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THE MAGELLAN-ANTARCTIC CONNECTION: LINKS AND FRONTIERS AT HIGH SOUTHERN LATITUDES.
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Zoogeographical relationships of the littoral ascidiofauna around the Antarctic Peninsula, in the Scotia Arc and in the Magellan region*

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SUMMARY: Three Spanish Antarctic research cruises (Ant-8611, Bentart-94 and Bentart-95) were carried out in the South Shetland Archipelago (Antarctic Peninsula) and Scotia Arc (South Orkney, South Sandwich and South Georgia archipelagos) on the continental shelf and upper slope (10-600 m depth). They have contributed to our knowledge about ascidian distribution and the zoogeographical relationships with the neighbouring areas and the other Subantarctic islands. The distribution of ascidian species suggests that the Scotia Arc is divided into two sectors, the South Orkney Archipelago, related to the Antarctic Province, and the South Georgia Archipelago (probably including the South Sandwich Archipelago), which is intermediate between the Antarctic Province and the Magellan region.

Keywords: ascidians, Antarctic, Scotia Arc, Magellan, biogeography.

RESUMEN: RELACIONES ZOOGEOGRÁFICAS DE LA ASCIDIOFAUNA LITORAL EN LA PENÍNSULA ANTÁRTICA, ARCO DE SCOTIA Y REGIÓN MAGALLÁNICA. – Tres campañas antárticas españolas (Ant-86, Bentart-94 y Bentart-95) en el Archipiélago de las Shetland del Sur (Península Antártica) y Arco de Scotia (Archipiélagos de las Órcadas del Sur, Sandwich del Sur y Georgia del Sur), sobre fondos de la plataforma continental y parte superior del talud (profundidades entre 10 y 600 m), han contribuido a ampliar el conocimiento de la distribución de las ascidias en estas zonas, y sus relaciones biogeográficas con las áreas vecinas y otras islas subantárticas. Desde el punto de vista de la ascidiofauna, el Arco de Scotia se divide en dos sectores, por un lado las Órcadas del Sur más relacionadas con la Provincia Antártica; y por otro el Archipiélago de las Georgias del Sur (y probablemente las islas Sandwich del Sur) que ocupa una posición intermedia entre la Provincia Antártica y la región magallánica.

Palabras clave: ascidias, Antártida, Arco de Scotia, Magallanes, biogeografía.

INTRODUCTION

The Antarctic Province represents one of the most clearly defined biogeographic divisions in the world. Its northern limit is defined by the Antarctic Convergence (Ekman, 1967, Hedgpeth, 1969; Briggs, 1974; Knox, 1994; Crame, 1999). However, there are several hypotheses about the subdivisions of the Antarctic region, and their relationships with the Scotia Arc and the Magellan region. Ekman (1967) and Briggs (1974) consider two main subdivisions (subregions of Ekman, and provinces *sensu* Briggs). The latter proposed: i) a high Antarctic subregion or South Polar Province containing the continental coastal area and adjoining islands (including the South Shetland, South Orkney and South Sandwich archipelagos); and ii) a low Antarctic subregion or South Georgia Province containing the

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South Georgia Archipelago and the Shag Rock Bank. Dell (1972) opposed this hypothesis on the relationships of the Antarctic benthic fauna, emphasising that there is little evidence to warrant biogeographic subdivisions. Recently, Knox (1994), following Hedgpeth's scheme (1969), considered the Subantarctic region to be divided into the Magellan and Kerguelen Provinces or subregions; the Antarctic region in the western Antarctic, with the Antarctic Peninsula and the Scotia Arc (with the South Georgia district); and the Continental Antarctic. Longhurst (1998), basing his conclusions on plankton ecology, proposed that the Scotia Arc and the South Georgia Archipelago be included in the Austral Polar Province (Antarctic continent and adjoining islands). Arntz (1999) stressed the necessity of more effort in taxonomy to improve knowledge on floral and faunal relationships between the Antarctic and Magellan regions.

From a biogeographical point of view, the ascidians represent an excellent taxon for studying possible affinities between zones (Kott, 1969; Millar, 1971; Monniot and Monniot, 1983; Ramos-Esplá, 1991), and they have a high percentage of endemisms in the Antarctic region (about 34-38% in the Antarctic and Subantarctic regions in Monniot and Monniot, 1983). In terms of numbers and biomass, ascidians represent one of the main sessile benthic groups on the Antarctic continental shelf (Kott, 1969; Monniot and Monniot, 1983; Arnaud *et al.*, 1998), and they play an important role in the structure of filter-feeding communities (Gallardo, 1987; Jazdzewski *et al.*, 1986; Dayton, 1990; Galéron *et al.*, 1992; Arntz *et al.*, 1994, 1997; Sahade *et al.*, 1998; Kowalke, 1999; Gili *et al.*, 2001).

The Antarctic ascidiofauna has been well studied (see references in Van Name, 1945; Millar, 1960; Kott, 1969; Monniot and Monniot, 1983), and recent studies have focused on the South Shetland Archipelago and Weddell Sea (Rauschert, 1991; Monniot and Monniot, 1994; Luján and Ramos-Esplá, 1996; Tatián *et al.*, 1998; Varela and Ramos-Esplá, 2003). Also, the Scotia Arc and the Magellan region have been the subject of recent ascidian studies (Sanamyan and Schories, 2003). (Tatián and Sahade in Arntz and Brey, 2003). This study explores the biogeographical relationships of the Antarctic Peninsula and Scotia Arc with the Antarctic continent, Magellan region and the Subantarctic islands from the point of view of littoral ascidiofauna.

MATERIAL AND METHODS

Ascidians were collected (Table 1) on three Spanish Antarctic cruises: Ant-8611 (Scotia Arc and Elephant Island) with the fisheries vessels 'Pescapuerta IV' and 'Nuevo Alcocero'; and Bentart-94 (Livingston and Deception Islands) and Bentart-95 (Livingston, Deception and Trinity Island, and Bransfield Strait) with the RV 'Hespérides'. The samples were taken from the continental shelf and from upper slope locations, between 10 and 600 m depth, by SCUBA diving and remote sampling gears (Agassiz trawl, rocky and anchor dredges and Van Veen grab). Macrobenthos ($\varnothing \geq 1$mm) was sorted by sieve and the ascidians were separated, anaesthetised in menthol, and fixed/preserved in neutral formalin (10% in sea water with borax).

With regard to the ascidian distribution, we considered the following zones: i) the Antarctic region separating the Antarctic Peninsula (Graham and Palmer Lands, and adjoining islands, including the South Shetland Archipelago) from the Antarctic Continent; ii) the Scotia Arc, including the South Orkney, South Sandwich and South Georgia archipelagos; iii) the Magellan region, south of a line from Chiloé Island (at 42°S) to the mouth of the Rio de la Plata (at 35°S); and iv) the Subantarctic islands (Bouvet, Prince Edwards, Marion, Crozet, Kerguelen, Heard, MacDonald, Macquarie). For the purpose of distributional analysis we considered the shore or littoral ascidiofauna extending from the surface down to 500 m depth. This arbitrary depth was selected because the Antarctic ascidian fauna is rather uniform over this range (Briggs, 1974) and some deep Antarctic ascidian species such as *Cibacapsa gulosa* reach 500-600 m depth (Monniot and Monniot, 1983, 1994).

The presence/absence data were aggregated by the Bray-Curtis similarity index, and the analysis of the relationships between species and zones was carried out by hierarchical agglomerate (group average) clustering for the species and multidimensional scaling analysis (MDS) for the zones indicated above: the Antarctic Continent (AC), the Antarctic Peninsula (AP), the South Orkney (SO), South Sandwich (SS) and South Georgia (SG) archipelagos, the Magellan region (MR) and the Subantarctic islands (SAI), using the PRIMER software package (Clarke and Warwick, 1994). With regard to the ascidian distribution, we followed mainly the work of Monniot and Monniot (1983: Table IV) and completed it with recent data.

TABLE 1. – Ascidians recorded on the Spanish Antarctic cruises (Ant-8611, Bentart94 and Bentart95). Depth range: (1) 0-100 m; (2) 101-200 m; (3) 201-500 m; (4) 500-800 m.

Cruises (date)	Ant-8611 (22/11/86-05/02/87)						Bentart-94 (24/01-11/02/94)			Bentart-95 (16/01-04/02/95)									Total
Area	S. Georgia Is.		S. Sandwich Is.		S. Orkney Is		South Livingston Is.			Deception Is.		Livingston Is.			Antarctic Peninsula				Ind/col.
Latitude (S)	53°22'-55°28'		56°14'-59°00'		60°26'-61°53'		62°38'-62°45'			62°49'-62°59'		62°01'-62°46'			63°56'-63°59'				
Longitude (W)	34°21'-42°07'		26°14'-27°33'		43°03'-47°12'		60°21'-60°44'			60°32'-60°40'		60°19'-60°40'			60°41'-60°59'				
Depth range (n° ascidian samples)	2 (15)	3 (23)	2 (3)	3 (1)	3 (14)	4 (1)	1(27)	2 (12)	3 (2)	1 (2)	2 (6)	1 (7)	2 (5)	3 (7)	1 (1)	2 (1)	3 (2)		
Aplidium cyaneum Monniot and Monniot, 1983	.	.	.	.	.	.	6	1	.	.	.	1	.	.	.	.	.		8
Aplidium falklandicum Millar, 1980	7	2	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.		19
Aplidium imbutum Monniot and Monniot, 1983	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.		1
Aplidium loricatum F. Monniot, 1970	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.		2
Aplidium meridianum (Sluiter 1906)	2	1	1	.	1	.	15	.	.	.	.	1	.	.	.	.	10		31
Aplidium millari Monniot and Monniot, 1994	.	.	.	.	.	.	19	.	.	.	.	.	.	.	.	.	.		19
Aplidium radiatum (Sluiter, 1906)	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.		3
Synoicum adareanum (Herdman, 1902)	19	11	4	1	3	.	130	64	.	.	14	177	30	11	1	15	31		511
Synoicum ostentor Monniot and Monniot, 1983	.	.	.	.	.	.	70	20	.	.	.	.	.	.	.	.	.		90
Cystodytes antarcticus Sluiter, 1912	.	.	.	.	.	.	2	.	.	.	.	.	1	.	.	.	.		3
Distaplia colligans Sluiter, 1932	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.		1
Distaplia cylindrica (Lesson, 1830)	2	5	.	.	1	.	1	1	.	.	.	2	3	3	.	.	.		18
Sycozoa georgiana (Michaelsen, 1907)	.	.	.	.	.	.	12	.	.	.	.	.	.	.	.	.	.		12
Polysyncraton trivolutum (Millar, 1960)	.	.	.	.	.	.	5	.	.	.	3	31	.	.	.	.	.		39
Tylobranchion speciosum Herdman, 1886	.	.	.	.	.	.	122	4	2	.	.	10	.	.	.	.	.		138
Corella eumyota Traustedt, 1882	.	.	.	.	.	.	9	3	.	.	.	8	3	.	.	.	.		23
Agnezia biscoei (Monniot and Monniot, 1983)	.	.	.	.	5	.	94	.	52	.	.	80	.	.	.	.	.		231
Caenagnesia bocki Ärnback, 1938	.	.	.	.	.	.	126	.	.	.	9	.	.	.	.	.	.		135
Caenagnesia schmitti Kott, 1969	.	.	.	.	.	.	1	.	.	.	1	.	.	.	.	.	.		2
Ascidia challengeri Herdman, 1882	.	3	.	.	.	1	29	7	.	.	3	183	3	.	.	1	.		230
Cnemidocarpa drygalskii (Hartmeyer, 1911)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3		3
Cnemidocarpa pfefferi (Michaelsen, 1898)	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	2		4
Cnemidocarpa verrucosa (Lesson, 1830)	.	8	.	.	4	2	8	1	.	4	22	6	.	3	2	2	2		64
Dicarpa insinuosa (Sluiter, 1912)	.	.	.	.	.	.	.	1	.	.	2	.	.	.	.	1	.		4
Styela glans Herdman, 1881	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.		1
Styela wandeli (Sluiter, 1911)	3	.	.	.	.	.	55	.	.	.	.	16	.	.	.	.	.		71
Bathypera splendens Michaelsen, 1904	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.		1
Pyura bouvetensis (Michaelsen, 1904)	1	6	.	.	5	.	.	.	.	.	1	7	.	5	19	14	16		69
Pyura discoveryi (Herdman, 1910)	38	80	.	.	2	1	5	.	.	.	.	.	.	1	1	1	3		132
Pyura georgiana (Michaelsen, 1898)	4	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		15
Pyura legumen (Lesson, 1830)	1	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		8
Pyura lycoperdon Monniot and Monniot, 1983	.	.	.	.	.	.	16	17	.	.	.	9	.	.	.	.	.		42
Pyura obesa Sluiter, 1912	.	.	.	.	2	.	12	.	.	.	.	11	2	1	.	.	.		28
Pyura setosa (Sluiter, 1905)	.	.	.	.	.	.	.	3	.	.	.	1	1	.	.	1	9		15
Pyura squamata Hartmeyer, 1909	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		1
Eugyrioides polyducta Monniot and Monniot, 1983	.	.	.	.	.	.	22	.	.	.	3	5	15	.	.	.	.		45
Molgula enodis (Sluiter, 1912)	.	.	.	.	.	.	24	.	.	.	1	6	.	.	.	.	.		31
Molgula hodgsoni Herdman, 1910	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	5	.		1
Molgula marioni Millar, 1960	2	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		5
Molgula mortenseni (Michaelsen, 1922)	.	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		7
Molgula pedunculata Herdman, 1881	1	9	.	.	2	.	93	5	.	140	338	107	10	8	.	.	.		713
Paraeugyrioides arnbackae (Millar, 1960)	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.		1
N° colonies or individuals	80	154	5	1	28	4	890	128	54	144	397	664	70	32	23	40	76		2790
N° species	11	14	2	1	11	3	27	13	2	2	11	19	11	7	4	8	8		42

RESULTS AND DISCUSSION

Species groups

On the three Spanish Antarctic cruises Ant-8611, Bentart-94 and Bentart-95, forty-two species (Table 1) with about 2800 specimens were identified. Some species have enlarged their distribution zones: i) *Synoicum adareanum, Styela wandeli, Pyura bouvetensis, P. legumen, P. squamata, Molgula marioni* and *M. mortenseni* in South Georgia; ii) *Aplidium millari* and *Synoicum ostentor* in the South Shetlands (Antarctic Peninsula); iii) *Synoicum adareanum* and *Aplidium meridianum* in the South Sandwich Islands; and iv) *Agnesia biscoei, Cnemidocarpa pfefferi* and *Pyura obesa* in the South Orkney Islands.

The species cluster analysis (Fig. 1) from the sampled ascidians, with the records (Table 2) of different authors (Millar, 1960; Kott, 1969, 1971; Monniot and Monniot, 1983; 1994; Sanamyan and Schories, 2003), discriminates two main groups of species (similarity < 40%): I) the South Georgia-Magellan group (4 spp, 9.5% of the total), *Pyura legumen, Molgula marioni* and *M. mortenseni*, and *Pyura georgiana* (an endemic species to South Georgia); and II) species with Antarctic distribution (38 spp., 90.5% of the total), some of them present in the Magellan region, the Scotia Arc and/or the Subantarctic islands.

In this second group three subgroups can be distinguished:

IIa) Species only found in the Antarctic Peninsula: *Aplidium radiatum, Cystodytes antarcticus* and *Pyura lycoperdon*.

IIb) Species found off the Antarctic Continent, the Antarctic Peninsula, the South Orkney and/or the South Sandwich archipelagos: *Aplidium cyaneum, A. loricatum, Aplidium millari, Synoicum ostentor, Agnesia biscoei, Caenagnesia schmitti, Pyura obesa, P. setosa,* and *Molgula enodis* and *Paraeugyroides arnbackae,* with *Styela glans* and *Bathypera splendens* (euribathyc species also reported in the Magellan region).

IIc) Species present in the Antarctic Region, the Scotia Arc, including South Georgia Archipelago (*Caenagnesia bocki, Cnemidocarpa pfefferi, Dicarpa insinuosa, Syela wandeli, Pyura discoveryi, Eugyroides polyducta* and *Molgula hodgsoni*), and some of them with a wide distribution in the Magellan Region and/or in the rest of the Subantarctic islands (*Aplidium falklandicum, A. imbutum, A. meridianum, Synoicum adareanum, Distaplia colligans, D. cylindrica, Sycozoa georgiana, Polysyncraton trivolutum, Tylobranchion speciosum, Corel-*

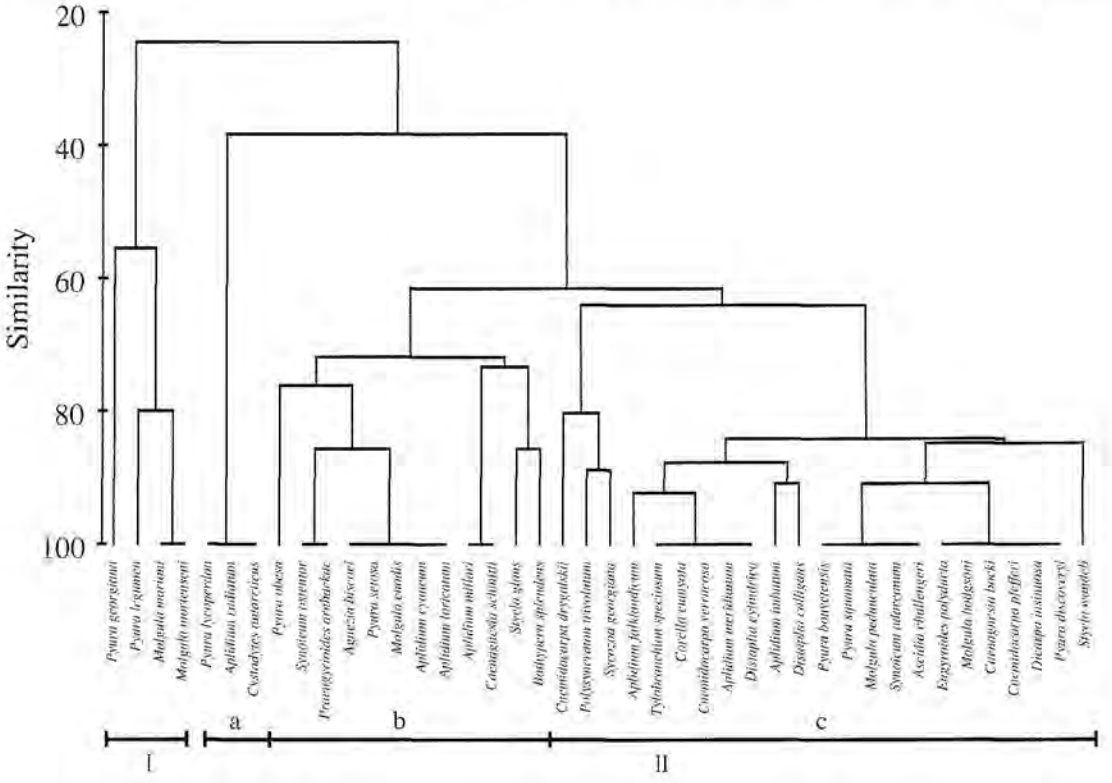

FIG. 1. – Cluster dendrogram of the sampled ascidian species with regard to the biogeographical affinities.

TABLE 2. – Distribution of the Antarctic and Subantarctic ascidiofauna: (AC) Antarctic continent; (AP) Antarctic Peninsula; (MR) Magellan region; (SAI) Subantarctic islands (Gough, Bouvet, Prince Edward, Marion, Crozet, Kerguelen, Heard, McDonald, Macquarie); (SG) South Georgia Is.; (SO) South Orkney Is.; (SS) South Sandwich Is.. (Dr) depth range: (1) 0-200 m; (2) 201-500 m; (3) 501-1000 m); (4) > 1000 m. (AZ) other zones: (1) Chile (<42°S), Peru (>17°S); (2) New Zealand sector (<50°S); (3) Tasmania, Southern Australia; (4) South Africa, Namibia; (5) Cosmopolitan.

	MR	SG	SS	SO	AP	AC	SAI	Dr	AZ
Fam. Polyclinidae Verrill, 1871									
Aplidiopsis discoveryi Millar, 1960	+	.	.	.	.	.	.	1	2
Aplidiopsis pyriformis Herdman, 1886	.	.	.	.	.	.	+	1	.
Aplidium acropodium Monniot and Gail, 1978	.	.	.	.	.	.	+	1	.
Aplidium annulatum Sluiter, 1906	.	.	.	.	+	.	.	1	.
Aplidium aurorae (Harant and Vernières, 1938)	.	.	.	.	.	+	.	1-2	.
Aplidium balleniae Monniot and Monniot, 1983	.	.	.	.	.	+	.	1	.
Aplidium bilinguae Monniot and Monniot, 1983	.	+	.	.	.	+	.	1-2	.
Aplidium circumvolutum (Sluiter, 1900)	+	+	.	.	+	.	+	1-2	1
Aplidium cyaneum Monniot and Monniot, 1983	.	.	.	+	+	+	.	1-4	.
Aplidium didemniformis Monniot and Gail, 1978	.	.	.	.	.	.	+	1	.
Aplidium falklandicum Millar, 1960	+	+	.	+	+	.	+	1-2	.
Aplidium fuegiense Cunninghan, 1871	+	+	.	+	+	+	+	1-3	1
Aplidium globosum (Herdman, 1886)	.	.	+	+	.	.	+	1-3	.
Aplidium gracile Monniot and Monniot, 1983	+	.	.	.	.	.	.	1-3	.
Aplidium hians Monniot and Gail, 1978	.	.	.	.	.	.	+	1	.
Aplidium imbutum Monniot and Monniot, 1983	+	+	.	+	+	+	.	1-3	.
Aplidium irregulare (Herdman, 1886)	+	.	.	.	.	.	.	1-3	.
Aplidium laevigatum Herdman, 1886	+	.	.	.	.	.	+	1	.
Aplidium leviventer Monniot and Gail, 1978	.	.	.	.	.	.	+	1	.
Aplidium longum F.Monniot, 1970	+	.	.	.	.	.	+	1	.
Aplidium loricatum (Harant and Vernières, 1938)	.	.	.	+	+	+	.	1-3	.
Aplidium magellanicum Sanamyan and Schories, 2003	+	.	.	.	.	.	.	1	
Aplidium meridianum, (Sluiter, 1906)	+	+	+	+	+	+	+	1-4	.
Aplidium millari Monniot and Monniot, 1994	.	.	.	.	+	+	.	1-2	.
Aplidium miripartum Monniot and Monniot, 1983	.	.	.	.	+	.	.	1-2	.
Aplidium nottii (Brewin, 1951)	.	.	.	.	.	.	+	1	2
Aplidium novaezealandiae Brewin, 1952	.	.	.	.	.	.	+	1	2
Aplidium ordinatum (Sluiter, 1906)	.	.	.	.	+	+	.	1-2	.
Aplidium ovum F. Monniot and Gaill, 1978	+	.	.	.	.	.	+	1-2	3
Aplidium paessleri (Michaelsen, 1907)	+	+	.	.	.	.	.	1	.
Aplidium pellucidum Kott, 1971	+	.	.	.	.	.	.	1	.
Aplidium pererratum (Sluiter, 1912)	.	.	+	+	+	+	.	1-2	.
Aplidium peresi F. Monniot, 1970	.	.	.	.	.	.	+	1	.
Aplidium quadriversum Millar, 1982	.	.	.	.	.	.	+	1	.
Aplidium radiatum (Sluiter, 1906)	.	.	.	.	+	.	.	1	.
Aplidium recumbens (Herdman, 1886)	+	.	+	+	+	.	.	1-2	.
Aplidium retiforme (Herdman, 1886)	.	.	.	.	.	.	+	1	.
Aplidium siderum Monniot and Monniot, 1983	.	.	.	.	+	.	.	1	.
Aplidium stanleyi Millar, 1960	+	+	.	.	+	.	.	1-2	.
Aplidium stewartense (Michaelsen, 1924)	+	+	.	.	.	.	+	1	2
Aplidium triplex (Sluiter, 1906)	+	.	.	.	+	.	.	1-2	.
Aplidium undulatum F. Monniot and Gaill, 1978	+	.	.	.	.	.	+	1	.
Aplidium vanhoffeni Hartmeyer, 1911	.	.	.	.	.	+	.	2	.
Aplidium variabile (Herdman, 1886)	+	+	.	.	.	.	+	1-2	2
Aplidium vastum (Sluiter, 1912)	.	.	.	.	+	.	.	1	.
Aplidium vexillum Monniot and Gail, 1974	.	.	.	.	.	.	+	1	.
Placentella translucida Kott, 1969	.	.	.	.	+	.	.	2	.
Polyclinum sluiteri Brewin, 1956	+	.	.	.	.	.	.	2,3	2
Ritterella mirifica Monniot and Monniot, 1983	.	.	.	.	+	+	.	2	.
Synoicum adareanum (Herdman, 1902)	.	+	+	+	+	+	+	1-3	.
Synoicum georgianum Sluiter, 1932	+	+	+	+	+	+	+	1-2	.
Synoicum giardi (Herdman, 1886)	+	+	.	.	.	.	+	1	.
Synoicum kerguelenense Hartmeyer, 1911	.	.	.	.	.	.	+	1	.
Synoicum ostentor Monniot and Monniot, 1983	.	.	+	.	+	+	.	1-2	.
Synoicum polygyna Monniot and Monniot, 1980	.	.	.	.	.	+	.	2	.
Synoicum ramulosum Kott, 1969	.	.	.	.	.	+	.	1	.
Synoicum salivum Monniot and Gail, 1978	.	.	.	.	.	.	+	1	.
Fam. Didemnidae Giard, 1872									.
Didemnum biglans (Sluiter, 1906)	.	+	+	+	+	+	.	1-4	.
Didemnum studeri Hartmeyer, 1911	+	+	.	+	.	.	+	1-4	2,3
Didemnum subflavum (Herdman, 1886)	.	.	.	.	.	.	+	1	.
Didemnum tenue (Herdman, 1886)	+	+	.	.	.	.	.	2-4	.
Diplosoma antarcticum Kott, 1969	.	.	.	.	+	+	.	1	.
Diplosoma longinquum (Sluiter, 1912)	.	+	.	.	+	.	.	1-2	.
Leptoclinides capensis (Michaelsen, 1934)	.	.	.	.	.	.	+	1	4
Leptoclinides kerguelenensis Kott, 1954	.	.	.	.	.	.	+	1	.
Polysyncraton trivolutum (Millar, 1960)	+	+	.	.	+	+	+	1-3	.
Trididemnum auriculatum (Michaelsen, 1934)	+	.	.	.	.	.	.	1	.
Trididemnum propinquum (Herdman, 1886)	+	.	.	.	.	.	.	2	.

TABLE 2 (CONT.). – Distribution of the Antarctic and Subantarctic ascidiofauna: (AC) Antarctic continent; (AP) Antarctic Peninsula; (MR) Magellan region; (SAI) Subantarctic islands (Gough, Bouvet, Prince Edward, Marion, Crozet, Kerguelen, Heard, McDonald, Macquarie); (SG) South Georgia Is.; (SO) South Orkney Is.; (SS) South Sandwich Is.. (Dr) depth range: (1) 0-200 m; (2) 201-500 m; (3) 501-1000 m); (4) > 1000 m. (AZ) other zones: (1) Chile (<42°S), Peru (>17°S); (2) New Zealand sector (<50°S); (3) Tasmania, Southern Australia; (4) South Africa, Namibia; (5) Cosmopolitan.

	MR	SG	SS	SO	AP	AC	SAI	Dr	AZ
Fam. Polycitoridae Michaelsen, 1904									
Cystodites antarcticus Sluiter, 1912	.	.	.	.	+	.	.	1-2	.
Distaplia colligans Sluiter, 1932	+	+	.	+	+	.	.	1-2	.
Distaplia concreta (Herdman, 1886)	.	.	.	.	.	.	+	1	.
Distaplia cylindrica (Lesson, 1830)	+	+	+	+	+	+	+	1-3	.
Eudistoma australe F. Monniot, 1978	.	.	.	.	.	.	+	1	.
Polycitor magalhaensis (Michaelsen, 1907)	+	.	+	+	.	.	.	1	.
Sycozoa anomala Millar, 1960	.	.	.	.	+	.	.	1	2
Sycozoa gaimardi (Herdman, 1886)	+	+	.	.	+	+	.	1-2	.
Sycozoa georgiana (Michaelsen, 1907)	.	+	.	.	+	+	+	1-2	.
Sycozoa sigillinoides Lesson, 1830	+	+	+	.	+	+	+	1-3	2
Tetrazona glareosa (Sluiter, 1906)	.	.	+	.	+	.	.	1	.
Fam. Cionidae Lahille, 1890									
Tylobranchion speciosum Herdman, 1886	+	+	+	+	+	+	+	1-2	.
Ciona antarctica Hartmeyer, 1911	.	.	.	.	+	+	.	1-2	.
?Ciona intestinalis (Linnaeus, 1767)	+	.	.	.	.	.	.	1-2	5
Fam. Corellidae Lahille 1890									
Corella eumyota Traustedt, 1882	+	+	.	+	+	+	+	1-3	1,2,3,4
Corynascidia cubare Monniot and Monniot, 1994	.	.	.	.	.	+	.	2	.
Xenobranchion insigne Ärnbäck-Christie-Linde, 1950	+	.	.	.	.	.	.	1	.
Fam. Agneziidae Hunstsman, 1912									
Adagnesia henriquei Monniot and Monniot, 1983	+	.	.	.	.	.	.	1	.
Adagnesia weddelli Monniot and Monniot, 1994	.	.	.	.	.	+	.	2-4	.
Agnezia antarctica Kott, 1969	.	.	.	.	.	.	+	1	.
Agnezia arnaudi (Monniot and Monniot, 1974)	.	.	+	.	.	+	+	1	.
Agnezia biscoei (Monniot and Monniot, 1983)	.	.	+	+	+	+	.	1	.
Agnezia glaciata (Michaelsen, 1898)	+	.	.	.	.	.	.	1	.
Agnezia tenue (Monniot and Monniot, 1983)	+	.	.	.	.	.	.	1	.
Caenagnesia bocki Ärnback, 1938	.	+	+	.	+	+	.	1-3	.
Caenagnesia schmitti Kott, 1969	.	.	.	.	+	+	.	1-4	.
Fam. Ascidiidae Adams, 1858									
Ascidia challengeri Herdman, 1882	.	+	.	+	+	+	+	1-4	3,4?
Ascidia meridionalis Herdman, 1880	+	+	.	.	.	.	.	1-4	.
Ascidia translucida Herdman, 1880	.	+	.	.	.	.	+	1-2	3
Fam. Styelidae Sluiter, 1895									
Alleocarpa bacca Ärnbäck, 1929	+	.	.	.	.	.	.	1	.
Alleocarpa bridgesi Michaelsen, 1900	+	.	.	.	.	.	.	1	.
Alleocarpa bigyna C. Monniot, 1978	.	.	.	.	.	.	+	1	.
Alleocarpa incrustans (Herdman, 1886)	+	+	.	.	.	.	.	1	.
Cnemidocarpa barbata Vinogradova, 1962	.	.	.	.	.	+	+	1	.
Cnemidocarpa drygalskii (Hartmeyer, 1911)	.	.	.	.	+	+	+	1-3	.
Cnemidocarpa effracta C. Monniot, 1978	.	.	.	.	.	.	+	1	.
Cnemidocarpa eposi Monniot and Monniot, 1994	.	.	.	.	.	+	.	2	.
Cnemidocarpa minuta (Herdman, 1881)	.	.	.	.	.	.	+	1	.
Cnemidocarpa nordenskjöldi (Michaelsen, 1898)	+	.	.	.	.	.	.	1	.
Cnemidocarpa ohlini (Michaelsen, 1898)	+	.	.	.	.	.	.	1-2	.
Cnemidocarpa pfefferi (Michaelsen, 1898)	.	+	.	+	+	+	.	1-3	.
Cnemidocarpa robinsoni Hartmeyer, 1926	+	.	.	.	.	.	.	1	1
Cnemidocarpa verrucosa (Lesson, 1830)	+	+	+	+	+	+	+	1-2	.
Cnemidocarpa victoriae Monniot and Monniot, 1983	+	.	.	.	.	.	.	1-2	.
Dextrocarpa misanthropos C. Monniot, 1978	.	.	.	.	.	.	+	1	.
Dicarpa cornicula (C. Monniot, 1978)	.	.	.	.	.	.	+	1	.
Dicarpa insinuosa (Sluiter, 1912)	.	+	.	.	+	+	.	1-2	.
Dicarpa tricostata (Millar, 1960)	.	+	.	.	.	+	.	1	.
Oligocarpa megalorchis Hartmeyer, 1911	.	.	.	.	.	.	+	1	.
Polyzoa minor C. Monniot, 1970	.	.	.	.	.	.	+	1	.
Polyzoa opuntia Lesson, 1830	+	+	+	.	.	.	+	1	.
Styela glans Herdman, 1881	+	.	.	.	+	+	.	1-4	.
Styela malgalhaensis Michaelsen, 1898	+	.	.	.	.	.	.	1-3	.
Styela mallei C. Monniot, 1978	.	.	.	.	.	.	+	1	.
Styela materna Monniot and Monniot, 1983	.	+	+	.	.	.	.	1-2	.
Styela paessleri Michaelsen, 1898	+	.	.	.	.	.	.	1	.
Styela schmitti f. simplex Millar, 1960	+	.	.	.	.	.	.	1	.
Styela squamosa Herdman, 1881	?	+	+	+	.	+	.	1-4	3
Styela talpina C. Monniot, 1978	.	.	.	.	.	.	+	1	.
Styela wandeli (Sluiter, 1911)	.	+	.	+	+	.	.	1	.

TABLE 2 (CONT.). – Distribution of the Antarctic and Subantarctic ascidiofauna: (AC) Antarctic continent; (AP) Antarctic Peninsula; (MR) Magellan region; (SAI) Subantarctic islands (Gough, Bouvet, Prince Edward, Marion, Crozet, Kerguelen, Heard, McDonald, Macquarie); (SG) South Georgia Is.; (SO) South Orkney Is.; (SS) South Sandwich Is.. (Dr) depth range: (1) 0-200 m; (2) 201-500 m; (3) 501-1000 m); (4) > 1000 m. (AZ) other zones: (1) Chile (<42°S), Peru (>17°S); (2) New Zealand sector (<50°S); (3) Tasmania, Southern Australia; (4) South Africa, Namibia; (5) Cosmopolitan.

	MR	SG	SS	SO	AP	AC	SAI	Dr	AZ
Fam. Pyuridae Hartmeyer, 1904									
Bathypera splendens Michaelsen, 1904	+	.	.	+	+	+	.	1-4	.
Pyura bouvetensis (Michaelsen, 1904)	.	+	.	+	+	+	+	1-3	.
Pyura chilensis Molina, 1782	+	.	.	.	.	.	.	1	1
Pyura discoveryi (Herdman, 1910)	.	+	.	+	+	+	.	1-4	.
Pyura georgiana (Michaelsen, 1898)	.	+	.	.	.	.	.	1-2	.
Pyura legumen (Lesson, 1830)	+	+	.	.	.	.	.	1	.
Pyura lycoperdon Monniot and Monniot, 1983	.	.	.	.	+	.	.	1,2	.
Pyura obesa Sluiter, 1912	.	.	.	+	+	.	.	1-2	.
Pyura paessleri (Michaelsen, 1900)	+	.	.	.	.	.	.	1,2	.
Piura pilosa Monniot and Monniot, 1974	.	.	.	.	.	.	+	1	.
Pyura setosa (Sluiter, 1905)	.	.	.	+	+	+	.	1-2	.
Pyura squamata Hartmeyer, 1909	.	+	.	+	+	+	+	2-4	.
Pyura stubenrauchi (Michaelsen, 1900)	+	.	.	.	.	.	.	1	.
Pyura tunica Kott, 1969	.	.	.	.	.	+	.	1	.
Fam. Molgulidae Lacaze-Duthiers, 1877									.
Eugyrioides guttula (Michaelsen, 1900)	+	.	.	.	.	.	.	1	.
Eugyrioides kerguelensis (Herdman, 1881	.	.	+	.	+	.	+	1	.
Eugyrioides polyducta Monniot and Monniot, 1983	.	+	+	.	+	+	.	1	.
Eugyrioides septum (C. Monniot, 1978)	.	.	.	.	.	.	+	1	.
Eugyrioides vannamei (C. Monniot, 1970)	+	.	.	.	.	.	.	1	.
Gamaster vallatum C. Monniot, 1978	.	.	.	.	.	.	+	1	.
Molgula arnbackae C. Monniot, 1978	.	+	+	.	.	.	+	1	.
Molgula enodis (Sluiter, 1912)	.	.	.	+	+	+	.	1	.
Molgula estadosi Monniot and Monniot, 1983	+	.	.	.	.	.	.	1	.
Molgula euplicata Herdman, 1923	.	+	+	+	+	+	.	1-3	.
Molgula georgiana Michaelsen, 1900	.	+	+	.	.	.	+	1	.
Molgula hodgsoni Herdman, 1910	.	+	.	+	+	+	.	1-2	.
Molgula macquariensis Kott, 1954	.	.	.	.	.	.	+	1	.
Molgula marioni Millar, 1960	+	+	.	.	.	.	+	1	.
Molgula mortenseni (Michaelsen, 1922)	+	+	.	.	.	.	.	1	2
Molgula pedunculata Herdman, 1881	.	+	+	+	+	+	+	1-3	.
Molgula pigafettae Monniot and Monniot, 1983	+	.	.	.	.	.	.	1-2	.
Molgula pulchra Michaelsen, 1900	+	+	+	.	.	.	+	1-2	.
Molgula pyriformis Herdman, 1881	+	+	.	.	.	.	.	1-4	.
Molgula robini Monniot and Monniot, 1983	.	+	.	.	+	+	.	1-4	.
Molgula setigera Ärnback-Christie-Linde, 1938	+	.	.	.	.	.	.	1	.
Molgula variazizi C. Monniot, 1978	.	.	.	.	.	.	+	1	.
Molguloides coronatum C. Monniot, 1978	.	.	.	.	.	+	+	2	.
Molguloides crinibus C. Monniot, 1978	.	.	.	.	.	.	+	2	.
Molguloides glans C. Monniot, 1978	.	.	.	.	.	.	+	2	.
Paraeugyrioides arnbackae (Millar, 1960)	.	.	+	.	+	+	.	1-4	.
Paraeugyrioides macquariensis Kott, 1954	.	.	.	.	.	.	+	1	.
Paramolgula gregaria (Lesson, 1830)	+	+	.	.	.	.	.	1-2	1
Paramolgula canioi Monniot and Monniot, 1983	+	.	.	.	.	.	.	1	.
Total spp.	70	55	28	34	63	58	73		

la eumyota, Ascidia challengeri, Cnemidocarpa drygalskii, Cnemidocarpa verrucosa, Pyura bouvetensis, P. squamata and *Molgula pedunculata*).

Zoogeographical affinities

The MDS analysis between zones (Fig. 2) for the 172 species listed in Table 2 shows the proximity between the Antarctic continent and the Antarctic Peninsula, and a clear separation from the Scotia Arc islands. The South Orkney Archipelago has a similar component to the Antarctic groups, and the ascidian fauna of the South Georgia and South Sandwich archipelagos is intermediate between that of the Antarctic, the Magellan region and the rest of the Subantarctic islands.

The comparison at species level of the main families (with percentages > 5%: Polyclinidae, Styelidae, Molgulidae, Pyuridae, Polycitoridae, Didemnidae, and Agneziidae; Table 3) confirms the differences between the archipelagos of the Scotia Arc. The South Orkney islands show similar percentages of Molgulidae (12%), Styelidae (12%), Polycitoridae (9%) and Didemnidae (6%) to the

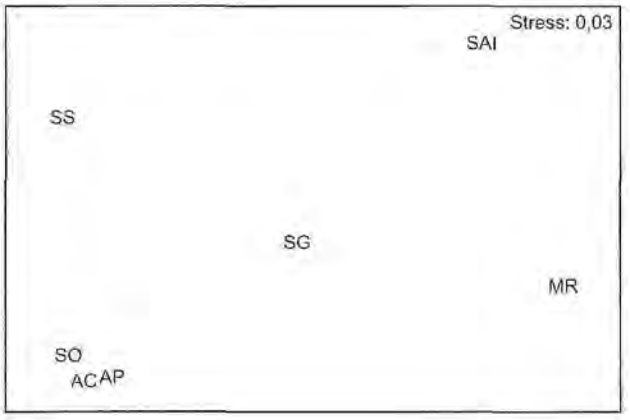

FIG. 2. – MDS analysis of the zones, based on the sampled ascidiofauna (distribution data completed with Monniot and Monniot, 1983). Legend: (AC) Antarctic Continent (without Antarctic Peninsula); (AP) Antarctic Peninsula (plus South Shetland Archipelago); (M) Magellan region; (SAI) Subantarctic Islands; (SG) South Georgia Archipelago; (SO) South Orkney Archipelago; (SS) South Sandwich Archipelago.

Antarctic region, and higher values than South Georgia and South Sandwich for Polyclinidae (32%) and Pyuridae (18%). The South Georgia and South Sandwich archipelagos have the lowest and the highest percentages of Polyclinidae (24-25%) and Molgulidae (22-29%) respectively among the Antarctic and Subantarctic zones; and Styelidae (14-16%) is intermediate between the Antarctic (12-13%) and Subantarctic (18-19%) regions. However, Pyuridae and Didemnidae are relatively important in South Georgia (9%), but scarce or never recorded (Pyuridae) in the South Sandwich Islands, whereas Agneziidae are well represented in the South Sandwich Islands (3 spp.), as in the Antarctic and Magellan regions (3-5 spp.). The lack or scarcity of the Pyuridae in the South Sandwich Islands is noteworthy, since this family presents big specimens and is easy to separate from the samples. Off the rest of the Subantarctic islands, Pyuridae are poorly represented (3 spp., with *Pyura bouvetensis* only reported from Bouvet island).

The biogeographical position of the ascidian fauna in the Scotia Arc is controversial. Reporting on this taxon, Kott (1969, 1969a) included the Antarctic Peninsula (with the Bellingshausen Sea) and the Scotia Arc in the South Georgia Province (or western Antarctic subregion, cf. Knox, 1994). However, Millar (1971) and Monniot and Monniot (1983) consider the South Georgia Archipelago to occupy an intermediate position between the Antarctic and Magellan regions, and to be a separate province, whereas the South Orkney and South Sandwich islands belong to the Antarctic region, in accordance with Ekman (1967) and Briggs (1974).

The present study supports the inclusion of the Antarctic Peninsula and adjacent islands in the Antarctic Province and the division of the Scotia Arc into two sectors: the South Orkney Archipelago, more related to the Antarctic Province, and the South Georgia Archipelago, a separate area, intermediate between the Antarctic Province and the Magellan region. The position of the South Sandwich islands is doubtful. It is related on the one hand to the South Georgia Archipelago and the Subantarctic islands, and on the other hand to the Antarctic Province. Nevertheless, the Scotia Arc has been poorly sampled, and much more sampling effort (as the LAMPOS cruise) must be carried out to elucidate its biogeographical relationships.

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TABLE 3. – Distribution by number of species (percentage in brackets) of the littoral ascidian families: (AR) Antarctic region; (MR) Magellan region; (SG) South Georgia; (SS) South Sandwich; (SO) South Orkney; (SAI) Subantarctic islands; (SAR) Subantarctic region (data from Table 2).

Families	MR	SAI	SG	SS	SO	AR	AR+SAR
Polyclinidae	23 (32.9)	27 (37.0)	13 (23.6)	7 (25.0)	11 (32.4)	29 (37.2)	57 (33.1)
Didemnidae	5 (7.1)	5 (6.8)	5 (9.1)	1 (3.6)	2 (5.9)	4 (5.1)	11 (6.4)
Polycitoridae	5 (7.1)	5 (6.8)	5 (9.1)	4 (14.3)	3 (8.8)	8 (10.3)	12 (7.0)
Cionidae	2 (2.9)	1 (1.4)	1 (1.8)	1 (3.6)	1 (2.9)	2 (2.6)	3 (1.7)
Corellidae	2 (2.9)	1 (1.4)	1 (1.8)	-	1 (2.9)	2 (2.6)	3 (1.7)
Agneziidae	3 (4.3)	2 (2.7)	1 (1.8)	3 (10.7)	1 (2.9)	5 (6.4)	9 (5.2)
Ascidiidae	1 (1.4)	2 (2.7)	3 (5.5)	-	1 (2.9)	1 (1.3)	3 (1.7)
Styelidae	13 (18.6)	13 (17.8)	9 (16.4)	4 (14.3)	4 (11.8)	10 (12.8)	31 (18.0)
Pyuridae	5 (7.1)	3 (4.1)	5 (9.1)	-	6 (17.6)	8 (10.3)	14 (8.2)
Molgulidae	11 (15.7)	14 (19.2)	12 (21.8)	8 (28.6)	4 (11.8)	9 (11.5)	29 (16.9)
N° of species	70	73	55	28	34	78	172

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