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SPECIAL FEATURE: APPLYING ECOLOGY

Conservation biology in Chile: Are we fulfilling our social contract?

Conservación biológica en Chile: ¿Estamos cumpliendo nuestro contrato social?

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ABSTRACT

Biodiversity conservation needs to be informed by science. On this regard, scientific efforts ought to be allocated to tackle research priorities; offer sound and explicit advice, and results ought to be translated into conservation plans and programs. If such conditions are met, scientists would be fulfilling their social contract, sensu Lubchenco. In this brief essay I analyze the fulfillment of such a contract in Chile. In general, the scarce priorities set for addressing conservation issues are not considered, only a third of scientific publications in conservation-related issues offer explicit advice and a minor fraction of relevant scientific information is considered in the preparation of conservation plans. Current mismatch between conservation science and practice weakens longstanding efforts to achieve an effective conservation of the Chilean biota. Suggestions are advanced to close the gap.

Key words: conservation practice, conservation research.

RESUMEN

La conservación de la biodiversidad requiere apoyo científico. En este sentido, desde el ámbito científico se deberían destinar esfuerzos para abordar las prioridades de investigación, ofrecer recomendaciones explícitas, y los resultados de la investigación científica deberían ser incorporados a los planes y programas de investigación. De cumplirse estos pasos, los científicos estarían satisfaciendo su contrato social, sensu Lubchenco. En este breve ensayo analizo el cumplimiento de tal contrato en Chile. En general, el escaso conjunto de prioridades existente no ha sido abordado, solamente un tercio de las publicaciones científicas en temas de conservación biológica ofrecen consejo explícito y una fracción menor de la información relevante y pertinente es considerada en la elaboración de planes y programas de conservación. El desacople entre la ciencia y la práctica de la conservación debilita esfuerzos de larga data tendientes a lograr una efectiva conservación de la biota chilena. Para intentar cerrar esta brecha, ofrezco algunas sugerencias.

Palabras clave: ciencia de la conservación, conservación en la práctica.

INTRODUCTION

Biodiversity loss is a biological issue of social relevance. The extinction of biological diversity alters the composition, structure and dynamics of the biota as well as the provision of goods and services for Humankind (Millennium Ecosystem Assessment 2005). Sound and effective biodiversity conservation depends upon policy and regulatory frameworks, which in turn ought to be science– and evidence-based (Soulé 1995, Sutherland et al. 2004, 2009). Indeed, the conservation of biodiversity requires scientific and technical knowledge to properly inform policy and decision-making in order to maintain life-support systems, to preserve genetic diversity and to allow the sustainable use of species and ecosystems (IUCN/UNEP/WWF 1991). This process involves at least three stages ranging from the genesis to the implementation of information, including setting research priorities and performing research accordingly, the proposal of recommendations for policy or specific actions derived from research results, and the adoption and implementation of these recommendations by conservation agencies (Lubchenco et al. 1991). In doing so, scientists will be addressing a pressing environmental problem in a socially responsible manner. That is, scientists will be fulfilling its social contract: allocating intelligence and resources to a critical environmental issue in exchange for public funding (Lubchenco 1998).

Ecology –and other biological sciences– enhances our understanding of factors that

impinge upon the distribution and abundance of organisms, including the changes brought about by human activities over all biodiversity components and levels. Therefore, they can contribute theoretical and empirical knowledge to inform public policies and to strength decision-making for an effective biodiversity conservation (Erhlich & Wilson 1991). This is particularly critical as research in conservation-related topics has been often disconnected from real-world problems, with low effectiveness, weakening their implementation due to low biological foundations (Svankara et al. 2005, Robinson 2006). In fact, the 2010 target of the Convention of Biological Diversity, the reduction of the rate at which biodiversity is lost, was not achieved. To enhance the implementation of the Convention, it is aimed that by 2020 "knowledge, the science base and technologies relating to biodiversity, its values, functioning, status, and trends, are improved" (Perrings et al. 2010).

The loss of biodiversity is recognized as an environmental problem in Chile (Simonetti 1994). In fact, Chile has a long standing tradition in the conservation of its biological diversity. Concerns and regulations to protect it started in Colonial times, currently arranged in a wide array of policies, laws and other regulations, including the enactment of a National Biodiversity Strategy, and explicit policies for the Protection of Endangered Species and Protected Areas among others, and programs for the protection and recovery of several endangered species (Ormazábal 1993, Simonetti 2002). The commitment to Nature's protection is also reflected in the allocation of approximately 19 % of the continental surface to parks, reserves and other type of protected units (Rovira et al. 2005). Despite these efforts, regarding conservation of biodiversity and its habitat, Chile performs lower than countries in the Americas and lower as well compared to countries of similar GDP. In fact, on environmental issues, biodiversity depicts the lowest performance compared to other environmental policy categories such as air pollution, climate change and environmental health (Esty et al. 2008). Further, Chile has been requested to build the scientific basis needed for the management of biodiversity. However, efforts to date have not received support enough to cope with the long-term threats menacing Chilean biological diversity (OECD 2005).

Interestingly, scientific productivity in topics relevant for biodiversity conservation such as forestry and fisheries management, environmental management and protected areas has steadily increased in the last decades (Fig. 1). Scientists devoted to biodiversity conservation comprise around 5 % of Chilean scientists in environmental sciences (Arroyo et al. 2006). The point is then, how relevant and useful their research has been for informing policy and practice of Chilean biodiversity conservation. That is, to what extent Chilean researchers are fulfilling their social contract (sensu Lubchenco 1998). Within this framework, in this essay I will briefly review the three stages associated to this contract: (a) whether research priorities (if any) have been dully attended, (b) whether research carried out offers explicit advice to deal with a conservation issue, and (c) whether available scientific information is adopted in the formulation and implementation of conservation plans and programs. This overview will enables us to test whether there is a matching between the conservation science and practice in Chile.

DO WE FOCUS ON RESEARCH PRIORITIES?

Lack of information is a menace to the survival of species. In fact, data deficiency regarding population trends and distribution is an impediment to establish the status of the biota (UICN 2001). The assessment of threatening processes, population dynamics and community interactions ought to be strengthened to prepare and carry out conservation plans (Mace et al. 2001). To set explicit priorities, be they topics or species contributes to solve this problem, aiding to focus intelligence and resources on critical issues. Next, I present two examples regarding the consideration of research priorities for the conservation of Chilean biodiversity. The first one refers to research on endangered albeit scarcely known species. The second one refers to ecosystem services.

In 1985, the Corporación Nacional Forestal (CONAF), through an expert workshop

–including natural scientists–, assessed the conservation status of Chilean trees and shrubs species. At the same time, research priorities were established listing species requiring urgent studies to adequately ensure their conservation (Benoit 1989). A total of 11 species were listed as priority: *Avellanita bustillosii* Phil. (Euphorbiaceae), *Beilschsmiedia berteroana* (Gay) Kos. (Lauraceae), *Berberidopsis corallina* Hook. F. (Flacourtiaceae), *Berberis litoralis* Phil. (Berberidaceae), *Dalea azurea* (Phil.) Reiche (Papilionaceae), *Gomortega keule* (Mol.) Baillon (Gomortegaceae), *Metharme lanata* Phil. (Zygophyllaceae), *Nothofagus alessandrii* Esp. (Fagaceae), *Pitavia punctata (*R. et P.) Mol. (Rutaceae), *Reichea coquimbensis* (Barn.) Kaus. (Myrtaceae) and *Valdivia gayana* Remy (Escallonaceae) (Benoit 1989). To test the matching between the establishment of priorities and the subsequent research activities, along with two students, L. Calderón and F. Zorondo, we compared the publication rate of scientific articles regarding the 11 threatened species before (1950-1988) and after (1990-2002). As a contrasting group, we analyzed publication rate on two species with no conservation problem (*Aristotelia chilensis* (Mol.) Stuntz and *Nothofagus pumilio* (Poepp. et Endl.) Krasser). If listing priority species for research is being dully addressed, publication rate ought to have increased significantly through time, at a higher pace than that for non-endangered species.

Rather than comprehensive reviews, this and other literature perusals in this essay aim to be illustrative of the state of the art in conservation science in Chile. For research carried out in Red Listed species, literature perusal included ISI Web of Knowledge, EBSCO and SciELO listed journals, along other Chilean journals of natural history, botany and other covering a time spam from 1955 to 2005. Regardless of the topic, all publications dealing with a listed species were tallied. Publications, despite being scant in numbers, increased after the workshop. However, research efforts are skewed, publications focusing largely on G. *keule* and *N. alessandrii* (e.g., Torres-Díaz et al. 2007, García-González et al. 2008). Other species, like *D. azurea* have received either little or no direct attention. The increase in publication rate of endangered species is modest compared with that exhibited by control

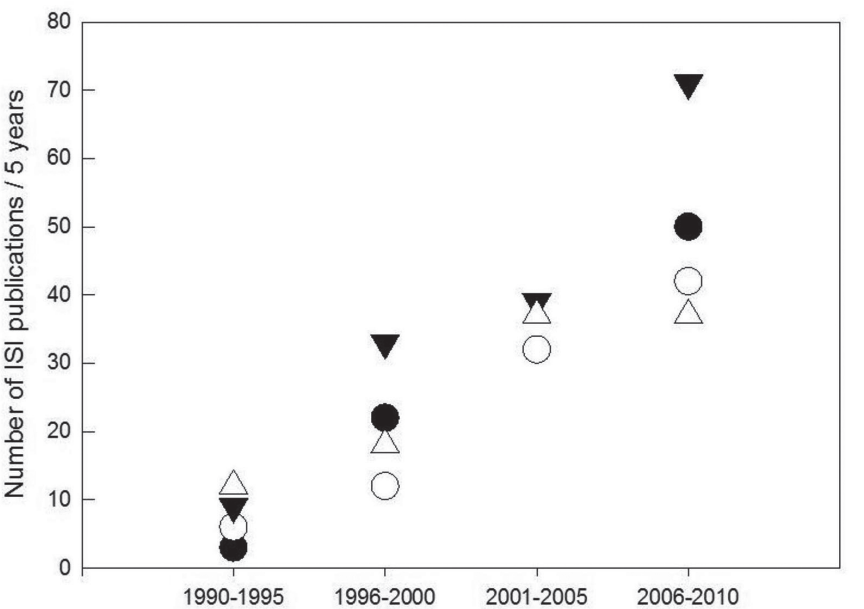

Fig. 1: Chilean scientific productivity. Figures are the number of ISI publications for (a) forestry management (open circle), (b) fisheries management (open triangle), (c) environmental management (closed triangle), and (d) protected areas in Chile (closed circle; data from ISI Web of Knowledge, November 2010).

Productividad científica chilena. Valores son el número de publicaciones ISI en: (a) manejo forestal, (b) manejo pesquero, (c) manejo ambiental, y (d) áreas protegidas (datos de ISI Web of Knowledge, noviembre de 2010).

species. In fact, publication rate for *A. chilensis* and *N. pumilio* was significantly higher after 1985, year when Chilean experts claimed for increased attention in the suite of 11 endangered species (Fig. 2). That is, despite the agreed set of priorities, research –including that carried out by scientists attending the workshop– has focused in species other than the ones in critical need of information to strength any conservation action.

Lower likelihood to obtain funding and working with small samples that might increase difficulty to publish, among other factors, might bias studies against endangered species, exacerbating their risk of extinction (e.g., McKinney 1999, Stein et al. 2002). Therefore, if priority listing is not accompanied by competitive funds to support research on endangered species, information needed to enhance their conservation might not be gathered at the required rate. Hence, despite pioneer efforts to agree a research agenda on a handful of species, such agreement did not foster the research activity that species prioritization was aimed, quite possibly as there were no specific questions nor funding for such research. Attending world, nation and sectorial-wide efforts to establish critical scientific questions of policy relevance (e.g., Nicholson et al. 2009, Sutherland et al. 2009), a similar set could be established for enhancing the level of activity and effectiveness of Chilean research aimed to conserve its biota.

Human well-being depends on ecosystem services. Such services are an outcome of ecosystem functioning (Díaz et al. 2006). To properly understand and inform management

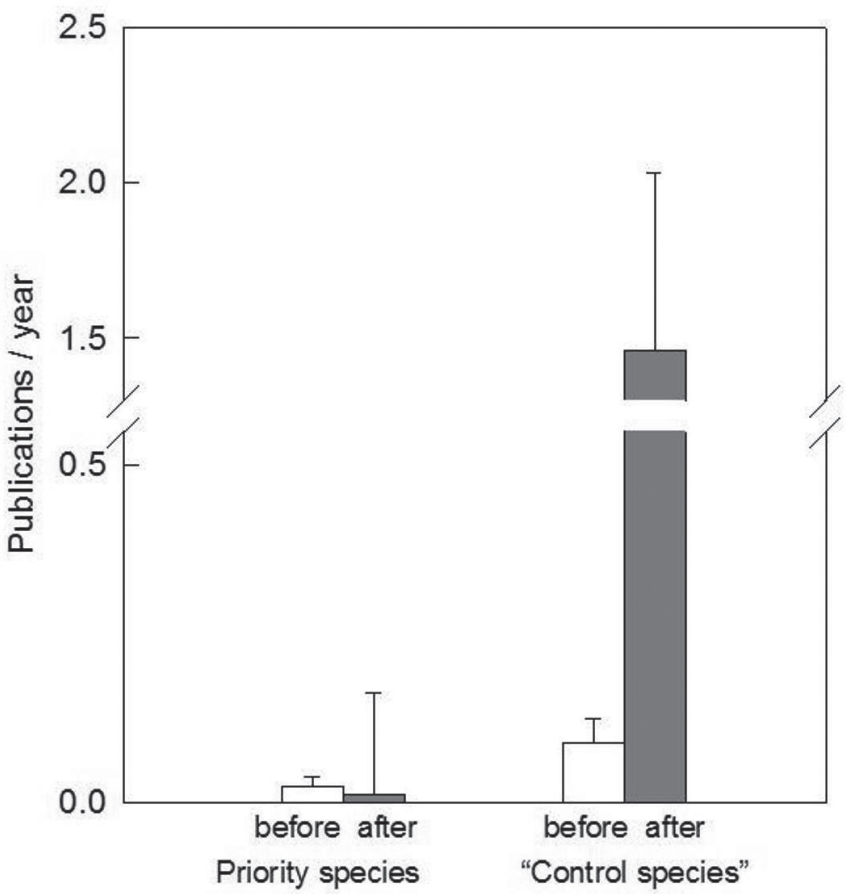

Fig. 2: Scientific productivity. Figures are the publication rate (publications/yr) for species listed as priority for studies compared to control ones (see text) prior to and after their listing as priority.

Productividad científica. Valores son la tasa de publicación (número de publicaciones/año) para especies listadas como prioritarias para estudios comparadas con especies control (véase texto) antes y después de ser listadas como prioritarias.

of ecosystem services, research at the ecosystem level ought to be frequent (e.g., Daily et al. 2009). This is particularly critical when payment for ecosystem services is regarded as a conservation tool, including Chile (e.g., Cabrera 2010). A review of the level of organization studied in conservation-related research indicates this is not yet the case in Chile.

Scientific articles published during 2000-2007 in top conservation and management related journals (Conservation Biology, Biological Conservation, Biodiversity and Conservation, Oryx, Fisheries Management and Ecology, Forest Ecology and Management, Rangeland Ecology and Management, Wetlands Ecology and Management, Journal of Wildlife Management, Ecological Applications and Journal of Applied Ecology) focused largely on the species-population level (Fig. 3). Ecosystem-level studies accounted for 1 % of publications, while nearly 60 % dealt with single species population-level (including genetic studies, followed by species assemblages- and community-level studies (Fig. 3).

Research has largely focused on forests, particularly temperate ones, which account for 46 % of studies while aquatic environs account for 22 % of studies. A third of publications describe distribution or abundance of one or more taxa, with another fifth of studies tackling aspects of the species biology. Just seven percent of publications are dealing with threats to biodiversity and around 1 % is dealing with their management. The most common threats studies are habitat fragmentation, extraction, introduced species and small sizes. These studies have focused on issues considered the most pressing and challenging ones for biodiversity conservation across the Neotropical region (Ceballos et al. 2009), albeit tackling them mostly in descriptive ways (see Grez et al. 2006 for a review of the ecology of fragmented environs). Further, understanding of ecosystem processes cannot be interpolated from population- and community-level studies. The rate of a given ecosystem process for instance, might or might not be a function of species richness and composition, nor all more abundant populations account for the largest

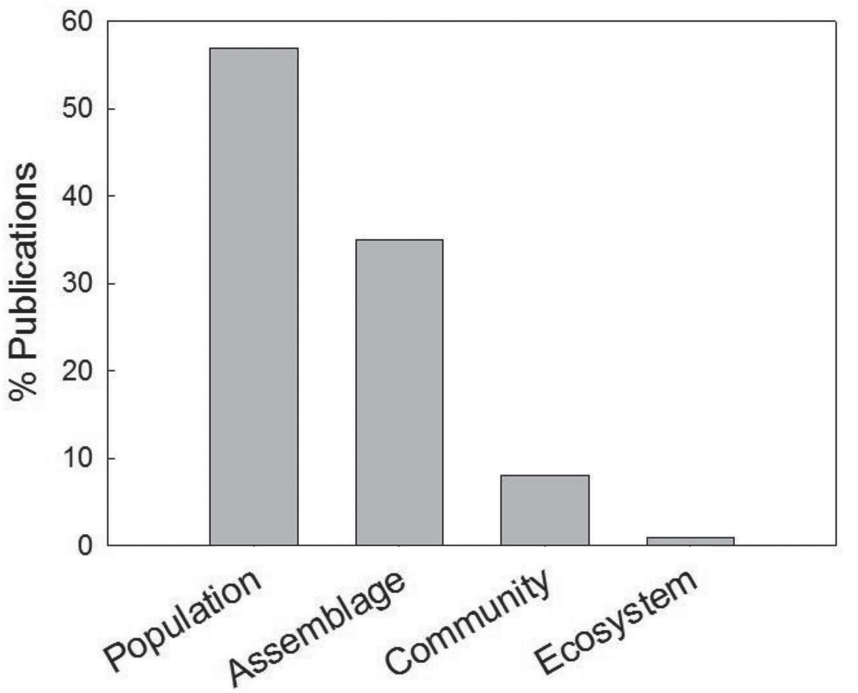

Fig. 3: Proportion of studies dealing with different organization levels of the Chilean biodiversity. See text for sources. Population-level includes species level studies as well.

Proporción de estudios según nivel de organización analizado en publicaciones sobre la biodiversidad de Chile. Véase texto para las fuentes.

fraction of the ecosystem process (e.g., Sala et al. 1996). Therefore, to ignore ecosystem level processes, determinant for the provision of services for Humanity, is a significant drawback for their conservation (Mace et al. 2009).

The above two examples highlight the mismatch between the researches needed with those currently carried out. Overall, less than 5 % of publications generated by Chilean scientists are dealing with biodiversity. Of these, 80 % of publications are devoted to basic science, and just 12 % tackle basic biological issues relevant for conservation (Estades 2008). Focusing the analysis on conservation and management related journals, we should expect that more studies ought to be dealing with solving-problem topics. As shown, this was not the case. In this regard, most biological research in the conservation of the Chilean biota is curiosity rather than necessity-driven (di Castri 2000). Hence, this part of the social contract is only partially fulfilled.

DO WE OFFER RECOMMENDATIONS?

Policy and management decisions ought to be informed by science (Lubchenco 1998). Here, the objective of the study, the consideration of the management or policy implications of the study results and the clearness in which the conservation message is delivered determine the relevance of a scientific publication for policy and decision-making in managerial actions (Fazey et al. 2005). Here, I analyze whether publications on the Chilean biota are relevant for its conservation. After Fazey et al. (2005), I particularly checked if scientific publications contain a clear and explicit message pertaining to a conservation problem, be it empirical or theoretical. To do so, I reviewed the 64 articles published by Chilean scientists in three types of journals during 2000-2007. The first group comprises the four most important journals on biological conservation: Conservation Biology, Biological

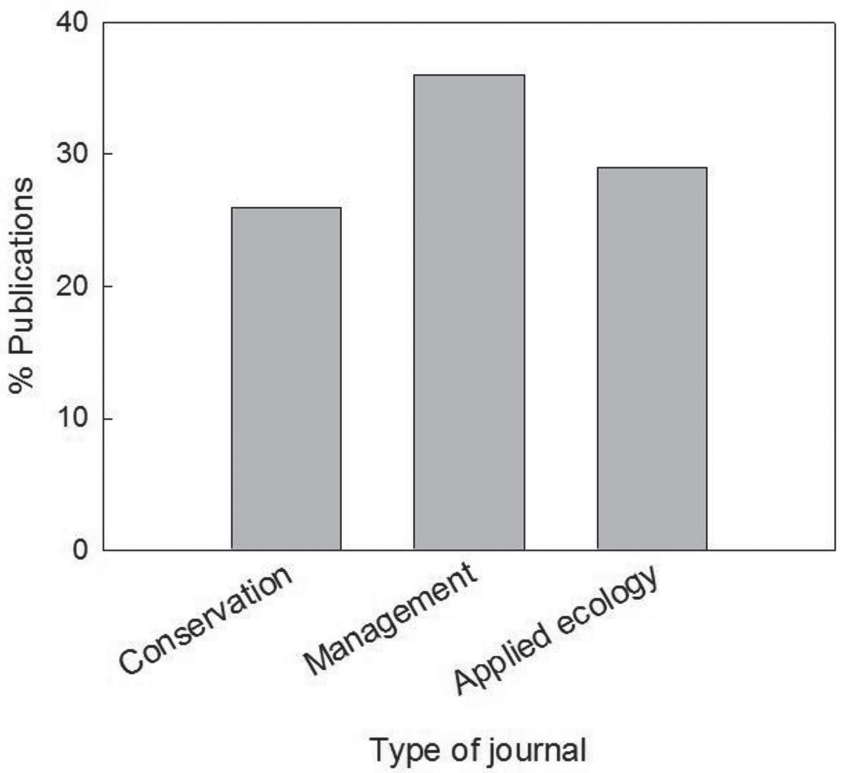

Fig. 4: Percentage of publications offering explicit conservation recommendations for the Chilean biota (sensu Fazey et al. 2005). See text for sources.

Porcentaje de publicaciones que contienen recomendaciones explícitas para la conservación de la biota chilena (sensu Fazey et al. 2005). Véase texto para fuentes.

Conservation, Biodiversity and Conservation, and Oryx. The second group includes five journals dealing with management of natural resources: Fisheries Management and Ecology, Forest Ecology and Management, Rangeland Ecology and Management, Wetlands Ecology and Management and Journal of Wildlife Management. A third group considers two journals in applied Ecology: Ecological Applications and Journal of Applied Ecology.

Twenty-eight percent of publications contains an explicit recommendation (sensu Fazey et al. 2005). Publications in management-oriented journals contains a proportion of publications with conservation messages 1.3 times higher than conservation or applied ecology journals (Fig. 4). Interestingly, the fraction of Chilean publications offering direct advice (e.g., Ullenberg et al. 2006) resembles those of the conservation community world-wide (Fazey et al. 2005). The lack of explicit messages further reduces the chances to significantly contribute to biodiversity conservation. If messages are not explicit, it is unlikely that policy makers and managers will invest efforts to reach for information in difficult to access sources, as scientific journals represent for them (Pullin et al. 2004). Coupled to a reduced spectrum of publications referring to prirotity issues, the scant advice provided determines that the second component of the social contract (sensu Lubchenco) is only partially satisfied, further undermining the options to effectively conserve Chilean biodiversity.

IS SCIENCE CONSIDERED IN POLICY AND PRACTICE?

Relevant information generated by scientific research ought to be dully considered and incorporated into policy and programs, in order to strength its likelihood of success. Determining alternative action paths, selecting among them, setting biologically meaningful and verifiable objectives are activities that scientific information can contribute to biodiversity conservation (Sutherland et al. 2004). Here, I analyze if that is the case in Chile, reviewing a selected set of biodiversity conservation plans and programs. Like in Australia and UK however, most plans and programs are experience- rather than evidence-based (Sutherland et al. 2004, Cook et al. 2010). I support this claim based on the information used to support conservation plans for four endangered species, one management plan for a small reserve, and two regional biodiversity regional strategies as examples.

Gomortega keule, Pitavia punctata, *Chinchilla lanigera* (Molina, 1782) and *Cyanoliseus patagonus* Olson, 1995 are four endangered species with conservation plans underway (Galaz 2005a, 2005b, Maldonado & Benoit 2005, Vila & Benoit 2005). To avoid problems related to accessibility to information, I tallied scientific publications freely available on websites, on topics that directly impinge upon the species management, usually referring to distribution, abundance, ecology, genetics and physiology. Even tough, at best 30 % of available scientific information is used to support the species status, diagnose their threats, and advance solutions (Fig. 5). Similarly, only 50 % of the technical work used to support the management plan of the reserve bound to protect *G. keule* are scientific articles. Half the supporting information is internal reports of CONAF, the entity charged with its administration (CONAF 1999). Finally, two regional strategies illuminate problems and a potential solution. The "Estrategia Regional y Plan de Acción para la conservación y uso sustentable de la diversidad biológica de la Región de Antofagasta" issued in 2002 (available online at Ministerio del Medio Ambiente web site http://www.mma.gob.cl) does not include any scientific or technical reference to sustain the proposal. This fact is in striking contrast with efforts deployed by the Comisión Nacional de Investigación Científica y Tecnológica (CONICYT), another public entity, to unravel biodiversity structure and functioning in the region, though the "Terrestrial and Marine biomes and climates of northern Chile Program", whose main results were published in 1998 in a widely known and accessible journal: Revista Chilena de Historia Natural. On the other hand, the "Estrategia Regional y Plan de Acción de la biodiversidad IV Región Coquimbo" relies on nine out of over 100 scientific papers on the regional biota. Interestingly, 67 % of the cited works are books or book chapters, published in Spanish (e.g.,

Cepeda et al. 2000). Reviews, synthesizing main findings and proposals are more likely to be considered, and should be encouraged as a way to expedite communication between science and practice (Sutherland et al. 2004, Fazey et al. 2005). Like in the other two topics: research priorities and recommendations, in implementation of scientific knowledge we have yet to deliver. Publishing reviews as books might be such a bridge.

FINAL COMMENTS

Biodiversity conservation is inherently associated with Human welfare (Sachs et al. 2009). Chile has advanced on assessing its biodiversity and carrying out conservation efforts (Ormazábal 1993, Simonetti et al. 1995, Simonetti 2002). However, these efforts have not been dully supported in order to build the scientific basis needed for its conservation (OECD 2005). Rather than a problem of economic resources, the lack of political will seems to hamper conservation efforts (Asmüssen & Simonetti 2007). This lack of will also involves the low commitment of the scientific community into grasping the fundamental questions that are required to elaborate and implement policy and management actions for biodiversity conservation. Research carried out by scientists devoted to biodiversity conservation, despite ranging over a wide array of topics, types of organisms, habitats and geographic regions, and being published in highly visible outlets for the Academia, fails to engage in questions that are of interest to policy-making or managerial actions, scarcely offering explicit recommendations. These factors undermine the institutionalization of knowledge and experience.

An outstanding example of institutionalization of solid basic scientific work into regulatory frameworks is depicted by research regarding the ecology and exploitation of benthic resources (Castilla 1994). This research highlight that applied-inspired basic research (Pasteur´s quadrant sensu Stokles 1997) simultaneously advances knowledge and immediate applications. Greater communication between policy makers and scientists is therefore required in order to agree on those fundamental questions of policy relevance, which properly financed, ought to mobilize intelligence and resources and expedite implementation. Doing so, we might increase the fulfillment of our social contract.

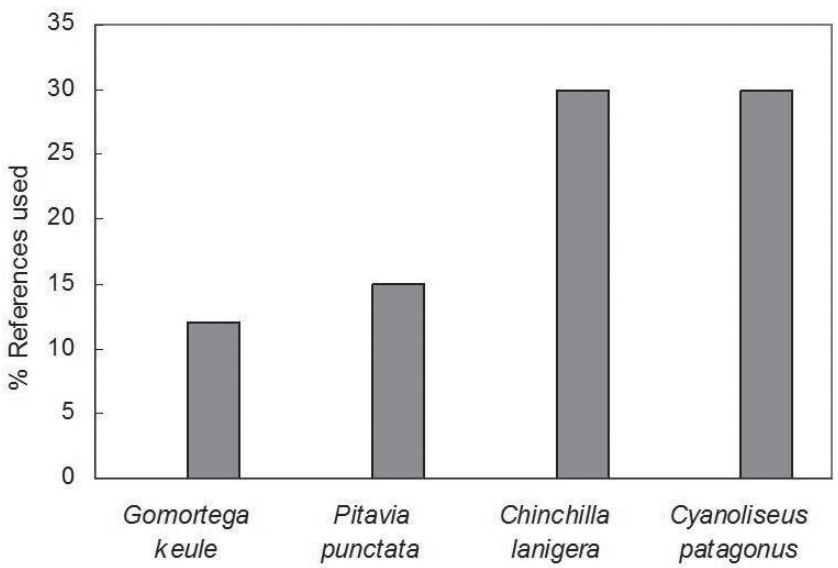

Fig. 5: Incorporation of scientific knowledge: proportion of available publications used to support conservation plans of Chilean species.

Incorporación de conocimiento científico: proporción de publicaciones disponibles empleadas para apoyar la elaboración de planes de conservación de especies chilenas.

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