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**New records of the hypercalcified sponge *Plectroninia* (Calcarea, Minchinellidae) in the Recent deep ocean**

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3 New records of the hypercalcified sponge *Plectroninia* (Calcarea, Minchinellidae) in  
4 the Recent deep ocean  
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### 6 **Abstract**

7 Numerous small specimens of hypercalcified sponges of the genus *Plectroninia*  
8 (Jurassic to Recent) are recorded from deep water in the Atlantic, Indian and Pacific  
9 oceans, where they are attached to diverse hard substrata, mostly scleractinian  
10 skeletons. Being represented as skeletons of linked calcareous tetractines with an  
11 incomplete free spicule complement the specimens could not be identified at the  
12 species level. These observations show that *Plectroninia* spp. have a wide distribution  
13 in the bathyal zone of the Recent World Ocean, where they may be the most common  
14 calcareous sponges.  
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16

17  
18 **Keywords:** Porifera; calcareous sponges; bathyal zone; Minchinellidae; Lithonida.  
19

### 20 **Introduction**

21 Minchinellidae Dendy & Row, 1913 (Calcarea, Lithonida) is a family of  
22 calcareous sponges well represented in the fossil record among the “pharetronids”—a  
23 polyphyletic group of hypercalcified sponges now classified in diverse taxa of  
24 Calcarea and for some of them even in Demospongiae. In the Mesozoic, hypercalcified  
25 sponges were significant reef-builders. However, in the Recent, there are a few  
26 remnant survivors which have often been considered as relicts. The family  
27 Minchinellidae is characterized by a skeleton of tetractine spicules linked together in a  
28 rigid structure (Vacelet *et al.* 2002, Vacelet 2012). ). In this family, the genus  
29 *Plectroninia* Hinde, 1900 was first described in the fossil record as *P. halli* Hinde,  
30 1900 from Australia, then considered as Eocene but now dated to Early and Middle  
31 Miocene (Pickett 1983). After its description as fossil, the genus has been found in the  
32 Recent by Kirkpatrick (1900, 1911), who described two species from 90 m depth from  
33 the tropical Indo-Pacific. Subsequently, more species have been described from  
34 present-day seas, and of the 13 species presently known in the Recent, most occur in  
35 dark submarine caves of the tropical Indopacific and the Mediterranean (Vacelet  
36 2012). First bathyal records (down to 1600 m) were from the north Atlantic and the  
37 Mediterranean (Könnecker 1989, Vacelet *et al.* 1989, Könnecker & Freiwald 2005).  
38 The diagnosis of the genus *Plectroninia* in Systema Porifera is: Minchinellidae with a  
39 basal skeleton made up of two types of fused tetractines, a layer composed of large  
40 tetractines and a layer of small tetractines. Tetractines fused by their basal actines, with  
41 the apical actine remaining free and pointing outwards. Basal actines attached by  
42 simple zygotis in small tetractines, zygotis reinforced by a cement layer in large  
43 tetractines. Cortical skeleton of free spicules tangentially arranged (Vacelet *et al.*  
44 2002).  
45

46 Our additional new records throughout the World Ocean confirm the wide  
47 distribution of the genus *Plectroninia* and show that it should no longer be considered  
48 as a rare relict or a refuge group in present-day seas.  
49

50 The new samples presented here were mostly found on coral skeletons collected  
51 in various areas of the World Ocean and mostly from bathyal depths (Table 1). The  
52 samples are reduced to the rigid skeleton and do not include the free spicules.  
53 Accordingly, they cannot be identified at the species level. Nevertheless, this unique  
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3 collection is of great interest by widely improving our knowledge of *Plectroninia* spp.  
4 in the Recent.  
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### 6 **Material and methods**

7  
8 The collection of *Plectroninia* resulted from sorting samples taken during various  
9 oceanographic cruises (Table 1), mostly by dredging, occasionally by picking up from  
10 a submersible. In order to identify scleractinians, corals were often treated with hot  
11 sodium hypochlorite solution which contributed to making small calcified epifauna  
12 more evident. Tiny *Plectroninia* were thus easier to recognize than on the raw material  
13 where they are commonly concealed by trapped sediment or, when already dead,  
14 overgrown by “soft” sponge crusts.  
15

16 However, the living tissue and free spicules of the dermal layer were lost during  
17 the bleach treatment, and the specimens, in most cases reduced to the basal skeleton of  
18 linked spicules, could not be identified or described to the species level. The  
19 specimens were observed and photographed under a binocular microscope. Some were  
20 sputter-coated with gold-palladium and observed under a Hitachi S570 scanning  
21 electron microscope.  
22

23 The *Plectroninia* collection has been deposited as a whole in the Porifera  
24 collection of Muséum National d’Histoire Naturelle, Paris, number MNHN-IP-2015-  
25 1480 to 1543.  
26  
27

### 28 **Results**

29  
30 All specimens are small encrustations, roughly circular, with a minimum size of 0.5 x  
31 0.5 mm, and up to 5 x 6 mm (Figs. 1–3). The number of specimens found by sampling  
32 sites was variable according to the number of corals skeletons that were examined. In  
33 most sites, there was a single specimen. However, up to 24 specimens were found in a  
34 New Caledonia site (Alis Musorstom 6, DW 400, 14/02/1989). A total number of 109  
35 specimens was found. Most are reduced to a well preserved basal skeleton composed  
36 of two layers of tetractines fused or intermingled by their *basal* actines with the apical  
37 actine free and pointing outward. The basal layer, generally well visible near the edge  
38 of the crust, is made of small tetractines, and is covered by a layer of larger tetractines,  
39 conforming to the typical structure of the Recent species in the genus *Plectroninia*  
40 (Figs 1–3). In a few cases, some free spicules from the dermal layer and choanosome,  
41 diactines, triactines, and tuning fork (diapasons) triactines, remain intermingled with  
42 the linked tetractines. Some specimens, already dead when sampled, show an eroded,  
43 poorly preserved basal skeleton. Siliceous skeletons of encrusting lithistids, also  
44 present on some of the substrates, are easily distinguished from the calcareous  
45 *Plectroninia* skeletons.  
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49 Size and skeleton characters (in particular spicule ornamentation) show some  
50 variation. The free apical actine of the large tetractines is generally smaller than 200  
51  $\mu\text{m}$ , with a maximum length of 234  $\mu\text{m}$  observed in a specimen from New Caledonia.  
52 These free actines may be nearly smooth with only a few spines near the base, or bear  
53 a variable number of short, conical spines, arranged in rows in a specimen from La  
54 Réunion (Fig. 2D). The basal actines have more numerous conical spines, also  
55 frequently in rows, and are linked together by enlarged ends (Figs. 1C & D, 2B & F,  
56 3B, E & F). Growth stages of these tetractines are observed in some specimens (see,  
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3 for example Fig. 3B). The small tetractines are more heavily spined, with spines  
4 sometimes nearly as large as the free apical actine and bearing a secondary spination.  
5 In some individuals the underside of the sponge could be seen and shows that it was  
6 attached to the substrate by the enlarged ends of the basal actines of the small  
7 tetractines (Figs. 2D, 3F).  
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### 10 Discussion

11 The samples here can be identified with the genus *Plectroninia* as it is  
12 conventionally understood while the placement of these Recent forms in the same  
13 genus with the fossil *Plectroninia halli* (type of the genus) is pending, awaiting a  
14 revision of other fossil genera in the Minchinellidae (Finks *et al.* 2011, Vacelet 2012).  
15 In some cases, the basal skeleton is eroded and poorly preserved, making the  
16 identification as *Plectroninia* less certain. However, the preservation is good enough to  
17 prevent confusion with other Recent genera of Minchinellidae. *Petrostroma* Döderlein,  
18 1892 and *Minchinella* Kirkpatrick, 1908 are erect rather than encrusting. *Petrostroma*  
19 is known from a single record from the upper bathyal in the tropical Pacific and has a  
20 rigid skeleton forming radial lines (Vacelet 2012), a feature absent in all our  
21 specimens. *Minchinella* has a rigid skeleton made of a single category of large  
22 tetractines partly embedded in a cement, whereas all our specimens have linked  
23 tetractines of two size classes and are devoid of embedding cement. In  
24 *Monoplectroninia* Pouliquen & Vacelet, 1970, from Mediterranean submarine caves,  
25 the rigid skeleton consists of a single type of small tetractines. In *Tulearinia* Vacelet,  
26 1977 the rigid skeleton is feebly linked and would not resist the drastic cleaning by  
27 sodium hypochlorite.  
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32 Being mostly reduced to the basal rigid skeleton, without the free spicules of  
33 the choanosome and dermal layer, our specimens cannot be identified to any of the 13  
34 known Recent species listed in World Porifera Database (Van Soest *et al.* 2015), for  
35 which a comparative table of spicules has been given by Könnecker *et al.* 2005.  
36 However, the differences in size and spination of the tetractines of the basal skeleton  
37 indicate that several species are present, as implied by the worldwide provenance of  
38 the material. Only two species, *P. celtica* Könnecker & Freiwald, 2005 and *P.*  
39 *norvegica* Könnecker, 1989 have been specifically identified in the bathyal zone of a  
40 single area (the North–East Atlantic) and it is obvious that the diversity of bathyal  
41 *Plectroninia* spp. can be expected to be higher in the World Ocean. We observed a  
42 maximum length of 234  $\mu\text{m}$  for the free apical actine, indicating that we did not find *P.*  
43 *norvegica* which is characterized by distinctly larger actines up to 500  $\mu\text{m}$  long.  
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46 The presence of calcareous sponges of the Class Calcarea in the deep sea has  
47 been underestimated for a long time (Rapp *et al.* 2011). In fact they are more common  
48 than formerly expected and our data suggest that the genus *Plectroninia* may be one of  
49 the most common Calcarea in the bathyal zone, worldwide. Being minute and having  
50 the dermal layer often covered by mud, they are easily overlooked when deep sea  
51 material is sorted, whether they incrust hard substrates or live loose on muddy sand  
52 (Könnecker 1989). However, their rigid basal skeleton of fused or linked spicules (apt  
53 for fossilization) can withstand drastic cleaning and thus becomes more easily visible.  
54 The cleaning technique that we used here reveals that these sponges may be very  
55 common in the deep sea, with a very large distribution in bathyal depths. Presently, the  
56 maximum depth record of *Plectroninia* is 1644 m on the Vavilov Seamount in the  
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Western Mediterranean (Table 1), with other remarkably deep records to 1600 m from the western Mediterranean (Vacelet *et al.* 1989) and ~~other remarkably deep records~~ to 1269 m and 1391 m from the eastern Mediterranean basin (Ilan *et al.* 2003), i.e., in a sea that is commonly considered as having a poor deep-sea fauna.

The absence of locations in wide areas of the World Ocean in our distribution map (Fig. 4) should not be interpreted as presenting the reality of *Plectroninia* distribution. We did not have access to potential substrates from all areas. We also admit that our records may be biased by more attention having been given to tiny epifauna in one coral collection than in another, according to circumstances (need to having a collection treated fast or not, diversity of the components, quantity, etc.).

Due to sampling bias, our records are more frequent in certain areas, for instance around New Caledonia, a region covered by many cruises which provided an exceptionally large quantity and diversity of bathyal scleractinian corals. Of particular interest are the records from Barbados and Brazil, Tropical Western Atlantic. No representative of Minchinellidae was previously recorded from this area where submarine caves are famous for the fauna of hypercalcified demosponges (“Sclerosponges”) as in Jamaica (Hartman & Goreau 1970).

Our observations suggest that minute *Plectroninia* spp. are the most common calcareous sponges in the Recent bathyal environment. It is not clear if this was the case also in the geological past. Minchinellidae have been considered as rather shallow in Eocene strata (Finks *et al.* 2011), but this was mostly based on the obsolete idea that in the Present Calcarea are confined to depths shallower than 60 m. This assumption has already been questioned (Borojevic & Graat–Kleeton 1965, Vacelet 1988, Janusszen *et al.* 2003, Rapp *et al.* 2011). We now have reasons to consider the fossil Minchinellidae as a relatively deep-water group, thriving at sub-photic depths as suggested for *Porosphaera*, a genus common in the fossil record, and other Minchinellidae from the Cretaceous (Nestler 1961 & 1965, Reitner 1992, Wilmsen *et al.* 2012). In more recent times, in the Upper Miocene (Messinian), *Plectroninia* is clearly a member of a diversified upper bathyal assemblage (Barrier *et al.* 1991).

Table 1: Collection data of the specimens.

Fig. 1: A–D: Specimen from Brazil, 217 m depth. Note the presence of a tuning fork triactine in D (arrow). E–F: specimen from Azores, 914 m depth.

Fig. 2: A–D: Specimen from La Réunion, 470–540 m depth. B and C show some preserved free spicules, including a tuning fork triactine in C (arrow). D is a view of the underside, showing the attachment of the small tetractines by an enlarged ends on the substratum. E–F: specimen from New Caledonia, 270 m depth.

Fig. 3: A–C: Specimen from New Caledonia, 360 m depth. In B, presence of a tuning fork triactine and of a growing stage of large triactine (arrows). D–F: other specimen from New Caledonia, 360 m depth. In A & D, an area of the underside detached from the substratum.

Fig. 4: Localization of the new records of *Plectroninia*.

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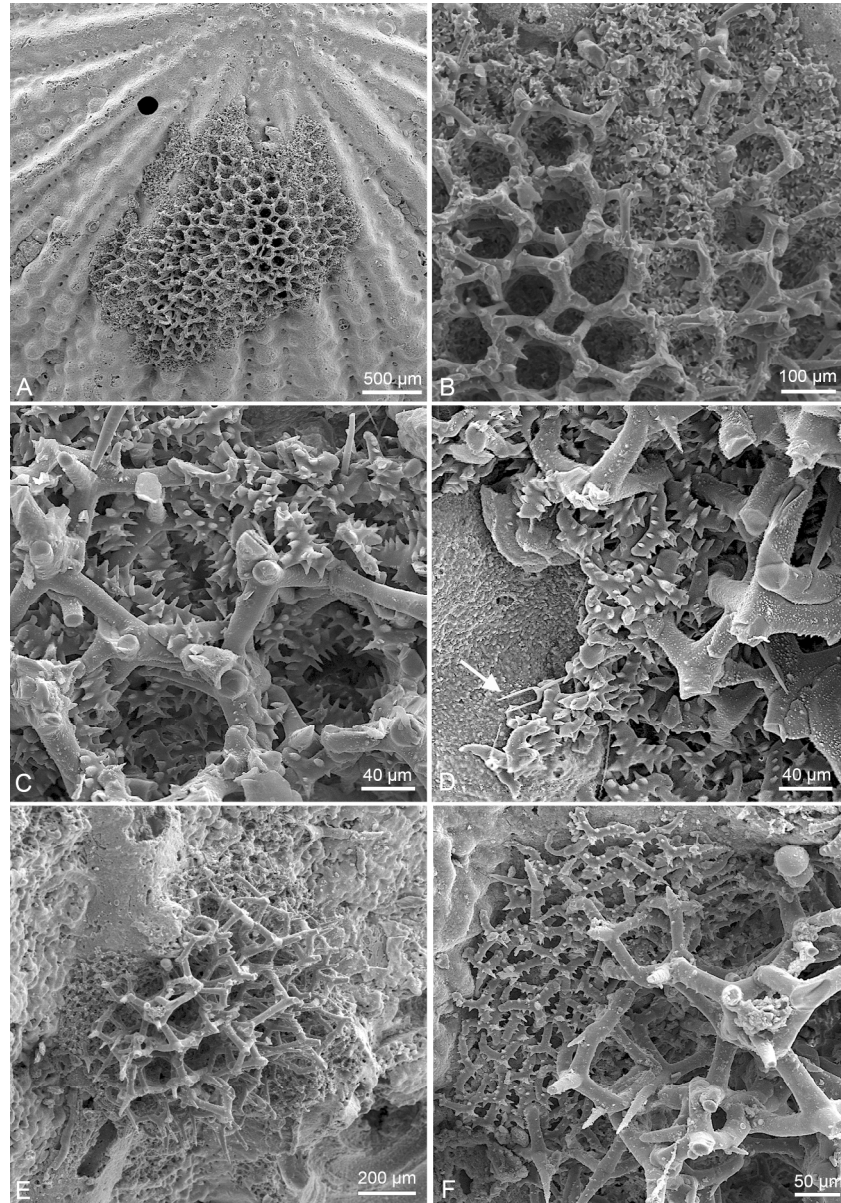


Fig. 1: A-D: Specimen from Brazil, 217 m depth. Note the presence of a tuning fork triactine in D (arrow).  
E-F: specimen from Azores, 914 m depth.

241x346mm (300 x 300 DPI)

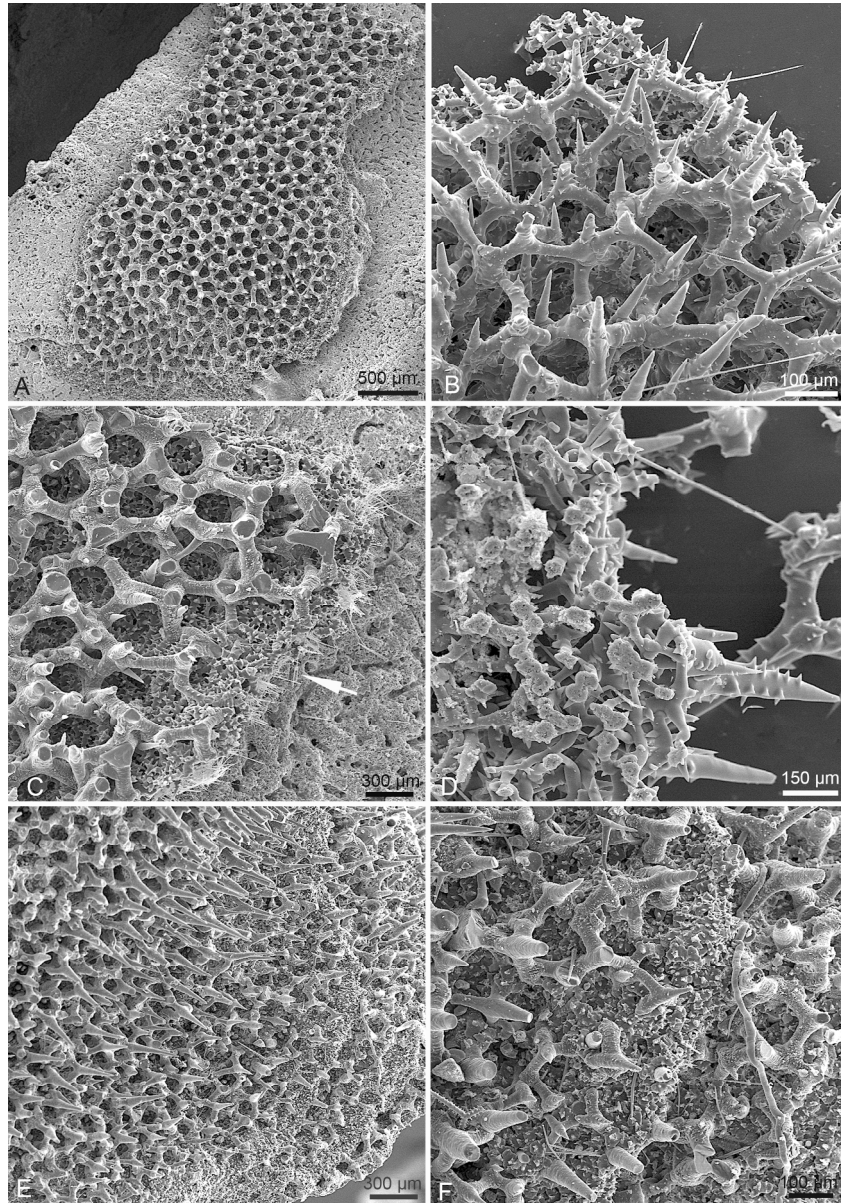
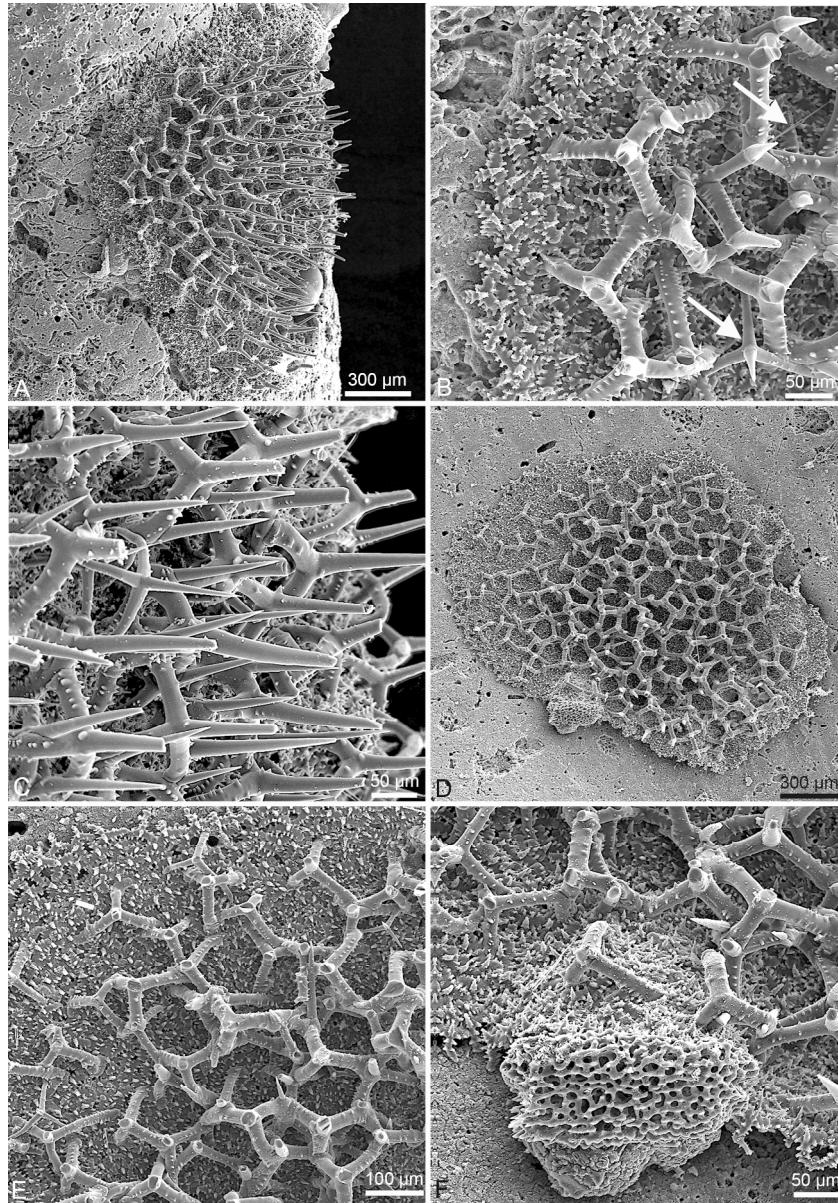


Fig. 2: A–D: Specimen from La Réunion, 470–540 m depth. B and C show some preserved free spicules, including a tuning fork triactine in C (arrow). D is a view of the underside, showing the attachment of the small tetractines by an enlarged ends on the substratum. E–F: specimen from New Caledonia, 270 m depth.

168x241mm (300 x 300 DPI)



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Fig. 3: A–C: Specimen from New Caledonia, 360 m depth. In B, presence of a tuning fork triactine and of a growing stage of large triactine (arrows). D–F: other specimen from New Caledonia, 360 m depth. In A & D, an area of the underside detached from the substratum.

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168x241mm (300 x 300 DPI)



Fig. 4: Localization of the new records of *Plectroninia*.

376x281mm (72 x 72 DPI)

Ship-Cruise	Station	Date	Depth (m)	Lat-Long	Area
(on land)	(Messinian fossil)			Carboneras	SE Spain
<i>Cryos</i> Balgim	DW152	17/06/1984	534-560	35°56.7'N-5°34.7'W	Gibraltar
<i>Cryos</i> Balgim	DW128	14/6/1984	480	35°35.3'N-3°45.1'W	Alboran Sea
<i>Capricorne</i> Biomedel	BS15	28/8/1976	1600	42°53'N-6°10'E	NW Mediterranean
<i>Antedon</i>	dredge	9/1/1971	180	43°08'N-5°32'E	NW Mediterranean
<i>Antedon</i>	dive	25/9/1992	21	La Ciotat, cave	NW Mediterranean
<i>Le Suroit</i> Marco	DR46	28/7/1995	1150	43°43.20'N-9°18.09'E	NW Corsica
<i>Sonne</i> SO-41	DC123	16/3/1986	1644	39°56.24'N-12°37.80'E	Vavilov Seamount, NW Med.
<i>Urania</i> CS-96	157	31/12/1996	257	36°29'04"N-12°56'00"E	Sicily Strait
<i>Calypso</i>	1902	4/1965	150	32°42'N-14°14'E	Libya
<i>Bioce</i>	2692	31/8/1994	1162	64°26.60'N-28°15.50'W	SW Iceland
<i>Heliotrope</i>	trawl	4/1989	1100	52°50'N-15°W	W Ireland
<i>Victor Hensen</i> VH97	79	21/4/1997	359	36°34.7'N-11°00'W	Gorringe Seamount
<i>Le Suroit</i> Seamount-1	DE95	11/10/1987	270	35°04.6'N-12°55.3'W	Ampere Seamount
<i>Cryos</i> Balgim	DW43	2/6/1984	150	35°54.1'N-6°14.5'W	Lusitanian Bight
<i>Jean Charcot</i> Biaçores	?	1971	500-900	?	Azores
<i>Jean Charcot</i> Gibraco	DR21	8/1972	914	38°35.07'N-30°40.05'W	Azores
P.W.Hummelinck	1443	19.2.1964	200	13°11'N-59°39'W	Barbados
<i>Akaroa</i>	5C	10/9/1965	370	9°01'S-34°51.2'W	Brazil
<i>Marion Dufresne</i> MD-55	CB103	1/6/1987	200-217	23°36.4'S-42°01.7'W	Brazil
<i>Valdivial</i>	P7	21/5/1982	234-243	26°11'S-6°19'E	Walvis Ridge
<i>Meiring Naudé</i>	SM232	25/6/1979	560-620	32°14.9'S-29°10.4'E	E South Africa
<i>Meiring Naudé</i>	ZA14	7/7/1987	500	26°55.5'S-32°56.8'E	E South Africa
<i>Meiring Naudé</i>	ZA21	8/6/1987	50	26°54.8'S-32°55.0'E	E South Africa
<i>Anton Bruun</i> IIOE-7	371E	18/7/1964	132	24°46'S-35°20'E	Mozambique
<i>Vityaz</i>	2733	18/12/1988	750-755	33°23'S-44°06'E	Madagascar
<i>Marion Dufresne</i> MD-30	DC129	16/2/1982	525	46°06'S-49°17'E	Crozet
<i>Marion Dufresne</i> MD-50	DC114	19/7/1986	160	39°00.5'S-77°46.37'E	St. Paul
<i>Marion Dufresne</i> MD-50	CP145	22/7/1986	825-1020	38°40.66'S-77°35.47'E	St. Paul
<i>Marion Dufresne</i> MD-32	DC27	16/8/1982	290-310	21°22.2'S-55°46.5'E	Reunion
<i>Marion Dufresne</i> MD-32	DR62	22/8/1982	630-710	21°08.7'S-55°11.8'E	Reunion
<i>Marion Dufresne</i> MD-32	FA96	28/8/1989	350-750	19°41.5'S-54°08.3'E	Reunion
<i>Marion Dufresne</i> MD-32	FA117	31/8/1982	450-540	20°51.5'S-55°08.5'E	Reunion
<i>Marion Dufresne</i> MD-32	FA119	1/9/1989	708-720	20°52.2'S-55°05.9'E	Reunion
<i>Marion Dufresne</i> MD-32	FA137	3/9/1982	940-980	20°45.8'S-55°35.6'E	Reunion
<i>Albatross</i>	5312	4.11.1908	256	21°30'N-116°32'E	E China Sea
<i>Vauban</i> Musorstom-1	32	23/3/1976	184-194	14°02.2'N-120°17.7'E	Philippines
<i>Coriolis</i> Musorstom-3	126	4/6/1985	266	11°49.2'N-121°22.1'E	Philippines

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4	Danish Exp Kei Isl	25	16.4.1922	85	5°34'20"S-132°55'E	Indonesia
5	Vauban	475	2/3/1985	415-460	18°35.7'S-163°11.2'E	New Caledonia
6	Jean Charcot Biocal	DW64	3/9/1985	250	24°47.93'S-168°09.12'E	New Caledonia
7	Jean Charcot Biogeocal	DW253	16/4/1987	310-315	21°31.75'S-166°28.7'E	New Caledonia
8	Jean Charcot Biogeocal	DW307	1/5/1987	470-480	20°35.38'S-166°55.25'E	New Caledonia
9	Coriolis Chalcal-2	DW78	30/10/1986	233	23°41.30'S-167°59.60'E	New Caledonia
10	Le Suroit Calsub	14/1029	5/3/1989	500	20°38'S-165°56.6'E	New Caledonia
11	Le Suroit Calsub	16/1031	7/3/1989	400-500	20°37.8'S-167°02'E	New Caledonia
12	Vauban Musorstom-4	DW162	16/9/1985	525	18°35.0'S-163°10.3'E	New Caledonia
13	Coriolis Musorstom-5	DW299	11/10/1986	360-390	22°47.70'S-159°23.70'E	New Caledonia
14	Coriolis Musorstom-5	DW304	12/10/1986	385-420	22°10.34'S-159°25.51'E	New Caledonia
15	Alis Musorstom-6	DW394	13/2/1989	570	20°49.64'S-167°09.11'E	New Caledonia
16	Alis Musorstom-6	DW397	13/2/1989	380	20°47.35'S-167°05.17'E	New Caledonia
17	Alis Musorstom-6	DW399	14/2/1989	282	20°41.80'S-167°00.20'E	New Caledonia
18	Alis Musorstom-6	DW400	14/2/1989	270	20°42.18'S-167°00.40'E	New Caledonia
19	Alis Musorstom-6	DW402	14/2/1989	520	20°30.27'S-166°49.28'E	New Caledonia
20	Alis Musorstom-6	DW407	15/2/1989	60	20°40.70'S-167°06.60'E	New Caledonia
21	Alis Musorstom-6	DW410	15/2/1989	490	20°38.05'S-167°06'E	New Caledonia
22	Alis Musorstom-6	DW416	16/2/1989	343	20°42.15'S-166°59.60'E	New Caledonia
23	Alis Musorstom-6	CP455	20/2/1989	260	21°00.65'S-167°26.08'E	New Caledonia
24	Alis Musorstom-6	DW459	20/2/1989	425	21°01.39'S-167°31.47'E	New Caledonia
25	Alis Musorstom-6	CP464	21/2/1989	430	21°02.30'S-167°31.60'E	New Caledonia
26	Alis Musorstom-6	CP468	21/2/1989	600	21°05.86'S-167°32.98'E	New Caledonia
27	Alis Musorstom-6	DW473	22/2/1989	236	21°08.80'S-167°55.50'E	New Caledonia
28	Alis Musorstom-6	DW474	22/2/1989	260	21°08.80'S-167°55.50'E	New Caledonia
29	Alis-Musorstom-6	DW483	23/2/1989	600	21°19.80'S-167°47.80'E	New Caledonia
30	Vauban SMIB-3	DW18	23/5/1987	338	23°41.5'S-167°59.4'E	New Caledonia
31	Alis SMIB-4	DW37	7/3/1989	515-540	24°54.50'S-168°22.30'E	New Caledonia
32	Alis SMIB-4	DW39	7/3/1989	525-560	24°56.20'S-168°21.50'E	New Caledonia
33	Alis-SMIB-4	DW53	9/3/1989	270	23°40.1'S-167°59.09'E	New Caledonia
34	Alis SMIB-5	DW71	7/3/1989	265	23°41.30'S-168°00.70'E	New Caledonia
35	Alis-SMIB-5	DW101	14/2/1989	270	23°21.1'S-168°04.9'E	New Caledonia
36	Alis SMIB-8	DW169	29/1/1993	447-450	23°37'S-167°42'E	New Caledonia
37	NZOI	C527	10.9.1960	508	32°30'S-179°12'W	Kermadec
38	S.P.Lee L3-84-SP	21-8	4/1984	700	24°56'S-176°38'W	Tonga
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