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Commentary

Less is more: a researcher's survival guide in times of economic crisis

Francesca CAGNACCI[a,*], Andrea CARDINI[b], Paolo CIUCCI[c], Nicola FERRARI[d], Alessio MORTELLITI[c], Damiano G. PREATONI[e], Danilo RUSSO[f], Massimo SCANDURA[g], Lucas A. WAUTERS[e], Giovanni AMORI[h]

[a] Dipartimento Biodiversità ed Ecologia Molecolare, Centro Ricerca e Innovazione - Fondazione Edmund Mach, via E. Mach 1, 38010 S. Michele all'Adige (TN), Italy
[b] Dipartimento di Scienze Chimiche e Geologiche, Università di Modena e Reggio Emilia, l.go S. Eufemia 19, 41121 Modena, Italy; Centre for Anatomical and Human Sciences, Hull York Medical School, University of Hull, Cottingham Road, Hull, HU6 7RX, UK; Centre for Forensic Science, The University of Western Australia, 35 Stirling Highway, Crawley WA 6009, Australia
[c] Dipartimento di Biologia e Biotecnologie "C. Darwin", Università "La Sapienza", viale dell'Università 32, 00185 Roma, Italy
[d] Dipartimento di Scienze Veterinarie e Sanità Pubblica, Sezione di Patologia Generale e Parassitologia Veterinaria, Università degli Studi di Milano, via Celoria 10, 20133 Milano, Italy
[e] Dipartimento di Scienze Teoriche e Applicate, Università degli Studi dell'Insubria, via J.H. Dunant 3, 21100 Varese, Italy
[f] Laboratorio di Ecologia Applicata, Dipartimento di Agraria, Universita degli Studi di Napoli "Federico II", via Università 100, 80055 Portici, Napoli, Italy; School of Biological Sciences, University of Bristol, Woodland Road, Bristol BS8 1UG, UK
[g] Dipartimento di Scienze della Natura e del Territorio, Università di Sassari, via Muroni 25, 07100 Sassari, Italy
[h] CNR - Istituto per lo Studio degli Ecosistemi, c/o Dipartimento di Biologia e Biotecnologie "C. Darwin", Università "La Sapienza", viale dell'Università 32, 00185 Roma, Italy

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Abstract

The global economic crisis leads to important changes in investment policies that hit scientific research too. Scientists are currently facing a period of limited availability of research funds. However, this period of shortage of economic resources may also represent an opportunity of renewal for scientific research, since it may call for improved efficiency and effectiveness and lead to a critical re-evaluation of strategies and priorities. In this opinion paper, we collated a scattered and non-exhaustive list of suggestions for mammal research during a period of limiting financial resources. Our main objective is to stimulate debate, and possibly provide some useful hints, especially to young mammalogists.

Introduction

The global economic crisis has hit science too. Scientific research may, or may not be considered a priority in critical times. It is a matter of cultural, social and political attitudes. In any case, times of economic crisis may lead to important changes in investment policies. Policy in critical times may avoid innovation to concentrate on basic activities or, to the opposite, focus on new achievements, that can drive reaction to static times.

Scientists are currently facing a period of limited availability of research funds. Scarce funding tends to consolidate around specific disciplines and to be invested for projects that more likely will provide quick answers to urgent applied questions. Growing competition for diminishing economic resources imposes a reduction and rationalization of expenses.

Mammal research is particularly sensitive to financial limitations, especially for studies based on empirical trials and field surveys. Mammals are generally elusive, often fast moving and frequently able to range over wide areas: using technological devices (Cagnacci et al., 2010) or undertaking large scale surveys (Ahumada et al., 2011) can be extremely beneficial to ob-

*Corresponding author
Email address: francesca.cagnacci@fmach.it (Francesca CAGNACCI)

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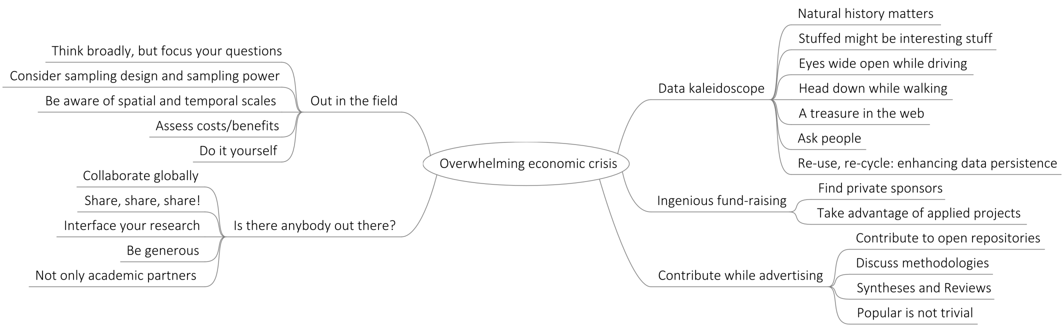

Figure 1 – Proposed actions for optimising research quality and effectiveness in times of economic crisis.

tain robust data, yet expensive. Moreover, both research on mammal species with a long life-cycle, such as usually large mammals, and on species with a short life-cycle, but complex population dynamics, e.g. most rodent species, largely benefit from long-term data records (Clutton-Brock, 2012) – which again usually require substantial and constant financial resources. Field data, however, are vital to the understanding of mammal biology and evolutionary ecology, and to undertake necessary conservation actions. Even key aspects of natural history are still unknown, or based on anecdotal reports, for many mammal species. Indeed, new species and genera are still being discovered (Ceballos and Ehrlich, 2009). Last but not least, theoretical and mechanistic models predicting future scenarios of species distribution and threats to wild populations, are based on parameter estimates obtained from empirical studies.

The current funding constraints may prove particularly limiting for young researchers who face more difficulties to get their work financed, especially when competing for funds with consolidated scientists. But are money and fund raising really everything in research? In a recent commentary on the role of funding in academic careers, Ioannidis (2011) pointed out that "Judging scientists by the size of their portfolio is equivalent to judging art by how much money was spent on paint and brushes, rather than the quality of the paintings".

We think that, as for other aspects of the society, this period of shortage of economic resources may also represent an opportunity of renewal for scientific research, since it may call for improved efficiency and effectiveness and lead to a critical re-evaluation of strategies and priorities.

In this opinion paper, we collated a non-exhaustive list of suggestions for mammal research during a period of limiting financial resources (Fig. 1). The list is largely based on our own experience and specific scientific interests in mammalogy, and therefore provides a partial view. Our main objective is to stimulate debate, and possibly provide at least a few useful hints, especially to young mammalogists.

1. Out in the field: research focus and study design

Do less, think more. In the last decades, information technology, communication and resources have amazingly sped up the rate of scientific production. However, one risk of this process, as indexed by publication rates (Mabe and Amin, 2001), may be a decrease in quality. Darwin needed no less than 20 years to come up with a sound picture of his evolutionary theory. Although Darwin's times have passed, good science can still only stem from good ideas.

Think broadly, but focus your questions. A project needs to reconcile the vital ambition for innovation, with focussed and realistically achievable objectives. Always wonder whether a given research line is promising and the adopted methods make it possible to exactly answer prospected questions will lead to an effective scientific production. While these are general principles that should always apply to scientific research, risks must be minimised with limited availability of resources – leading *de facto* to increased efficiency and efficacy: *less is more*.

Sampling design, and sampling power. Empirical studies rely by definition on sampling. A sound sampling design is the most direct way to put into practice the call for efficiency and efficacy stated above. In particular, the following questions should always have clear answers at the onset of a study: 1) what is the sampling unit? 2) what is the statistical power required to robustly answer the questions of the study? 3) what is the precision and accuracy limitations imposed by the tools used in the study? 4) what is the most efficient sampling strategy under the specific conditions of the study, i.e. the one implying the least effort for the least sampling variability? Again, these are some of the basic principles of empirical studies, but limitations of resources should recall that a sound study design implies that not only "minimum data" are to be collected, but also that, and equally importantly, "excess data" may not be desirable: resources invested in "excess data", i.e. collected "just in case", but with a relevant extra sampling effort, may be better used for other aims (e.g., robust data management, statistical advice, linguistic revisions etc.).

Be aware of spatial and temporal scales. In tight connection with the point above, the awareness of temporal and spatial scales most suitable to meet the objective of the study allows to carefully plan the investment of economic resources. Indeed, the spatial scale of the study, although clearly dependent on the biological issue at stake, may substantially affect the budget. Choices can be manifold: large scale studies (e.g. interregional or transnational scale) are feasible via collaboration with other scientists or research teams (see section 3). Alternatively, studies on a local scale can gain in significance by implementing robust designs, e.g. case-control studies, whereas long term studies may take advantage of re-using historical data (see section 2), and/or redistributing the budget over several years.

Assess the costs/benefits trade-off. Bottom line, cost-effectiveness of an empirical study can only be achieved with a careful assessment of costs and benefits. For example, what is the cost of applying certain techniques or using specific equipment, and what are the benefits with respect to the objective of the study? In mammal ecology, an individual-based study may rely on animal marking with advanced and costly technological devices (e.g. GPS collars), or with more dated, but cheaper instruments, which however require more manpower (e.g. VHF collars). However, the same study may be based on cheap indirect sampling (e.g. collection of droppings), followed by relatively expensive laboratory analyses (e.g., genetic techniques). Obviously, there is no unique answer, and assessing the benefits might be especially demanding, since they depend on the scale of the survey (see above) and, most of all, the specific aims of the study – theoretical or applied (e.g. Hebblewhite and Haydon 2010).

Do it yourself: consider using creative and inexpensive techniques. A time of financial crisis is a time when new cheap and creative techniques could be adopted, or even developed *ad hoc*. For example, morphological studies of mammals may rely on pictures taken in a standardized way with an inexpensive digital camera, or even take advantage of pictures published on web resources (see section 2); e.g., http://www.biocenter.helsinki.fi/bi/evodevo/morphobrowser/index.html or http://paleoview3d.marshall.edu/index.php and http://www.pri.kyoto-u.ac.jp/dmm/WebGallery/index.html. Sound analysis or simple playback experiments, rather than more expensive molecular approaches, may be used to explore major evolutionary issues (e.g. Russo et al. 2007).

2. The data kaleidoscope: multifaceted possibilities for data collection and data analysis

New collection of original data is usually the most expensive part of empirical research. However, useful data may be already available. As exceptionally advantageous fallouts, data-mining and synthesis of existing information enhance data persistence and help to wisely direct future research. Alternatively, data of interest may be ready at hand and inexpensively collected (e.g., museum specimens and road kills). Finally, we only mention the huge importance of simulations and models that might be tested and validated against field data (for example: home range behaviour, Moorcroft et al. 2006; Morales et al. 2004; Van Moorter et al. 2009).

Natural history matters. There are so many species of which we know very little, and many of which we do not know at all. Baseline information on natural history can be acquired relatively inexpensively. For example, droppings are an invaluable source of information under an adequate sampling design (Kohn and Wayne, 1997).

Stuffed might be interesting stuff. Museums and even small private collections offer lots of chances for low-cost data collection in biology (Suarez and Tsutsui, 2004). For instance, for an exploratory investigation using morphometrics (Colangelo et al., 2012), a careful protocol for taking pictures with a digital camera (e.g. Cardini and Tongiorgi 2003) is all one needs.

Eyes wide open while driving. Road kills are an interesting source of data, at very low costs. With the aid of a GPS, a camera and collecting material, they can inform about the distribution of uncommon species (Chanin, 2006), provide material for genetic (Banks et al., 2003), morphological (e.g. Nowak et al. 2008), and parasitological analyses (Sherrard-Smith et al., 2012).

Head down while walking. A biologist should always watch her/his step while walking in nature! A wealth of information is offered (almost) for free by tracks and signs of presence. Robust "indirect" sampling designs and analytical methodologies have been developed to assess biological and ecological properties of species from the signs left on terrain. Among the numerous examples, population density can be modelled with indirect distance sampling from droppings or dens (Marques et al., 2001), population survival and trend can be modelled with molecular Capture Mark Recapture based on snow tracking and collection of droppings (Marucco et al., 2009, 2012).

A treasure in the web. Internet is an incredible source of data. There are free electronic databases of standardized images (e.g. http://lkai.dokkyomed.ac.jp/mammal/en/mammal.html), DNA sequences (e.g. http://www.ncbi.nlm.nih.gov/genbank/), fossil records (http://pantodon.science.helsinki.fi/now/), parasites (http://www.mammalparasites.org/), tracking data (https://www.movebank.org/), etc.

Ask people. The human-dimension in wildlife studies is of great importance, not only to analyse human-wildlife conflicts (e.g. Gusset et al. 2009), but also to increase knowledge on species distribution and sometimes abundance (Fanshawe et al., 1997). Such information can improve considerably conservation actions (Martinoli et al., 2010). Questionnaires and interviews organised under a robust survey design can be a valuable yet inexpensive tool (Manfredo, 2008).

Re-use, re-cycle: enhancing data persistence. Data can have a very long life. Re-using and recycling is a good idea in science as well as in life: indeed, enhancing data persistence is not only advantageous for scientific research, but also ethically correct. Use of economic resources invested in data collection is optimised and maximised; data are made available to a wider audience than the one interested in the original study aims. Data collected on a local scale can be re-used, combined with other datasets, for large scale investigations or meta-analyses (e.g. Cagnacci et al. 2011; see section 2). Published data too can be reused for reviews or re-analysesd using current and potentially more powerful analytical tools (e.g. Amori and Luiselli 2013).

3. Is there anybody out there? The importance of cooperative science

Connectivity is of paramount importance in the career of a young researcher (Boughner, 2009). The huge advantages of being part of a network derive from merging diverse and possibly complementary skills, and ranges from widening the potential for data analyses, to increasing the chance of successful applications. It is also an excellent way to know about opportunities, and therefore be considered as a candidate.

Collaborate globally. The last decades progress in communication technologies has encouraged a worldwide development of research and allowed easy establishment of collaborations over long distances. Connecting with other scientists is no longer an issue in the era of the internet. Connecting broadly often means thinking broadly, and this might be crucial for tackling large scale issues such as the effects of global change on mammal conservation.

Share, share, share! Shared data can live a second life after the original aim for which they were collected (see section 2). Sharing data often leads to share aims, and integrate effort (Tenopir et al., 2011). Studies on species ranging globally almost obligatorily require a collaborative framework (e.g. http://www.topp.org/). However, even studies on species ranging locally would benefit from analyses undertaken at the species distribution range, which are usually possible only through data sharing (Cagnacci et al. 2011; www.eurodeer.org). Finally, global scale issues can only be tackled by means of shared information, which are usually available as web resources (e.g. Boitani et al. 2011).

Interface your research. Relevance of data can be enhanced and renewed also through multidisciplinary analyses. For example, behavioural observations on intra-specific interactions of mammals can be combined with parasitological data to derive models of disease transmission and dynamics (Ferrari et al., 2010).

Be generous: make your "by-products" available to colleagues. Capturing and marking individual mammals can be expensive operations. Their cost-effectiveness could be maximised by collecting samples that might not be of direct relevance to the original research, but could be extremely useful for others: for example ectoparasites, hair, faeces. Also opportunistic observations or encounters of specimen while undertaking fieldwork might be of great importance, for example as inputs in species distribution databases (e.g. therio.it, under development with the sponsorship of the Associazione Teriologica Italiana: http://www.distat.unimol.it/therio/), or for providing colleagues with samples. As far as sampling is carried out in compliance with existing local, national and international laws and regulations, this attitude can pay off according to a principle of mutuality and give rise to successful cooperation.

Not only academic partners. Local governmental agencies or protected areas often collect a great amount of data to comply with their mission to provide public services (e.g. wildlife management, public health, conservation). Most of these data are disseminated in grey literature, and therefore difficult to access, but often have the potential to help in scientific research. Cooperation between research institutes and governmental agencies is of reciprocal benefit and may pave the way to common grant applications.

4. Ingenious fund-raising: an essential quality

All points raised above probably help to support the idea that a huge amount of money may not always be necessary to perform high-quality research on mammals and other organisms. The necessary budget can be obtained (a) from multiple sources at a time, (b) or sources that are alternative to the "classic" institutional funds.

Mammals are "sexy". Although mammal species are difficult and costly to study, they often prove attractive for the general public, and are easily recognized and beloved. Recently, public attitude has considerably changed even for mammals formerly seen as unattractive and now much more popular and charismatic, such as bats. Researchers should take advantage of this privilege and get public support for research applications.

Find private sponsors. Wealthy individuals might be willing to donate funds to research either for philanthropy and maybe with the benefit of accessing tax-discounts. Alternatively, companies producing or marketing products used in research might be taken into consideration as sponsors, after carefully scrutiny of ethical issues.

Take advantage of applied projects. Many funds are devoted to applied management and conservation projects with no interest in pure (or applied) research (e.g., EU Life Natura projects). However, surveys and monitoring activities generally supported by these funds can provide research-valuable by products: not only is this attitude beneficial to the researchers, but also to the stakeholders, because it increases the project's overall quality.

5. Contribute while advertising: a win-win recipe

Dissemination of research outcomes can be particularly relevant in times of shortage of resources, and high public concern on how they are used. On one side, the information can be made available to a large scientific community to optimise the use of funds (see section 3). On the other, the research findings shall be made visible to stakeholders and the public: there is no good science without good communication.

Contribute to open repositories. Sharing data (section 3) or at least providing metadata to public repositories is a responsible act, since it helps to direct future projects, and at the same time is a good advertisement to one's research.

Discuss methodologies. The call for cost-effectiveness is also achieved by making public the performance of technological devices, equipment and pros and cons of protocols, either by means of methodological papers (Balestrieri et al., 2010; De Cena et al., 2011; Torre et al., 2010), or through web forum, wiki pages and email discussion lists.

Syntheses and Reviews. Synthesis of existing knowledge and discussion of research perspectives are fundamental to the advancement of science. When funds are scarce, though, these papers are particularly meaningful to help discerning urgent research topics and effectively directing resources. Moreover, these scientific contributions can be written at almost no expense and might sometimes be doable by young researchers teaming up with more experienced colleagues.

Popular is not trivial. Popular articles, dissemination events (e.g., science fairs, popular talks), TV documentaries, press releases are the most obvious, and yet less trivial way to make science available to the general public. When different parts of the society compete on economic resources, making the general public fully aware of the role of science should be a duty of all researchers.

In conclusion, we suggest that original thinking, careful design, the ability to obtain and produce low cost data, cooperate and make people aware of the importance of studying mammals might help researchers to survive these difficult economic times. Indeed, mammalogists should keep the level of their research as high as possible even when there is shortage of resources. Flexibility, adaptation to changes, and resilience to unfavourable conditions, might, after all, lead to innovative solutions, which enhance fitness by taking a positive view and making less become more.

> Then you better start swimmin', Or you'll sink like a stone, For the times they are a-changin'
>
> Bob Dylan

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