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The Antarctic-Magellan connection: Diversity and biogeography of turbellarians in the Scotia Arc

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The general objectives of this proposal were to evaluate the diversity and distribution of marine turbellarians throughout the Southern Ocean and to use this information to carry out a panbiogeographic analysis to test the vicariant processes proposed for the Scotia Arc. Sampling was carried out during two summer campaigns in King George Island (Southern Shetlands) and southern South America. The comparison of the results gathered by this project with the previous reports shows that the diversity of turbellarians in the area is greatly underestimated: A total of 106 turbellarian species were collected, including 66 that are new to science; the work carried out in the Scotia Arc area alone more than doubles the number of turbellarians previously known to be present in the whole area south of the 50ºS Parallel. This is the first time that representatives of the Order Macrostomida and the Suborder Dalyellioida have been found south of the same Parallel, and representatives of the Suborder Proseriata found in Antarctic waters. The proportion of the number of species of microturbellarians to the number of species of macroturbellarians turned out to be much higher than has been previously reported. Approximately 50% of the turbellarian species in the Southern Ocean, including those reported in the present study, have been found in a single operative unit. The generalized tracks and the node identified by the panbiogeographic study reflect the complex history of the Scotia Arc area as inferred from geological information and biogeographic data based on other taxa: an association of the northern and southern arms of the Scotia Arc was observed, as was a relationship between the Magellanic province with the northern arm. This suggests that turbellarians are a suitable group for historical biogeographic studies, which will hopefully encourage further sampling efforts to reveal more of the true distribution and diversity of this fauna.

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INTRODUCTION

The Antarctic and Magellanic biotas are clearly strongly linked, but connectivity studies are difficult because of data patchiness and quality (Arntz, 1999; Convey, 2007). Common problems include:

(i) The lack of specialists in many taxa, which leads to the lack of reliable species-level data.
(ii) The lack of studies on certain taxa in the Scotia Arc region. Comparative studies between South America and Antarctica have often had to focus on the greatly differing Magellanic region and Weddell Sea to minimize sampling bias, because the latter has been better investigated.
(iii) The highly varied biodiversity and quality of information across taxa and space in the Antarctic (Clarke *et al*., 2007). Furthermore, in recent years it has become clear that studies based on different groups of organisms yield strongly differing patterns (Griffiths *et al*., 2009), especially when comparing distributions of taxa with dispersive phases (e.g. compare Brandt *et al*, 1999; Liuzzi and Zelaya, 2004; Schrödl, 1999; Zelaya, 2005).

Living in an interstitial environment, turbellarians can be argued to have a practically null dispersal potential, which makes vicariant processes the most likely to explain their current distribution. Living in the intertidal zone means that both diversity and molecular data can be used to test the biological match to glaciological models of ice cover. This can be used to investigate whether populations have remained intact *in situ* for long periods and invasion timings where the retreat of 'permanent' ice from this habitat can be dated since the Last Glacial Maximum 15-20,000 years ago.

To date there are few examples of the use of these organisms in large-scale biogeographic studies, but they have all given consistent results:

(i) Sterrer (1973, 1977), studying the distribution of many interstitial phyla - including turbellarians - observed vast geographic ranges where the species composition of interstitial faunas showed high similarity. He proposed that, because of their low dispersal potential, the interstitial meiofauna behaves as a sessile fauna in a mobile substrate and that therefore the observed distribution was likely to be the result of slow speciation coupled with vicariant processes such as the continental drift.
(ii) Sluys (1989) studied the distribution of Southern Ocean marine planarians. He proposed vicariant geological events as the main factor to explain their current distribution, and that this observed distribution was likely to be the result of the division of a formerly continuous Gondwanian distribution area.
(iii) Sluys (1995) examined the distribution of several marine and terrestrial planarians. He pointed out that turbellarians show large-scale patterns of distribution that reflect

the continental breakdown, but that some patterns of distribution would require alternative models.

(iv) Ax and Armonies (1987, 1990) studied the distribution of boreal brackish water turbellarians, finding evidence of an ancient boreal circumpolar distribution.

The current SCAR Fellowship project aimed to provide significant data on the diversity and distribution of a group of organisms that has been overlooked in most studies of the benthic fauna of the Antarctic region, and to provide clues for the evolution of the Antarctic biota in a region of key importance for biogeographic studies. With the Antarctic Peninsula being one of the most rapidly changing environments in the world, it is imperative to undertake these kind of analysis urgently, in order to obtain reliable data before both human impact and climatic change alter the biogeographic signals provided by the biota.

OBJECTIVES

The general objectives of this proposal were to evaluate the diversity and distribution of marine turbellarians throughout the Southern Ocean and to carry out a historical Biogeographic analysis using turbellarians to test the vicariant processes proposed for the Scotia Arc.

Four specific objectives were defined:

(i) To construct a georeferenced database of contemporary turbellarian species distribution in the Southern Ocean.

(ii) To describe in more detail the biota of turbellarians in the Scotia Arc area, based on sampling in the Antarctic Peninsula, King George Island, Tierra del Fuego and the Magellan Strait.

(iii) To carry out a panbiogeographic analysis of Southern Ocean turbellarians in order to test the vicariant processes suggested for the Scotia Arc area by the available geological information.

(iv) To carry out an analysis of predictive modelling of species distribution to complement the biogeographic analysis.

METHODS

SAMPLING

Sampling was carried out during two summer campaigns (2009-2010 and 2010-2011) in the vicinity of the Base Científica Antártica Artigas (BCAA), King George Island, South Shetland

Islands (62°11’08”S, 58°54’03”W), in the surroundings of Ushuaia, Beagle Channel, Argentina (54°49’10”S, 68°11’25”W) and in the surroundings of Punta Santa Ana, Magellan Strait, Chile (53°37’57”S, 70°54’44”W). Due to adverse weather conditions, it was not possible to reach the sampling sites in the Antarctic Peninsula on either campaign.

Collections on rocky substrata were carried out in the intertidal zone, in areas with abundant *Adenocystis utricularis* (Bory de Saint-Vincent, 1825) Skottsberg, 1907 (Phaeophyceae, Ectocarpales, Adenocystaceae). On each opportunity, rock surfaces, crevices, tidal pools and substrata under rocks were searched for the presence of macroturbellarians, with a sampling effort of 2 hours. Random samples of algae were collected until an approximate volume of 0.5L was reached.

Sediment samples were taken in the intertidal zone, in areas with granules according to Wentworth’s granulometric scale. On each sampling event, an approximate volume of 0.5L was collected.

In all cases, samples were taken during the low tide period according to local tidal tables. They were kept cool at about 4ºC until they were processed, and turbellarians were extracted following Schockaert (1996).

TAXONOMY

All turbellarians in the samples were determined to the lowest possible taxonomic level (usually species level) using standard techniques, which included high-magnification observation of live animals, semi-permanent mounts and histological sections.

For the histological studies, specimens were fixed in hot (60ºC) Bouin’s picro-formol, washed with 70% ethanol, dehydrated with an ascending series of ethanol, cleared in xylene, and embedded in paraffin. Serial sections were cut at intervals of 3 µm (microturbellarians) or 5 µm (macroturbellarians), stained with Heidenhain’s iron hematoxylin and mounted in Canada balsam.

In addition, tissue samples and whole specimens were preserved in 100% ethanol and RNAlater for molecular work (including CO1 barcoding).

BIOGEOGRAPHIC ANALYSIS

STUDY AREA

The analysis was carried out using the entire distributions of all turbellarians reported from the Southern Ocean. The northern limit of the study area was set arbitrarily at the 50ºS Parallel, to include those species known to be present in the northern arm of the Scotia Arc and in the Falkland Islands. Distribution information was obtained from the data gathered from the samples and from the relevant literature.

The only species present in the study area that was not considered in the analysis was *Gyratrix hermaphroditus* Ehrenberg, 1831. Its exclusion is due to the existence of several works supporting the idea that this species is in fact a species complex (Curini-Galletti and Puccinelli, 1989, 1990, 1994, 1998; Heitkamp, 1978; Puccinelli and Curini-Galletti, 1987; Puccinelli *et al*., 1990), which would compromise any hypothesis of geographic similarity based on its populations.

OPERATIVE UNITS

The operative units were based on the system of provinces and ecoregions proposed by Spalding *et al*. (2007), defining the Marine Ecoregions of the World (MEOW). This system was chosen because it provides a higher resolution than other alternatives, and because it includes coastal and shelf areas, in which most of the marine turbellarians have been found.

Initially, data on latitude and longitude for each species were individually georeferenced on the biogeographic map of Spalding *et al*. (2007), and each locality was assigned to the corresponding ecoregion. Then minor modifications (subdivisions or combinations) were made to adjust the resolution according to the amount of information available in the different ecoregions.

PANBIOGEOGRAPHIC ANALYSIS

The distributions of informative species were used to generate individual tracks, i. e. minimum-spanning trees connecting the localities where a given taxon is present. Tracks were generated using the program Martitracks (Echeverría-Londoño & Miranda-Esquivel, 2011) because it uses a Euclidean distance parameter to simplify the initial complexity of the database.

The main criticisms directed to panbiogeographic analyses usually rest on the arbitrary nature of the construction of generalized tracks from the individual tracks. A few quantitative methodologies have been proposed to solve this, of which Parsimony Analysis of Endemicity (PAE) is the most widely applied (Ferrari *et al*., 2013). A PAE with progressive elimination of characters (PAE-PCE) was therefore applied to obtain the generalized tracks. Based on the distribution information, species were allocated to the operative units and a matrix of 76 areas per 84 taxa was constructed, including an outgroup consisting of a hypothetical area with absence of all species. Cladograms were obtained with the program TNT 1.1 (Goloboff *et al*., 2008). Wagner trees were constructed, swapping with multiple tree bisection and reconnection (TBR) applied to a series of 10 random additive sequences, saving 10 trees per replicate. When more than one equally parsimonious cladogram was found, these were summarized into a strict consensus. Clades supported by at least two synapomorphies were used to define the generalized tracks, and nodes were determined by the convergence of two or more generalized tracks.

RESULTS

TAXONOMY

A total of 106 species were collected:

1. Seventeen were identified as separate morphotypes but could not be determined to species level.

2. Eleven had already been reported for the study area: *Allostoma uterinum* (Westblad, 1952) (Prolecithophora); *Gandalfia bilunata* Willems, Artois, Vermin, Backeljau and Schockaert, 2005 (Typhloplanoida); *G. hermaphroditus*, *Porrocystis assimilis* (Levinsen, 1879) and *Uncinorhynchus flavidus* Karling, 1947 (Kalyptorhynchia); *Obrimoposthia hallezi* (Bohmig, 1908), *Obrimoposthia ohlini* (Bergendal, 1899), *Obrimoposthia wandeli* (Hallez, 1906), *Procerodes variabilis* (Bohmig, 1902) and *Synsiphonium liouvilli* Hallez, 1911 (Tricladida), and *Orthoplana bregazzii* Karling, 1973 (Proseriata).

3. Twelve are known species that have not been reported for the study area: *Archimacrostomum brasiliensis* (Marcus, 1952), *Macrostomum distinguendum* Papi, 1951, *Macrostomum peteraxi* Mack-Fira, 1971 and *Macrostomum pusillum* Ax, 1951 (Macrostomida); *Baltoplana magna* Karling, 1949, *Baltoplana valkanovi* Ax, 1959, *Carcharodorhynchus flavidus* Brunet, 1967, *Odontorhynchus lonchiferus* Karling, 1947, *Paracicerina maristoi* Karling, 1952 and *Parautelga bilioi* Karling, 1964 (Kalyptorhynchia); *Ptychopera avicularis* Karling, 1974 and *Subulagera rubra* Martens & Schockaert, 1981 (Typhloplanoida).

4. The remaining 66 species are new to science. These include 11 new genera and possibly 2 new Families.

The ratio of the number of species of macroturbellarians to the number of species of microturbellarians was identical in the three sampling areas (Figure 1).

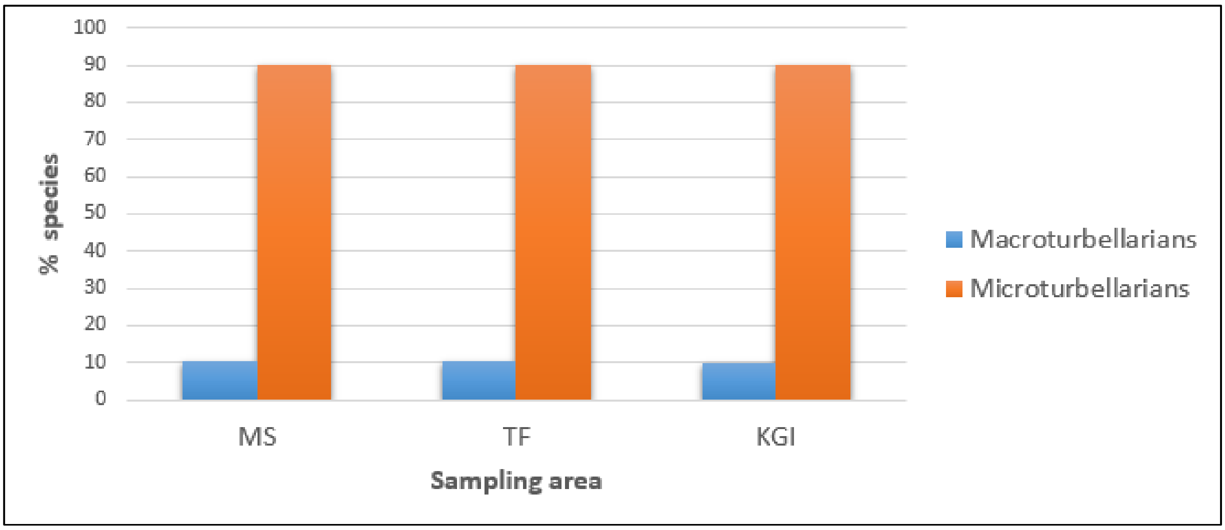

Figure 1. Proportion of macroturbellarians to microturbellarians in the three sampling areas. Abbreviations: KGI, King George Island; MS, Magellan Strait; TF, Tierra del Fuego.

Taxa composition was also similar in the three sampling areas (Figure 2): Kalyptorhynchia, Typhloplanoida and Proseriata were the more diverse taxa and Dalyellioida, Tricladida, Prolecithophora and Macrostomida were the less diverse. The latter was absent from King George Island.

BIOGEOGRAPHIC ANALYSIS

MICROENDEMIC SPECIES

Approximately 50% of the turbellarian species in the Southern Ocean, including those found in the present study, are present in a single operative unit. These are referred to as *microendemic* species, following García-Barros *et al*. (2002).

Ten out of the 15 operative units in the study area were found to host microendemism: East Antarctica and Weddell Sea (Continental High Antarctic province), Macquarie and Kerguelen Islands (Subantarctic Islands province), Channels and Fjords of Southern Chile and Falkland Islands (Magellanic province), South Georgia, South Shetland Islands and Antarctic Peninsula (Scotia Sea province) and Auckland Island (Subantarctic New Zealand province).

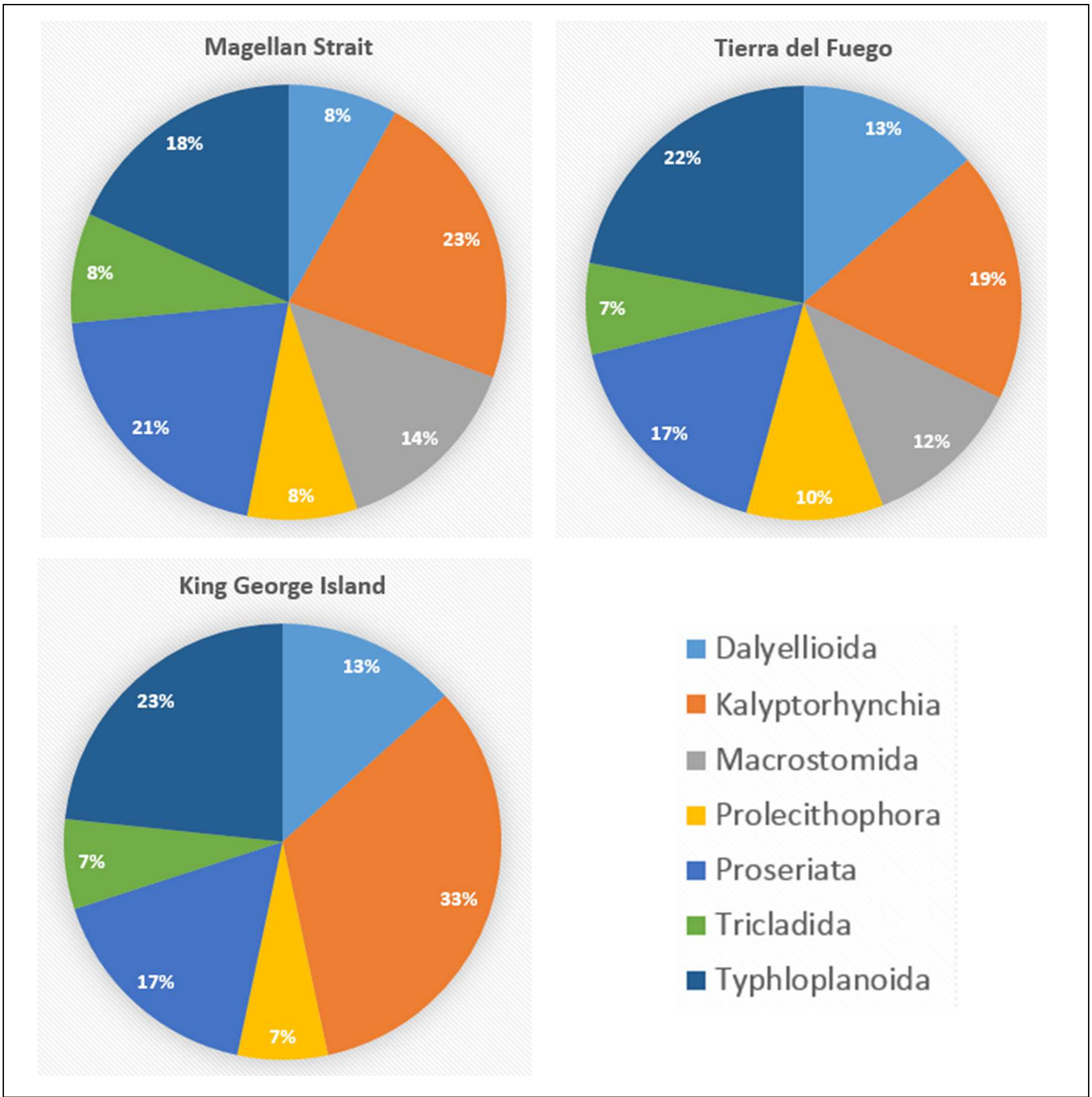

Figure 2. Taxa composition in the three sampling areas.

Density of microendemisms (Figure 3) was variable among the operative units, ranging from 1% (Macquarie and Auckland Islands) to 46% (Channels and Fjords of Southern Chile). In general, the higher density was found in the area of the Scotia Arc, given that 52% and 26% of the microendemisms were located in the Magellanic and Scotia Sea provinces, respectively.

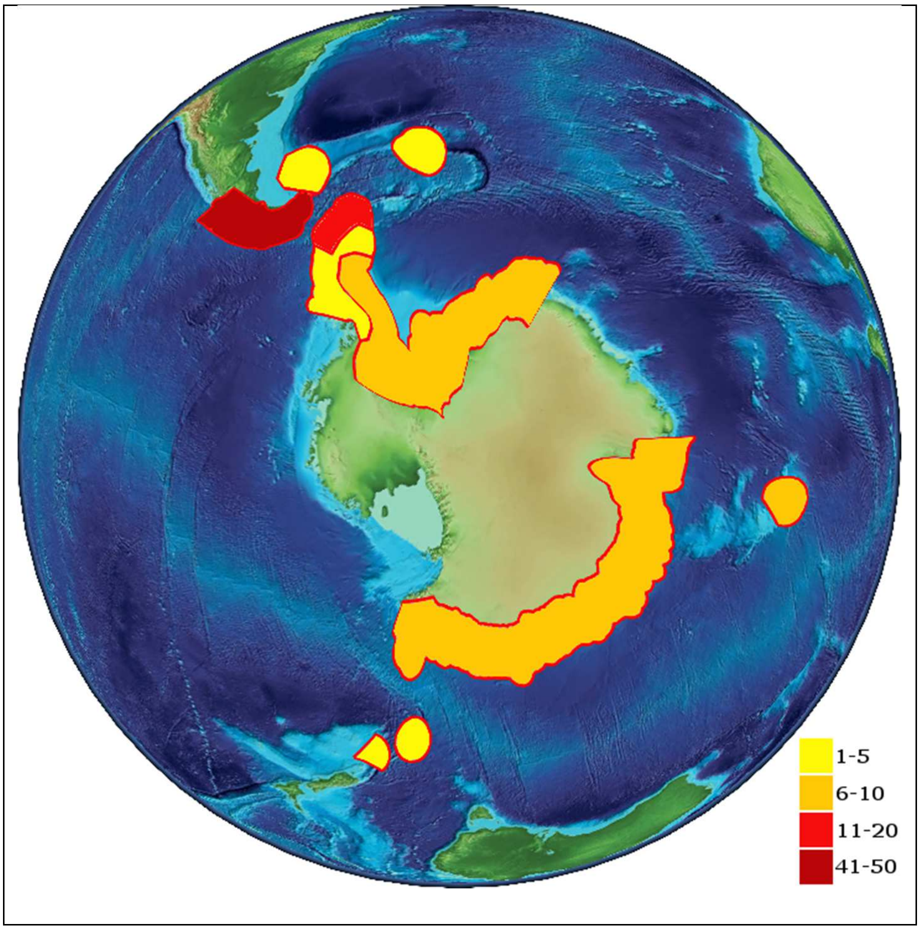

Figure 3. Density of microendemisms of turbellarians in the study area. Values indicate the number of species in each operative unit. Background image: NASA World Wind with Sea Level Standard layer (PanglossTech, 2006).

PAE-PCE

The analysis of individual tracks showed a tendency for macroturbellarians to be more widely distributed than microturbellarians (for an example, see Figure 4).

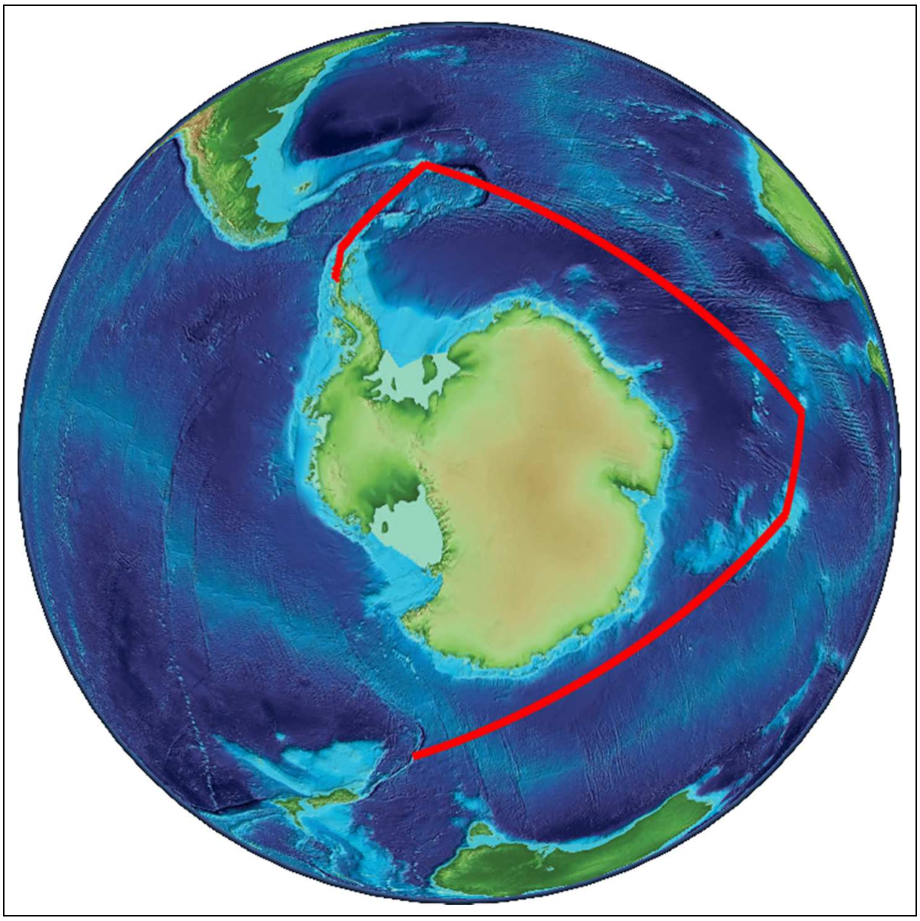

Figure 4. Individual track of *Obrimoposthia wandeli* (Tricladida, Uteriporidae), an example of a widely distributed turbellarian. Background image: NASA World Wind with Sea Level Standard layer (PanglossTech, 2006).

The PAE-PCE, performed with the 84 informative species present in the area (i. e. those present in more than one operative unit), gave a total of three generalized tracks (Figure 5):

1. In the first run there was support for two nested clades: (Magellan Strait – Tierra del Fuego) (18 synapomorphies) and ((Magellan Strait – Tierra del Fuego) (Burdwood Bank – South Georgia)) (2 synapomorphies).
2. In the second run there was support for a single clade: (((South Shetland Islands – Antarctic Peninsula) South Georgia) South Orkney Islands) (2 synapomorphies).
3. In the third run there was support for a single clade: (Falkland Islands – South Georgia) (7 synapomorphies).
4. The fourth run gave no clades supported by more than one synapomorphy.

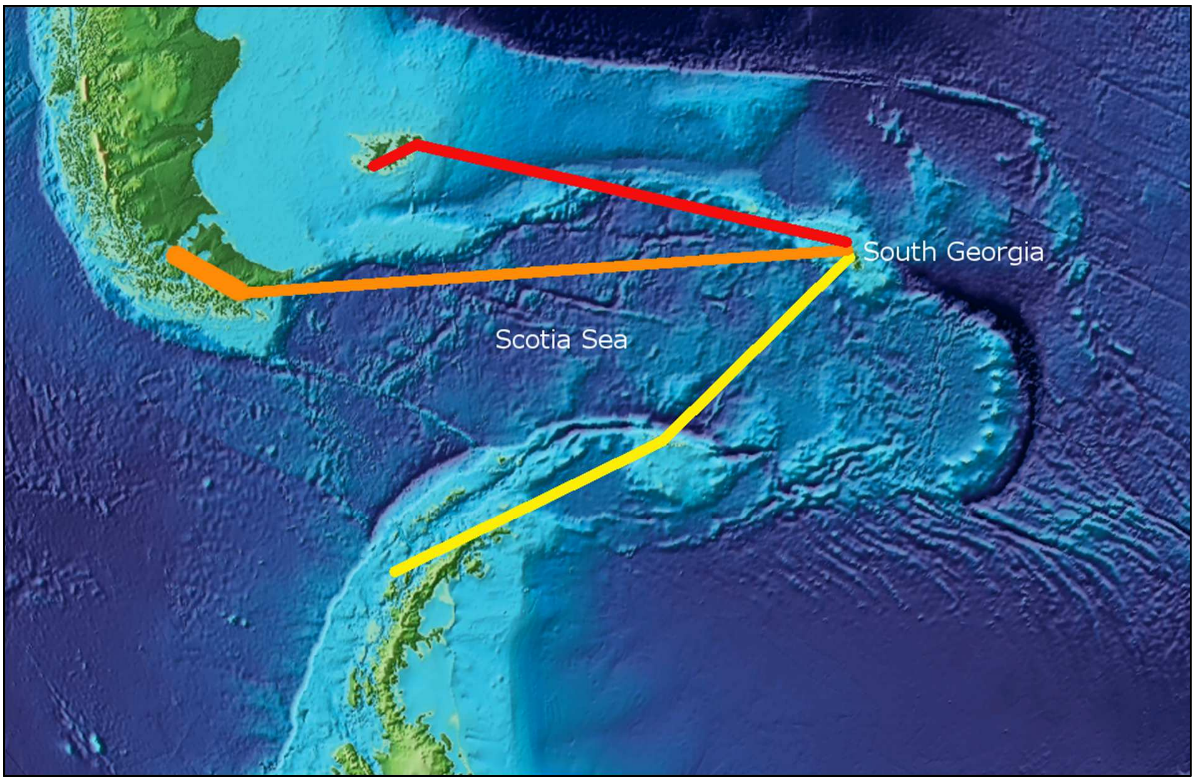

Figure 5. Generalized tracks obtained with PAE-PCE. Background image: NASA World Wind with Sea Level Standard layer (PanglossTech, 2006).

Based on the previous result a single node was identified in South Georgia, situated in the convergence of the three generalized tracks.

DISCUSSION

TAXONOMY

The known diversity of turbellarians in the Southern Ocean is low, compared to most other taxa or turbellarians in other regions. However, the comparison of the results gathered by this project with the previous reports shows clearly that the diversity of turbellarians in the area is greatly underestimated:

1. A review of all the literature on turbellarians from the study area shows that to date, only 88 species had been found since 1844. A total of 17 Prolecithophora, 17 Kalyptorhynchia, 15 Typhloplanoida, 15 Tricladida, 13 Polycladida, 9 Proseriata, 1 Mactostomida and 1 Lecithoepitheliata had been reported for the region. During the two

summer campaigns carried out as part of this study, 8 additional Prolecithophora, 25 additional Kalyptorhynchia, 20 additional Typhloplanoida, 1 additional Tricladida, 18 additional Proseriata, 12 Macrostomida and 11 Dalyellioida were found. Therefore, the work carried out in the Scotia Arc area more than doubles the number of turbellarians previously known to be present in the entire area south of the 50ºS Parallel.

2. This is the first time that representatives of the Order Macrostomida and the Suborder Dalyellioida have been found south of the 50ºS Parallel, and that representatives of the Suborder Proseriata have been found in Antarctic waters.

3. Based on all the existing literature on turbellarians from the study area, the ratio of the number of species of microturbellarians to the number of species of macroturbellarians was expected to be 2:1, but in all three sampling sites it was 9:1. This much higher ratio is likely to be the result of the sampling strategy utilized in the present study, designed to maximize the probabilities of finding both macro- and microturbellarians.

BIOGEOGRAPHIC ANALYSIS

MICROENDEMIC SPECIES

It is premature to draw conclusions about microendemic species, because only a small area of the Southern Ocean has been surveyed for the presence of turbellarians and clearly even in one of the best studied regions the diversity is much higher than previously thought; not only species but also higher level taxa are still being discovered, and known richness so far is strongly reflective of sampling effort.

There is, however, a tendency for microturbellarians to be less widespread than macroturbellarians, so most of the true endemic species would be expected to belong to the former group. The wide distribution of macroturbellarians in the Southern Ocean has been noted before (Sluys, 1989); however, this has not been ascribed to their being more dispersive (in fact, long-distance dispersal is considered unlikely), but to large-scale vicariant processes.

PAE-PCE

The number of cladograms generated in each run of the cladistic analysis was relatively high (30, 10, 40, and 10 cladograms in the first four runs, with retention indexes of 54, 45, 52 and 38 respectively), suggesting that the resolving power of the data was somewhat limited.

In panbiogeographic analyses, generalized tracks are primary biogeographic homologies; they indicate the pre-existence of ancestral biotas with a common history that became fragmented by tectonic and/or climatic changes (Morrone 2004, 2009, 2011). In a regionalization system, the biotic components could correspond to a province, domain, region or other biogeographic unit (Hechem *et al*., 2011). In this case:

1. The first generalized track (Magellan Strait – Tierra del Fuego - Burdwood Bank – South Georgia) gives support to an association between the Magellanic province and the northern arm of the Scotia Arc, belonging to the adjacent Scotia Sea province. In this track the richness of endemic species is higher in the Magellanic region (represented by a thicker line in Figure 5).

2. The second generalized track (Southern Shetland Islands – Antarctic Peninsula - South Orkney Islands - South Georgia) was recovered entirely within the limits of the Scotia Sea province and corresponds to the southern arm of the Scotia Arc. The only other ecoregion in this province, South Sandwich Islands, was not represented in the database because there are no turbellarian records from this area.

3. The third generalized track (Falkland Islands – South Georgia), as with the first, supports a relationship between the Magellanic and the Scotia Sea provinces. Despite their proximity, there was no support for a connection between the Falkland Islands and southern South America, although both lie within the Magellanic region.

In panbiogeographic analyses, nodes are complex, composite areas where two or more generalized tracks overlap (i. e. areas where two or more ancestral biotas entered into contact), and they are therefore interpreted as areas of tectonic and/or biotic convergence (Morrone 2009, 2011). The three generalized tracks identified by PAE-PCE gave support to a single node located at South Georgia:

1. The node indicates that South Georgia is the zone where three different biotas entered into contact. This is therefore the area with the highest biogeographic complexity found in the study, which is in agreement with the observation that South Georgia is a biodiversity "hotspot" in the Southern Ocean (Hogg *et al*., 2011).

On the whole, the generalized tracks and the node found in the present study reflect the complex history of the Scotia Arc area, as inferred from geological information (Dalziel *et al*., 2013; Lawver and Gahagan, 2003) and biogeographic data based on other taxa (Arntz *et al*., 2005). An association of the two arms of the Scotia Arc was observed, as was the relationship of the Magellanic province with the northern arm. This suggests that turbellarians are a suitable group for historical biogeography studies, which will hopefully encourage further sampling efforts to reveal more of the true distribution and diversity of this fauna.

COLLABORATIONS WITH OTHER RESEARCH GROUPS

To date, this Fellowship has facilitated the following collaborations:

Diversity and distribution of Southern Ocean turbellarians

Part of the funds allocated by SCAR were used to make a short-term visit to the British Antarctic Survey, Cambridge, UK. During this visit, a manuscript on Southern Ocean flatworm ecology and distribution was discussed and advanced with Dr. David K. A. Barnes (Host). In addition, the possibility of initiating molecular work on Southern Ocean turbellarians was discussed with Mr. Chester Sands, who designed a protocol for the fixation of samples for this purpose. Several specimens were successfully fixed using this protocol during the second summer campaign; these were kept frozen in the eventuality that they were needed for the taxonomic studies, but now that all species have been identified they will be sent to Mr. Sands.

Diversity of intertidal turbellarians of South Georgia

A collaboration with Dr. Paul Brewin (Shallow Marine Surveys Group, and Department of Natural Resources-Fisheries, Falkland Islands) has also been initiated. This involves the determination of turbellarians found in samples from the intertidal zone of South Georgia, collected as part of one of Dr. Brewin's projects, "Intertidal Assemblages of South Georgia". This collaboration, still ongoing, has already resulted in the publication of the description of a new species of marine planarian from South Georgia, *Allogenus sluysi*.

Presence of a non-indigenous dipteran at King George Island

A collaboration was initiated with Prof. Peter Convey (Host), Dr. Ewa Krzemińska (Polish Academy of Sciences) and Prof. Rodrigo Ponce de León (Facultad de Ciencias, Universidad de la República, Uruguay). This involved the collection, determination and publication of the report of the presence of the dipteran *Trichocera maculipennis* on King George Island. This species is widely distributed at higher latitudes in the Northern Hemisphere, and is likely to be preadapted to survive in Antarctic terrestrial ecosystems, which raises concern because it implies a potential for establishment and dispersal. While this work was not directly related to the core objectives of the Fellowship, it was made possible by the interaction with Prof. Convey during the visit to the British Antarctic Survey. Collaboration with Prof. Convey is ongoing, and in the near future work will be initiated involving the identification of turbellarians collected in the South Orkney Islands.

DELIVERABLES

PUBLICATIONS

1. Volonterio O and Brewin P. 2014. A new species of *Allogenus* (Tricladida, Maricola, Uteriporidae) from South Georgia, Sub-Antarctica. *Journal of the Marine Biological Association of the United Kingdom* 94(2): 309-316.

2. Volonterio O, Ponce de León R, Convey P and Krzemińska E. 2013. First record of Trichoceridae (Diptera) in the maritime Antarctic. *Polar Biology* 36(8): 1125-1131.

CONGRESS PRESENTATIONS AND SEMINARS

1. *Oral presentation*: Diversity and distribution of Southern Ocean turbellarians. Odile Volonterio, Rodrigo Ponce de León and David K. A. Barnes. SCAR XXI and Open Science Conference, session 28: Census of Antarctic Marine Life. 3-6th August 2010, Buenos Aires, Argentina.

2. *Seminar*: Antarctic Biodiversity. 4th November 2010, Faculty of Science, University of Alcalá de Henares, Alcalá de Henares, Spain.

3. *Poster presentation*: First report of meiobenthonic Kalyptorhynchia (Platyhelminthes) in the Maritime Antarctica. Rodrigo Ponce de León and Odile Volonterio. First Uruguayan Congress of Zoology. 5-10th December 2010, Montevideo, Uruguay.

4. *Poster presentation*: First record of Trichoceridae (Diptera) in the Maritime Antarctic. Odile Volonterio, Rodrigo Ponce de León, Peter Convey and Ewa Krzeminska. II Workshop of the Association of Polar Early Career Scientists (APECS). 14-17th May 2012, Rio Grande, Brasil.

5. *Poster presentation*: Confirmation of establishment and local dispersal of a previously unrecorded family of Diptera, Trichoceridae, in a research station in the maritime Antarctic. Odile Volonterio, Rodrigo Ponce de León, Peter Convey and Ewa Krzeminska. XXXII SCAR Open Science Conference, 13-25th July 2012, Portland, Oregon, United States.

6. *Poster presentation*: Two new microturbellarian tracks between Scotia Arc Islands (Southern Ocean). Odile Volonterio and Rodrigo Ponce de León. Second Uruguayan Congress of Zoology, 9-14th December 2012, Montevideo, Uruguay.

7. *Poster presentation*: A new species of *Allogenus* (Tricladida, Maricola, Uteriporidae) from South Georgia. Odile Volonterio and Paul Brewin. Second Uruguayan Congress of Zoology, 9-14th December 2012, Montevideo, Uruguay.

OTHERS

Internal deliverables. These include a collection of Antarctic and sub-Antarctic turbellarians identified at the species level, deposited in the Helminthological Collection of the Facultad de Ciencias, Universidad de la República, Uruguay; a taxonomic database with anatomical and morphometric information of the species; a biogeographic database with the detailed distribution of the species, and internal reports.

External deliverables. About 190 samples of turbellarians were sent to the International Barcode of Life Project (iBOL) at the University of Guelph (Canada), to be sequenced as part of the barcoding project of the Census of Antarctic Marine Life (CAML). In addition, as the publication of the results advances, a proportion of the specimens are being deposited in the Natural History Museum, London. External deliverables also include reports for funding institutions, the Uruguayan Antarctic Institute and the Programme for the Development of the Basic Sciences (PEDECIBA), Facultad de Ciencias, Universidad de la República, Uruguay.

FUTURE WORK

The information and material gathered during this Fellowship will be the basis for several additional activities to be carried out in the next few years:

1. An estimate of 20+ additional taxonomic articles will be published, together with the publication of the results of the biogeographic study, reviewing and updating the current state of knowledge on Antarctic and sub-Antarctic turbellarians.
2. The databases created for this project will be integrated into the SCARMarBIN international database.
3. Recommendations for the delimitation of protected areas will be made.
4. An analysis of predictive modelling of species distribution will be carried out to complement the biogeographic analysis.
5. Additional sampling will be carried out at locations of interest, to improve our knowledge about the true diversity and distribution of turbellarians in the Southern Ocean.
6. All the interactions with other research groups that were initiated thanks to this Fellowship will be strengthened with additional collaborative works.

ALLOCATION AND USE OF SCAR FUNDS

A total of 10.000 US$ were awarded. Part of the funds were spent as follows:

1. Travel, accommodation and living costs of a short-term visit to the British Antarctic Survey, Cambridge, UK: 3.500 US$.
2. Travel, accommodation, living costs and transportation during the two sampling campaigns in Tierra del Fuego: 2.500 US$.
3. Equipment and consumables for the histological studies: 300 US$.
4. Shipment of specimens donated to the Natural History Museum, London; the Institute of Systematics and Evolution of Animals, Krakow, Poland, and the International Barcode of Life Project (iBOL) at the University of Guelph (Canada): 300 US$.
5. Literature and software: 100 US$.

The remaining funds (about 3.300 US$) are earmarked for additional field work in a location to be coordinated with Dr. Barnes and Dr. Convey.

ACKNOWLEDGEMENTS

I would like to express my deep gratitude to SCAR for funding this Fellowship, which has allowed me to interact with top-level scientists in the field of Antarctic research. Special thanks to David Barnes, Peter Convey and Paul Brewin for their patient guidance and enthusiastic encouragement. I also wish to thank the Uruguayan Antarctic Institute and the staff of the Base Científica Antártica Artigas for providing the resources that allowed me to work in King George Island and the Magellan Strait; Rodrigo Ponce de León for his invaluable help during the field work and the taxonomic studies, and Fernando Pérez-Miles and Nelson Ferretti for their advice on how to conduct the biogeographic analysis.

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