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SOUTH AMERICAN AND ANTARCTIC INTERACTIONS IN THE MARINE ENVIRONMENT - BIOLOGICAL RELATIONSHIPS, GENERAL RELEVANCE AND RESEARCH PERSPECTIVE

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ABSTRACT

The relevance of faunistic intercontinental comparisons is discussed here in the context of the past and current projects related to Antarctic biodiversity research. Some of these have focussed on questions regarding Antarctic isolation and evolutionary pathways between South America and that continent, such as the 'Investigación Biológica Marina en Magellanes relacionada con la Antártida'(IBMANT), 'Ecology of the Antarctic Sea Ice Zone' (EASIZ), and more recently the 'Evolution and Biodiversity in the Antarctic' (EBA) as well as the 'Census of Antarctic Marine Life' (CAML) and the 'Scientific Committee on Antarctic Research Marine Biodiversity Information Network' (SCARMarBIN). The Latin American subproject of the 'Census of Antarctic Marine Life' (LA-CAML) provided a landmark to collect data on the biodiversity and life history for all groups of organisms ranging from microbes to endotherms. In addition to such fundamental knowledge the application of molecular techniques and highly sophisticated methods to study macroecological processes are necessary to better understand ecosystem functioning and large-scale comparisons in the southern hemisphere, especially between South America and Antarctica. More cooperation between scientists and more interdisciplinary approaches are required to develop reliable projections for the future of our biosphere under anthropogenic stress and its ecosystem services.
Keywords: Biodiversity; interdiscipinary studies; ecosystem functioning; predictions.

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RESUMO

INTERAÇÕES ENTRE AMÉRICA DO SUL E ANTÁRTICA NO AMBIENTE MARINHO – RELAÇÕES BIOLÓGICAS, RELEVÂNCIA E PERSPECTIVAS DE ESTUDO. A relevância de comparações intercontinentais relacionadas à fauna é discutida aqui no contexto de projetos científicos passados e atuais relacionados às pesquisas sobre biodiversidade na Antártica. Alguns destes estudos são focados em questões relacionadas ao isolamento do continente Antártico e nos processos de evolução entre América do Sul e Antártica, como por exemplo, os projetos 'Investigación Biológica Marina en Magellanes relacionada con la Antártida'(IBMANT), 'Ecology of the Antarctic Sea Ice Zone' (EASIZ), e mais recentemente o projeto 'Evolution and Biodiversity in the Antarctic' (EBA), bem como o 'Census of Antarctic Marine Life' (CAML) e o 'Scientific Committee on Antarctic Research Marine Biodiversity Information Network' (SCARMarBIN). O subprojeto Latino Americano do 'Census of Antarctic Marine Life' (LA-CAML) iniciou a coleta e reunião de informações referentes á biodiversidade e história de vida de todos os grupos de organismos desde micróbios a animais endotérmicos. Adicionalmente a estes conhecimentos básicos, a aplicação de técnicas moleculares e sofisticados métodos de estudos de processos macroecológicos são necessários para o melhor entendimento do ecossistema como um todos e de comparações de larga escala no hemisfério sul, especialmente entre América do Sul e Antártica. Uma maior cooperação entre cientistas e a realização de estudos interdisciplinares
são necessários para o desenvolvimento de projeções confiáveis para o futuro da nossa biosfera sob stress antropogênico e seus serviços ecológicos.
Palavras chave: Biodiversidade; estudos interdisciplinares; funcionamento de ecossistemas; previsões.

RESUMEN

INTERACCIONES ENTRE AMÉRICA DEL SUR Y ANTÁRTICA EN EL AMBIENTE MARINO – RELACIONES BIOLÓGICAS, RELEVANCIAS GENERALES Y PERSPECTIVAS DE ESTUDIO. En este trabajo se discute la importancia de las comparaciones intercontinentales relacionadas con la fauna, en el contexto de los proyectos científicos pasados y actuales relacionados con la investigación de la diversidad biológica Antártica. Algunos de dichos estudios están enfocados en aspectos referidos al aislamiento del continente Antártico y en los procesos evolutivos entre Sudamérica y Antártica, tales como 'Investigación Biológica Marina en Magallanes relacionada con la Antártica' (IBMANT), 'Ecology of the Antarctic Sea Ice Zone'(EASIZ), y más recientemente 'Evolution and Biodiversity in the Antarctic' (EBA) así como 'Census of Antarctic Marine Life' (CAML) y 'Scientific Committee on Antarctic Research Marine Biodiversity Information Network' (SCARMarBIN). El subproyecto latinoamericano de 'Census of Antarctic Marine Life' (LA-CAML) inició la recolección y recopilación de información referidas a la biodiversidad e historia de vida de todos los grupos de organismos, desde microbios hasta animales endotérmicos. Además de dicho conocimiento básico, es necesario la aplicación de técnicas moleculares y sofisticados métodos de estudio de procesos macroecológicos, para un mejor entendimiento del funcionamiento del ecosistema y de las comparaciones a gran escala en el hemisferio sur, especialmente entre Sudamérica y Antártica. Una mayor cooperación entre científicos y la realización de estudios interdisciplinarios son necesarios para el desarrollo de proyecciones confiables para el futuro de nuestra biosfera bajo estrés antropogénico y sus servicios ecológicos.
Palabras claves: Biodiversidad; estudios interdisciplinarios; funcionamento de los ecosistemas; predicciones.

CONNECTIONS - MORE OBVIOUS THAN SO FAR THOUGHT?

Waters around both the Antarctic and South American continents have been considered as home for independent marine ecosystems being quite isolated from each other for a long time. A major reason for this view was the strong emphasis laid on certain structures and facts that seemed to support separation of the two systems, such as the Antarctic Polar Front (APF) in combination with the Antarctic Circumpolar Current (ACC), acting as an efficient hydrodynamic barrier for most pelagic species; the discrete temperature cline of surface waters along the APF separating warm water in the north from much colder water in the south; and the intermediate to high proportions of endemic species in the Antarctic. Already the project 'Investigación Biológica Marina en Magallanes relacionada con la Antártida' (IBMANT, Arntz & Ríos 1999), as well as the biology programmes of the Scientific Committee on Antarctic Research (SCAR) 'Ecology of the Antarctic Sea Ice Zone' (EASIZ, Arntz & Clarke 2002), 'Evolution in the Antarctic' (EVOLANTA, Eastman *et al.* 2004), and 'Evolution and Biodiversity in the Antarctic' (EBA) detected a considerable coincidence of the fauna mostly on the genus and family levels.

One major output of the 'Census of Antarctic Marine Life' (CAML) between 2005 and 2010 was a shift in the interpretation towards the conviction that the faunas of both continents are not as separated as so far seen (Gutt *et al.* 2010, Schiaparelli & Hopcroft 2011). This refers to evolutionary processes, which already started before a deep-water basin developed 20 Mio years ago in combination with the cooling of Antarctica. Enormously increased sampling efforts in the deep sea before and during the 'Census of Diversity of Abyssal Marine Life' (CeDAMar) project have allowed first regional comparisons within a large stable cold and relatively homogenous environment inhabited by a fauna not being directly affected by the APF (see e.g. Brandt & Ebbe 2007). Rough estimations of the time of radiation and dispersal of species from the Antarctic into surrounding waters and vice versa using traditional and genetic methods show that this happened several times even after the geographic and hydrodynamic isolation of Antarctica.

Despite clear differences between the Antarctic shelves and worldwide deep-sea ecosystems, similarities, such as the constantly low temperature and the occurrence of deep-sea species on the Antarctic shelf have been recognised for decades. High resolution satellite images of recent oceanographic conditions show gyres in the upper water column

along the APF, which allow any floating material, e.g. plastics and other drifting substrata as well as larvae and macroalgae to penetrate this barrier in both directions.

Concerning adaptation to the environment, for some scientists the question of how populations of the same species can survive close to freezing point and at 8°C is more attractive than that of extreme ecological and physiological adaptation. In addition, databases such as SCAR-MarBIN, the regional node of OBIS recently renamed to ANTABIF (www.scarmarbin.be), provide historic as well as continuously increasing recent biogeographical data sets, which allow for first statistically sound large-scale biogeographical comparisons and classifications.

THE RELEVANCE OF LARGE-SCALE INTERCONTINENTAL COMPARISONS

Several examples in this volume demonstrate that a comparison in the Southern hemisphere is promising especially between South American and Antarctic waters. Such comparative studies do not only provide results on differences and similarities, but also give improved insights into peculiarities within the different adjacent ecosystems. In addition to the general similarities and obvious connections between the biota around both continents there might be three 'modern' reasons to focus and intensify such large-scale studies.

Firstly, the use of new technologies in molecular biology, 'omics', as well as physiology and traditional methods demand reference information from temperate regions when mechanisms of adaptation of species or systematic groups to Antarctic conditions are studied.

Secondly, in case of global climate change the most significant changes in biodiversity and ecosystem functioning will happen at the APF because it is expected to shift southward - a process that may have already started. In that case, the temperate South American pelagic habitat will extend its geographical range at the expense of the Antarctic open water ecosystem. A comprehensive compilation of changes in the physical and biological habitat is provided by the Antarctic Climate Change and the Environment report (ACCE, Turner *et al.* 2009, www.scar.org/publications/occasionals/acce.html).

Thirdly, if in the Antarctic region warming not only cause a biogeographical range shift, but also changes in ecosystem functioning, further effects can be expected. They are most likely triggered primarily from South America, e.g., by a possible invasion of species suddenly crossing the Drake Passage and competing in their new habitats with the original fauna and flora.

In case of regional warming within the Antarctic the temperate ecosystems could serve as a kind of ground truthing to develop future scenarios, e.g., when a shift from a benthic suspension to a deposit feeder community is expected, or if in the pelagic system krill is replaced by salps and small copepods.

A PERSPECTIVE FOR FUTURE PROJECTS – FROM SPECIFIC TO INTERDISCIPLINARY APPROACHES

As shown there are good reasons to intensify geographically comparative studies at all levels of biological organisation, all temporal scales and to include environmental constraints. Such studies demand detailed knowledge and modern techniques from different scientific disciplines, which provide the basis for interdisciplinary approaches. Examples for climatological phenomena affecting all ecosystems in the area are El Niño extending to the Antarctic, increasing westerly winds in the South Pacific, raising atmospheric temperature as well as upwelling of warm deep-water West of the Antarctic Peninsula, and -from a biological perspective- the even greater long-term changes between interglacials and glacials. Such processes have to be monitored and analysed with high spatial resolution to correlate them with patchy biological patterns in the benthic and pelagic systems.

In order to integrate environmental results and biogeographical information so-called correlative approaches have been recently developed for both marine and terrestrial ecosystems. On the one hand such species distribution models define potential habitats for faunistically known and unknown areas based on the knowledge of the environment in areas where species have already been sampled. In a second step, they allow to develop future scenarios especially for biodiversity patterns expected under changed environmental conditions. The advantage of this

approach is that it is based on true field observations. Reasonably sufficient biological and environmental information is available to cover large areas and, eventually, also a broad range of species. However, it assumes that the ecosystem is in a steady state and dynamic components are not considered.

Recent developments in molecular biology have allowed a continuation of the excellent work of the past decades on adaptation, especially of fishes, and should be adopted to other taxa being characteristically from pelagic and benthic communities, north and south of the APF. Not only more of such 'modern' highly sophisticated approaches are needed, but also additional basic information on the biodiversity and life history for all groups of organisms ranging from microbes to endotherms.

The CAML and its subproject Latin American CAML provided a landmark to collect such data, attracted general attention of their general relevance today, and as a legacy for future generations. Following the rules of good scientific practice such information must be made available in databases, which refers not only to environmental parameters, species occurrences and genetic information, but also to physiological data, abundances, biomass and variables of population dynamics. This is the most efficient way to perform comparisons across ecosystems, large systematic groups and different levels of biological organisation. If such information is sufficiently available, specific processes can be modelled in order to understand the functioning of ecosystems, at least partially, which is at present still in a stage of infancy.

Linking georeferenced data and knowledge on processes allows spatially and temporally explicit predictions on the future of large ecosystems. First promising studies of this kind are underway, but they are data hungry, whilst our knowledge is still full of gaps. When specialists from all disciplines recognise that their unique work benefits from its potential to contribute to larger and more relevant concepts, they might be motivated to adopt their specific foci and make their data generally available. The most ambitious, but realistic aim in this context would be to develop projections for the future of our biosphere under anthropogenic stress, taking into account its ecosystem services to human well being. The final conclusion is that for this challenge more cooperation between scientists having the same general aim, more interdisciplinary approaches, and more large-scale comparisons are needed, in the southern hemisphere especially between South America and Antarctica.

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