand picking; 2 workers and 1 ergatoid queen, India, Kerala, Periyar tiger reserve, 9°46'N, 77°14'E, 1005m a.s.l., 10.x.2011, hand picking (coll. Shahid A. Akbar). Holotype in PUAC and paratype in BMNH.

Worker description. Measurements (holotype in brackets): HL 0.55–0.66(0.66); HW 0.48–0.51 (0.51); EL 0.24–0.27(0.25); WL 0.60–0.66(0.66); MH 0.34–0.37(0.34); PrW 0.33–0.38(0.34); PL1 0.20–0.23(0.23); PW1 0.25–0.29(0.29); IIIAL 0.30–0.44(0.44); IIIAW 0.37–0.47(0.37); SL 0.21–0.27 (0.27); IVAL 0.58–0.61(0.61); IVAW 0.47–0.52(0.52). Indices: CI 77–87(77); SI 44–53(53); PI 125–126(126) (n=10).



Figures 17–19. *Cerapachys nayana* sp. n. **17** body in profile **18** body in dorsal view **19** head in full-face view.

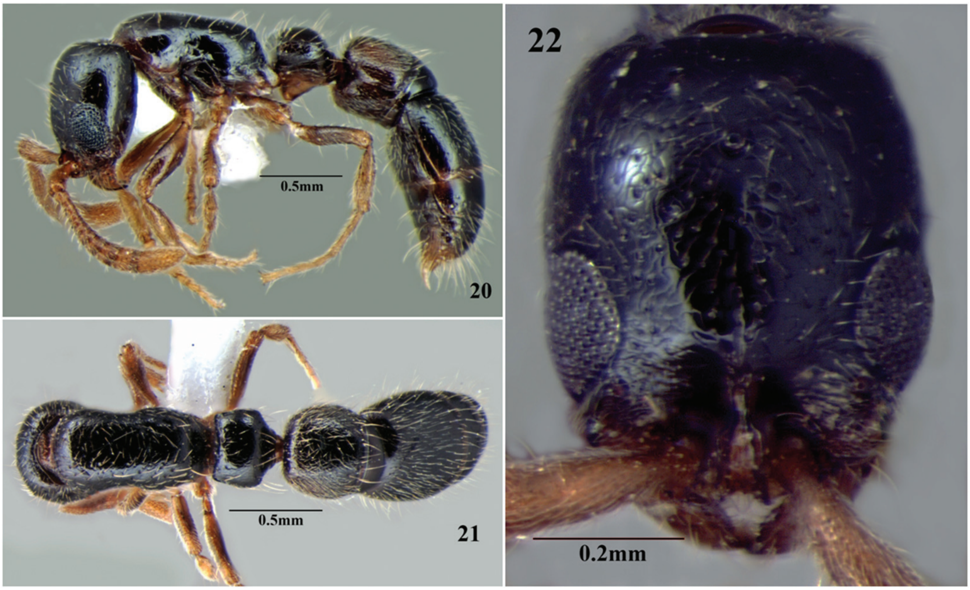
Head. Rectangular, longer than broad, widest at about its midlength; sides parallel, vertexal margin transverse to shallowly concave, posterior lateral corners weakly acute. Parafrontal ridges present but not raised, very low. Eyes large prominent. Mandibles subtriangular; masticatory margin without a row of small denticles. Lateroclypeal teeth small and reduced. Antennae 12 segmented; scapes short, reaching up to 4/5th of posterior margin of head.

Mesosoma. Moderately stout, rectangular in dorsal view; dorsal surface flattened, bordered laterally by a distinct angle, but no margin. Declivous face of propodeum with cariniform margins across the top and along the lateral margins.

Metasoma. Petiole broader than long, with strong overhanging dorsolateral margins. Anterior face concave while posterior face is transverse. Subpetiolar process small with stout acute apex, directed forward, located beneath anterior 1/3rd of the petiole; no fenestra present. Postpetiole sub trapezoidal, wider behind with the posterolateral angles uniformly rounded. Gaster elongate; base of cinctus of first gastral tergite with cross ribs; sting exerted.

Sculpture. Mandibles smooth and shining. Head with small punctures, spaced wider than their diameter, dorsum of head also with faint rugae in between the punctures. Similar sculpture on dorsal surface of mesosoma and petiole. Small continuous punctures produce a matt like appearance on the dorsum of the postpetiole. Gaster with similar matt-like appearance but less prominent. Cinctus of 1st gastral segment smooth and shining.

Vestiture. Body covered with moderate decumbent or subdecumbent hairs most prominent on postpetiole and gaster, head devoid of such hairs, only a few along sides; apical funicular segments with standing hairs.



Figures 20–22. *Cerapachys nayana* sp. n. ergatoid queen. **20** body in profile **21** body in dorsal view **22** head in full-face view.

Colour. Black with mandibles, antennae and legs castaneous.

Ergatoid queen measurements. HL 0.66–0.77; HW 0.55–0.60; EL 0.22–0.24; WL 0.79–0.82; MH 0.36–0.41; PrW 0.44–0.47; PL1 0.24–0.27; PW1 0.44–0.47; IIIAL 0.44–0.47; IIIAW 0.51–0.55; SL 0.18–0.22; IVAL 0.58–0.63; IVAW; 0.60–0.66. Indices: CI 77–83; SI 33–37; PI 174–183 (n=3).

Like the workers of the same colony, but larger, with thicker body, especially mesosoma and gaster. Ocelli present on vertex, prominent. The pilosity is much more prominent compared to workers. Distinction between ergatoid queens and worker is vague, with size variation of workers very high.

Variations. There is a considerable amount of size variation between individual specimens, the smaller workers are lighter in body colouration compared with larger specimens; the body sculpture and pilosity also differs between individuals.

Etymology. The species epithet is Sanskrit for "eyes", in reference to the large eye size of the species.

Differential diagnosis. With the marginate dorsolateral sides of its petiole, this species is easily distinguished from other Indian species of its genus. The new species shares most characters with *C. anokha* from which it is separated by the combination of characters given in the diagnosis of the latter species. *C. nayana* is compared with *C. longitarsus* which also has marginate dorsolateral sides to the petiole; however, the two species can be easily separated. *C. longitarsus* has characteristic bicolouration, with the head brown, trunk red or brown, petiole and postpetiole light to dark reddish and the gaster brown or black, while *C. nayana* is uniformly black coloured with mandibles, antennae and legs castaneous. The new species also resembles the Philippines, *C. luzuriagae* (Wheeler & Chapman, 1925) but can be easily separated from it. *C. nayana* is coloured black with the petiole broader than long, and with concave anterior and transverse posterior faces, the postpetiole with dense punctures and without dentition; while *C. luzuriagae* is reddish brown with the petiole as long as broad, with convex anterior and truncate posterior faces; postpetiole without dense punctures, and mandibles with prominent dentition.

Ecology. This species is widely distributed in the Western Ghats. It was collected from non-forested and forest habitats from small bushes, and foraging over dry soil surfaces.

***Cerapachys schoedli* sp. n.**
http://zoobank.org/38E7EC5E-E9F2-4FCC-B467-10E9208AA155
http://species-id.net/wiki/Cerapachys_schoedli
Figures 1, 3A, 6A, 8A, 23, 24, 25, 26, 27, 28, Table 1

Type material. Holotype worker: India. Kerala, Silent valley national park, 11°5'N, 76°26'E, 897m a.s.l., 25.ix.2011, Winkler. Paratypes: 13 workers and 3 ergatoid queens, same data as holotype; 2 workers, India, Kerala, Salim Ali Bird Sanctuary, 10°45'N, 76°44'E, 118m a.s.l., 6.xi.2011, Winkler; 10 workers, India, Kerala, Periyar tiger reserve, Manalar, 9°35'N, 77°18'E, 1630m a.s.l., 27.x.2011, hand picking (coll. Shahid A. Akbar). Holotype in PUAC and paratype in BMNH.

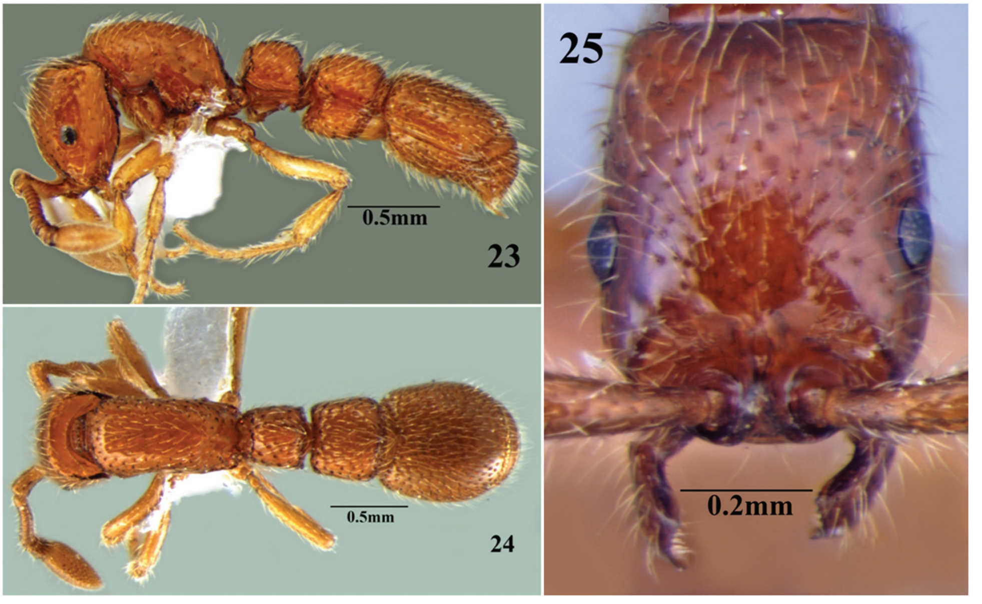
Worker description. Measurements (holotype in brackets): HL 0.64–0.68(0.68); HW 0.44–0.46(0.46); EL 0.07–0.11(0.11); WL 0.62–0.69(0.69); MH 0.41–0.48(0.48); PrW 0.31–0.35(0.35); PL1 0.24–0.27(0.27); PW1 0.28–0.31(0.31); IIIAL 0.28–0.32(0.32); IIIAW 0.39–0.41(0.41); SL 0.31–0.33 (0.33); IVAL 0.70–0.74(0.74); IVAW 0.58–0.60(0.60). Indices: CI 67–69 (67); SI 70–72(72); PI 114–116 (114) (n=11).

Head, rectangular, longer than broad; sides parallel; vertexal border transverse. Posterior lateral corners acute. Parafrontal ridges present, raised. Eyes medium sized, almost circular. Mandibles subtriangular; masticatory margins without a row of small denticles. Lateroclypeal teeth small. Antennae 12 segmented; scapes short, each falling short of posterior margin of head by 1/3rd of its length.

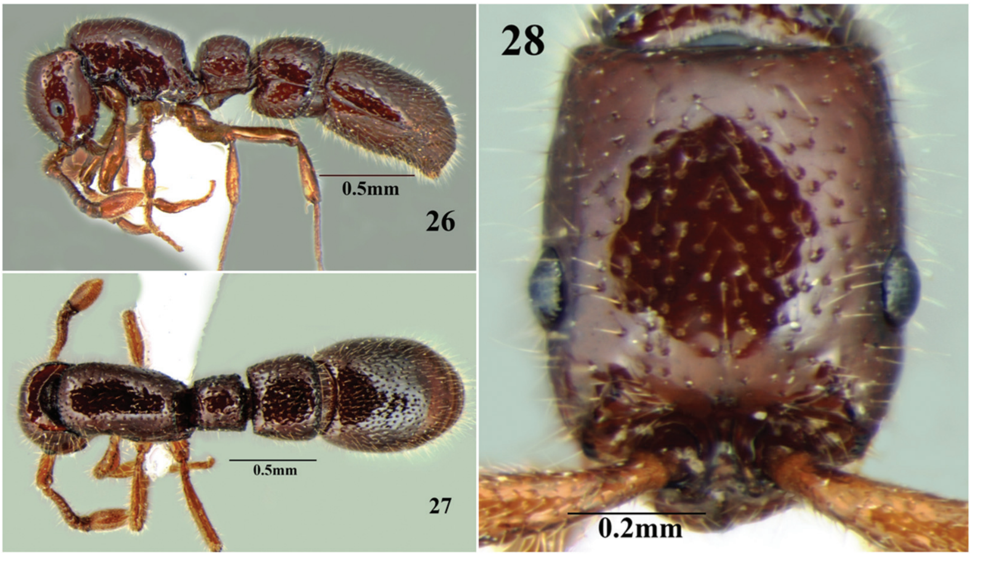
Mesosoma. stout, humped in profile view; dorsal surface convex, continuous with sides, no lateral margins. Declivous face of propodeum with cariniform margins across the top and along the lateral margins.

Metasoma. Petiole broader than long, and gently rounded towards the sides. Anterior and posterior faces transverse. Subpetiolar process stout, fenestra present. Postpetiole almost rectangular, wider behind, with the posterolateral angles not tuberculate but uniformly rounded. Gaster elongate; base of cinctus of first gastral tergite with cross ribs; sting exerted.

Sculpture. Mandibles with small punctures. Head smooth and shining with some punctures. Mesosoma mostly smooth and shining with some punctures along the sides. Petiole, postpetiole and gaster with continuous punctures.



Figures 23–25. *Cerapachys schoedli* sp. n. **23** body in profile **24** body in dorsal view **25** head in full-face view.



Figures 26–28. *Cerapachys schoedli* sp. n. ergatoid queen **26** body in profile **27** body in dorsal view **28** head in full-face view.

Vestiture. Body covered with moderate, decumbent or subdecumbent hairs, most prominent on gaster; apical funicular segments and legs also with standing hairs.

Colour. Bright yellowish orange to dark red.

Ergatoid queen measurements. HL 0.80–0.84; HW 0.59–0.63; EL 0.14–0.16; WL 0.88–0.92; MH 0.51–0.55; PrW 0.49–0.53; SL 0.41–0.43; PL1 0.29–0.31; PW1 0.38–0.41; IIIAL 0.44–0.50; IIIAW 0.57–0.59; IVAL 0.88–0.90; IVAW 0.86–0.88. Indices: CI 73–75; SI 68–69; PI 131–132 (n=3).

Like the workers of the same colony, but larger, with more stout body, especially the mesosoma and gaster. Ocelli absent on vertex. Distinction between ergatoid queens and worker is vague, with size variation of workers very high.

Etymology. The species is named in the honor of the late Dr. Stefan Schödl.

Differential diagnosis. This species is aberrant in many characters, with the cephalic dorsum bearing small punctures with average diameter lesser than the average distance separating them, a highly shinning body and reduced body sculpture, which separates it from other reported Indian species. *C. schoedli* shares most characters with *C. seema,* from which it can be easily distinguished by the combination of characters given in the diagnosis of the latter species. The new species can also be compared with *C. luteoviger* Brown, 1975 which also has small punctures on the cephalic dorsum, with diameter lesser than the average distance separating them. However, the peculiar petiolar node (with anterodorsal border concavely emarginate) and rounded head shape of *C. luteoviger* easily separates it from *C. schoedli,* which has the petiolar node broader than long and the posterior lateral corners of the head acute.

Ecology. This species seems to be common in the Western Ghats; it was collected in non-forest as well as forest habitats in leaf litter and on dry soil surfaces.

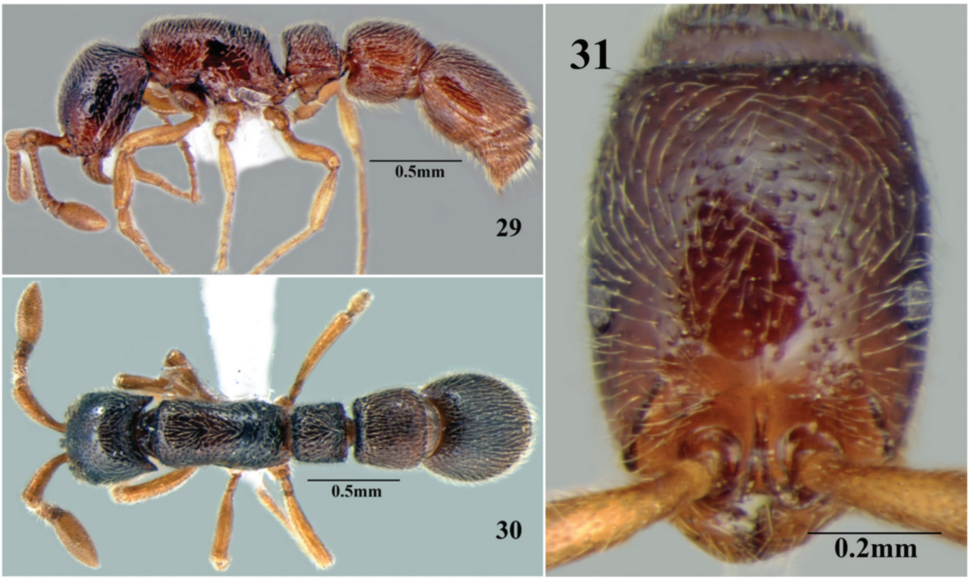
Cerapachys seema sp. n.

http://zoobank.org/AE131489-5514-422C-BE6E-5BDBCCA2F111
http://species-id.net/wiki/Cerapachys_seema
Figures 8B, 29, 30, 31, 32, 33, 34, 35, 36, 37, 41, Table 1

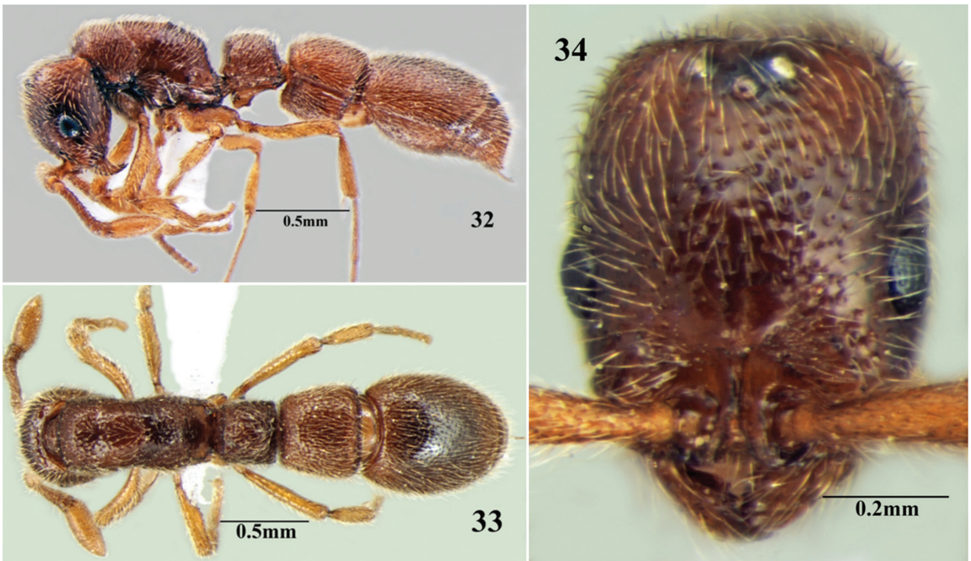
Type material. Holotype worker: India. Kerala, Periyar tiger reserve, Manalar, 9°35'N, 77°18'E, 1630m a.s.l., 24.x.2011, hand picking. Paratypes: 4 workers, 3 ergatoid queens and 1 gyne, same data as holotype (coll. Shahid A. Akbar). Holotype in PUAC and paratype in BMNH.

Worker description. Measurements (holotype in brackets): HL 0.72–0.74(0.74); HW 0.52–0.56 (0.56); EL 0.07–0.19(0.19); WL 0.77–0.82(0.77); MH 0.38–0.45(0.45); PrW 0.37–0.40(0.38); PL1 0.23–0.29(0.26); PW1 0.36–0.41(0.41); IIIAL 0.41–0.46(0.41); IIIAW 0.51–0.54(0.51); SL 0.33–0.41 (0.41); IVAL 0.70–0.74(0.74); IVAW 0.62–0.69(0.63). Indices: CI 72–75(75); SI 63–73(73); PI 141–157 (157) (n=9).

Head, longer than broad; sides converging posteriorly; vertexal margin transverse. Posterior lateral corners weakly acute. Parafrontal ridges prominent, raised. Eyes small. Mandibles subtriangular; masticatory margins deflexed and downcurved, with a row of small denticles. Lateroclypeal teeth prominent. Antennae 12 segmented; scapes clavate, reaching up to 2/3rd the distance to the posterior margin of head.

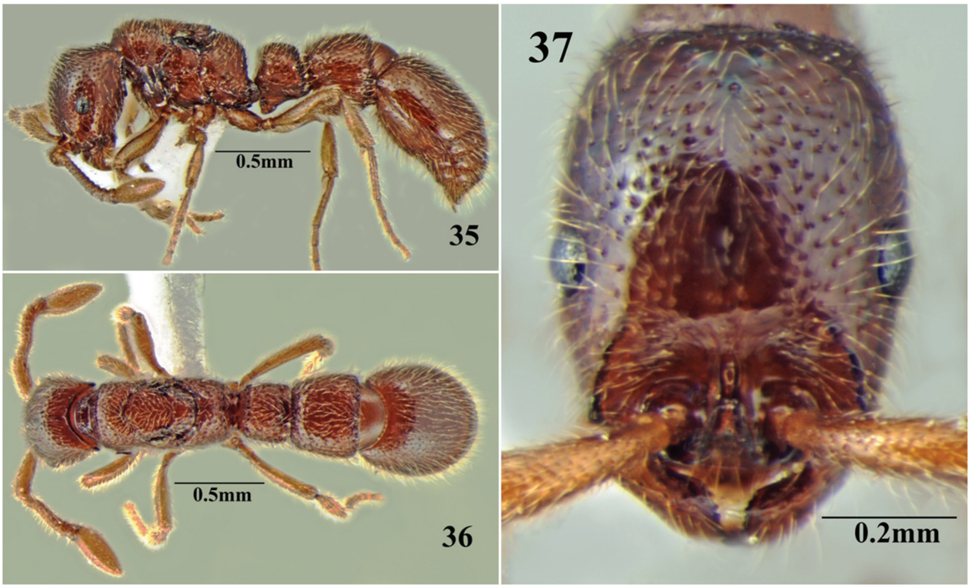


Figures 29–31. *Cerapachys seema* sp. n. **29** body in profile **30** body in dorsal view **31** head in full-face view.



Figures 32–34. *Cerapachys seema* sp. n. ergatoid queen. **32** body in profile **33** body in dorsal view **34** head in full-face view.

Mesosoma moderately stout, rectangular in dorsal view; dorsal surface flattened and gently rounded towards the sides. Declivous face of propodeum with cariniform margins across the top and along its lateral margins.



Figures 35–37. *Cerapachys seema* sp. n. queen. **35** body in profile **36** body in dorsal view **37** head in full-face view.

Metasoma, Petiole broader than long, lacking dorsolateral margins. Anterior and posterior faces transverse. Subpetiolar process well developed, located below the anterior 1/3rd of the petiole; fenestra present. Postpetiole broader than long with posterolateral angles uniformly rounded. Gaster elongate; base of cinctus of first gastral tergite with cross ribs; sting exerted.

Sculpture. Mandibles smooth with few punctures. Head with prominent punctures, spaced more widely than their diameter. Similar sculpture on dorsal surface of mesosoma. Petiole and postpetiole with larger punctures, forming a rugae-like surface on the dorsum. Gaster with similar sculpture to mesosoma. Cinctus of 1st gastral segment with prominent transverse ribs.

Vestiture. Whole body covered with dense decumbent or subdecumbent yellowish hairs, sides of head and mesosoma with fewer hairs; apical funicular segments and legs with standing hairs.

Colour. Dark brownish black with mandibles, antennae and legs castaneous.

Ergatoid queen measurements. HL 0.73–0.82; HW 0.55–0.60; EL 0.14–0.18; WL 0.81–0.86; PL1 0.27–0.29; MH 0.36–0.41; PrW 0.41–0.44; PW1 0.36–0.39; IIIAL 0.44–0.50; IIIAW 0.51–0.53; SL 0.39–0.42; IVAL 0.75–0.76; IVAW 0.72–0.77. Indices: CI 73–75; SI 70–71; PI 133–134 (n=3).

Like the workers of the same colony, but larger, with a more stout body, especially the mesosoma and gaster. Ocelli present on vertex, prominent. The pilosity is much more prominent when compared with the workers. Distinction between ergatoid queens and workers is vague with size variation of workers very high.

Gyne measurements. HL 0.77; HW 0.55; EL 0.08; WL 0.93; MH 0.44; PrW 0.41; PL1 0.27; PW1 0.36; IIIAL 0.38; IIIAW 0.49; SL 0.38; IVAL 0.76; IVAW 0.73. Indices: CI 71; SI 69; PI 133 (n=1).

Resembles the worker, with modifications expected for caste and the following differences; three prominent ocelli present on vertex, thicker body with heavy pilosity and prominent sculpture.

Etymology. The species epithet is Hindi for border, in reference to its type locality, Manalar, a place which marks border between Kerala and Tamil Nadu.

Differential diagnosis. The species is characterized by the punctures on the dorsum of the head being relatively small, separated, with their diameter smaller than the average distance separating them. The new species shares most characters with *C. schoedli*. However the two species can be easily separated. *C. seema* has dull body colouration, sculpture much more prominent and course, pilosity denser, eyes not breaking the lateral margins of head and head almost oval, with anterior and posterior sections of the sides converging, while *C. schoedli* is brightly coloured, its sculpture and pilosity are reduced, its eyes break the lateral margins of the head and the head is rectangular with parallel sides.

Ecology. Manalar, part of Periyar tiger reserve, the type locality of this species is a fascinating green hill station (with plenty of leaf litter) surrounded on all sides by the tea gardens of Tamil Nadu. This species was found nesting beneath the marker stone on the border which separates Kerala and Tamil Nadu. It is presumed that the nest was in its initial stages of establishment as there were hardly any galleries and underground chambers. A single queen, 3 ergatoid queens and 7 workers were collected. This species seems uncommon in the Western Ghats range, since it was not encountered again from any other locality.

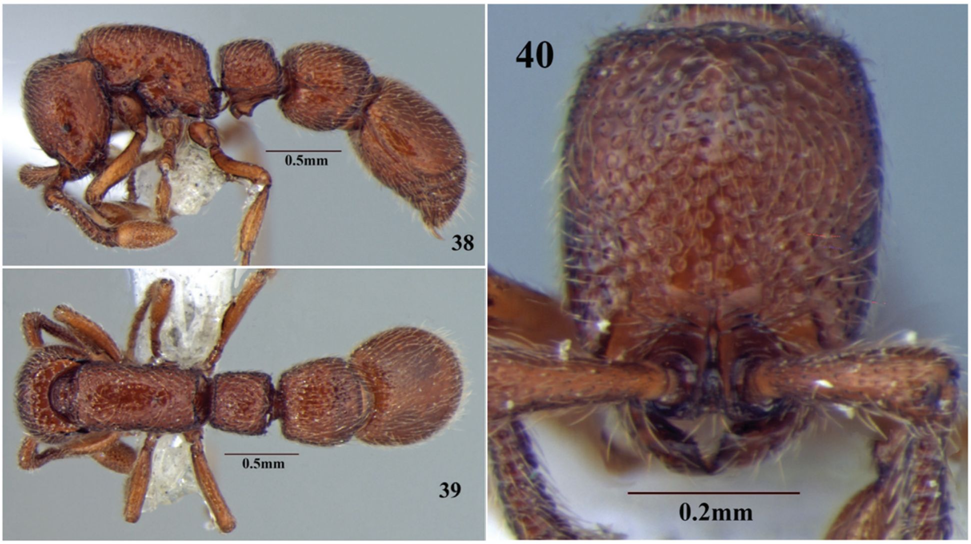
Cerapachys wighti sp. n.

http://zoobank.org/EB5CD657-F22C-4E1B-8352-995242B9531D
http://species-id.net/wiki/Cerapachys_wighti
Figures 5B, 6B, 9A, 38, 39, 40, Table 1

Type material. Holotype and paratype worker: India. Kerala, Silent valley national park, 11°5'N, 76°26'E, 897m a.s.l., 25.ix.2011, Winkler (coll. Shahid A. Akbar). Holotype in PUAC and paratype in BMNH.

Worker description. Measurements (holotype in brackets): HL (0.69)-0.71; HW (0.58)-0.59; EL (0.05); SL (0.38)-0.40; WL (0.66)-0.70; MH (0.43)-0.47; PrW (0.33)-0.35; PL1 (0.28)-0.29; PW1 (0.32)-0.33; IIIAL (0.41)-0.44; IIIAW (0.47)-0.49; IVAL (0.71)-0.72; IVAW (0.66)-0.68 Indices: CI 83-(84); SI (65)-67; PI 113-(114).

Head rectangular, longer than broad; sides rounding posteriorly, vertexal margin transverse, posterior lateral corners gently rounded, weakly acute. Parafrontal ridges raised, prominent. Eyes reduced. Mandibles subtriangular; masticatory margin without a row of small denticles. Lateroclypeal teeth reduced. Antennae 12 segmented; scapes short, clavate.



Figures 38–40. *Cerapachys wighti* sp. n. **38** body in profile **39** body in dorsal view **40** head in full-face view.

Mesosoma stout, compact, rectangular in dorsal view; dorsal surface slightly convex, the sides gently rounded without any distinct margin. Declivous face of propodeum with the upper sides margined.

Petiole broader than long, without strong overhanging dorsolateral margins. Anterior and posterior faces transverse. Subpetiolar process stout with hook like ventral margin; no fenestra present. Postpetiole sub trapezoidal, wider behind, posterolateral angles uniformly rounded. Gaster elongate; base of cinctus of first gastral tergite with cross ribs; sting exerted.

Sculpture. Mandibles punctured. Punctures on dorsum of head large, crowded, their diameter as large, or larger than, the average distance separating them. Mesosoma, petiole and postpetiole similarly sculptured. Gaster with smaller sized punctures compared with head, mesosoma and metasoma. Cinctus of 1st gastral with cross ribs.

Vestiture. Body with reduced pilosity; moderate decumbent or subdecumbent hairs. Mostly prominent on postpetiole and gaster. Apical funicular segments and legs with standing hairs.

Colour. Dark reddish brown with mandibles, antennae and legs lighter

Etymology. The species is named after botanist Robert Wight, who historically explored the area in 1847.

Differential diagnosis. The new species can easily be separated from most of the Indian species on the basis of the large crowded punctures on its cephalic dorsum, with diameter as large, or larger than, the average distance separating them. *C. wighti* shares most characters with *C. indicus,* which also has large crowded punctures on cephalic dorsum. However the two species can be easily separated. *C. wighti* is smaller in size (HW 0.59 mm), has lighter body colouration and reduced eyes (EL 0.05 mm), while *C. indicus* is larger in size (HW 0.77 mm), with darker body colouration and large eyes (EL 0.24 mm).

Ecology. The species seems to be of rare occurrence as it was encountered only once during the extensive surveys conducted in the area. It was collected from a litter sample taken near the Kuntipuzha river, which drains the entire length of the silent valley national park. With a pesticide free catchment area the region is rich in soil biota and ideal for cryptic ant species.

General discussion. Here we present a review of genus *Cerapachys* from India. 12 species are recognized of which 6 are described as new. Partly for convenience the 12 Indian species are placed into arbitrary groups. Group I species with 12 segmented antennae viz., *C. sulcinodis*, *C. anokha*, *C. schoedli*, *C. seema*, *C. indicus*, *C. aitkenii*, *C. wighti*, *C. longitarsus* and *C. nayana*. Of the 9 species given above the first four i.e., *C. sulcinodis*, *C. anokha*, *C. schoedli* and *C. seema*, have the punctures on the dorsum of the head relatively small, separated, with their diameter smaller than the average distance separating them. Among these *C. anokha,* with the declivous face of the propodeum lacking cariniform margins, and *C. sulcinodis,* with the dorsal surface of the petiolar node with a smooth, median area are distinct species in the group. *C. schoedli* and *C. seema* are easily separated. *C. seema* has dull body colouration, sculpture much more prominent and coarse, pilosity denser and head almost oval, with the anterior and posterior sections of its sides converging, while *C. schoedli* is brightly coloured, with sculpture and pilosity reduced and the head rectangular with parallel sides. The next 3 species i.e., *C. indicus*, *C. aitkenii* and *C. wighti,* have the punctures on the dorsum of the head large, their diameter greater than the average distance separating them. Among these *C. wighti* has the smallest size (HW 0.59 mm) and relatively reduced eyes (EL 0.05 mm) wereas *C. aitkenii* and *C. indicus* are easily separated from each other on the basis of body sculpture and colouration. *C. aitkenii* has characteristic bicolouration and its body sculpture is foveate, wereas *C. indicus* is mostly piceous with bluish iridescent sheen and reduced sculpture. The remaining 2 species i.e., *C. longitarsus* and *C. nayana* are members of '*Phyracaces* lineage' and easily recognized, with strong overhanging dorsolateral margins to the petiole. The two species are separated from each other on the basis of body colouration. *C. longitarsus* has characteristic bicolouration with head brown, trunk red or brown, petiole and postpetiole light to dark reddish and gaster brown or black, while *C. nayana* is uniformly black in colour, with mandibles, antennae and legs castaneous. Group II species have antennae with less than 12 segments viz., *C. biroi*, *C. alii* and *C. besucheti*. Among these *C. besucheti* has 11 segmented antennae while *C. biroi* and *C. alii* have 9 segmented antennae. *C. biroi* is characterized by its opaque body with closely spaced piligerous punctures, while *C. alii* has prominent foveate body sculpture.

Workers grade into a number of "atypical" reproductives. These morphologically "atypical" ant reproductives have been assigned a number of descriptive terms. However Peeters (2012) advocate use of "ergatoid queens" for all wingless reproductives that differ morphologically from workers. These ergatoid queens are formed as a response to selective pressures against long range dispersal and solitary colony foundation (Peeters and Molet 2010). Ergatoid queens have been reported previously in *Cerapachys* (Brown, 1975). Here we present ergatoid queens of three more species - *C. nayana, C. schoedli* and *C. seema*. In evaluating morphometric data of the three castes of *C. seema* i.e. worker, ergatoid queens and queen castes (Fig. 41) it is observed that ergatoid queens are

Table 1. Distribution of *Cerapachys* species. EQ= ergatoid queens; Q= queens; M=male; W=worker; + indicates reported and – indicates not reported.

N	Species	Distribution	EQ	Q	M	W
1	*C. alii* sp. n.	India, Kerala	-	-	-	+
2	*C. anokha* sp. n.	India, Kerala	-	-	-	+
3	*C. aitkenii* Forel, 1900	India, Kerala	-	-		+
4	*C. besucheti* Brown, 1975	India, Tamil Nadu	+	-	-	+
5	*C. biroi* Forel, 1907	Madagascar, Philippines, Puerto Rico, China, Nepal, India, Comoros, Seychelles, Mayotte, Japan, Viet Nam, Guam, Samoa, Marshall Islands, Northern Mariana Islands and Hawaii	+	+	+	+
6	*C. longitarsus* (Mayr, 1879)	Philippines, New Guinea, Israel, India, Bangladesh, Thailand, Saudi Arabia, Egypt, United Arab Emirates	+	+	+	+
7	*C. nayana* sp. n.	India, Karnataka, Kerala	+	-	-	+
8	*C. indicus* Brown, 1975	India, Kerala	-	+	-	+
9	*C. schoedli* sp. n.	India, Kerala	-	-	-	+
10	*C. seema* sp. n.	India,Kerala	+	+	-	+
11	*C. sulcinodis* Emery, 1889	Philippines, Indonesia China, India, Viet Nam and Thailand	+	+	+	+
12	*C. wighti* sp. n.	India, Kerala	-	-	-	+

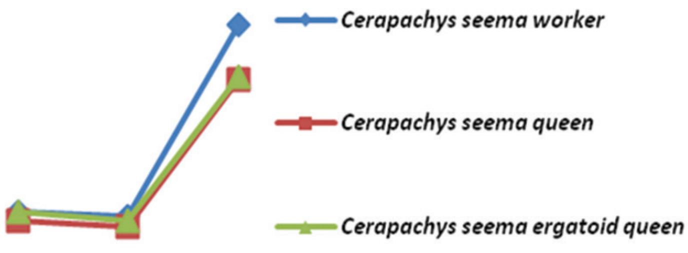


Figure 41. Graph plotted on evaluating morphometric data shows less affinity of ergatoid queens with workers compared with gyne/queen.

closer to gynes than the workers. Further inference and analysis on the subject is beyond the scope of this paper and would require much more information. However the aim of this review is to add further material for examination for understanding this fascinating aspect of ant biology and to promote more studies in this direction.

Notes. *Cerapachys keralensis* Karmaly, 2012 described on the basis of two minor? workers collected from the Palakkad district of Kerala. The new species is highly dubious. The description is minimal, superficial and contains no comparative notes. The photographs are derisory as illustrations supporting the inadequate descriptions. *Cerapachys keralensis* Karmaly, 2012 is here considered to be a species inquirenda.

Two unpublished new species (*C. browni* and *C. costatus*; Bharti and Wachkoo (in press)) are excluded from this paper. The two species can be easily separates from other reported Indian species. *C. browni* shares most affinities with *C. aitkenii* but with black colour (unicolorous), rugo-reticulate sculpture and strongly constricted cintus of gaster. *C. costatus* with remarkable costate sculpture, which is not reported in any other Indian species.

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