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Misinterpretation of 'slow science' and 'academic productivism' may obstruct science in developing countries

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The economies of developing nations are growing rapidly along with their contributions to scientific research. For example, the percentage of papers published by Brazilians compared to the worldwide total of published papers jumped from 0.8% in 1995 to 2.7% in 2009 (Regalado, 2010). Brazil leads scientific production in Latin America (Marques, 2012), and it is currently ranked 13th in the number of publications worldwide and 15th in the number of citations in the area of environmental/ecological science (Web of Knowledge – Thomson Reuters; assessed in October 2013). However, developing nations still need to grow scientifically (Loyola et al., 2012) as well as increase the scientific impact of their contributions. Regardless of economic development, science often presents a trade-off between quantity (number of papers published) and quality (the impact of those papers). Recently, Fischer et al. (2012) argued that "*we live in the era of ranks,*" with scientific productivity measured primarily by quantitative metrics. In contrast to quantity, a manifesto has been written that calls for a reduction in scientific productivity, arguing that researchers need time to produce high-quality research (the 'slow science manifesto' (SSM) see http://slow-science.org). We believe that many researchers are misinterpreting these ideas, especially in developing countries. In this paper, we discuss how the SSM has been misinterpreted and suggest how researchers from developing countries can solve the apparent paradox between increasing scientific productivity and producing work with high scientific standards.

Quantitative metrics have become the main indicator when measuring the performance of researchers and therefore an end in itself (e.g., Fischer et al., 2012). Nevertheless, harsh criticisms against academic 'productivism' (concerned only with the number of papers published) abound, and it has been suggested that the pace of scientific discovery needs to be reduced. Criticism of scientific research and evaluation extrapolated the academic environment, affecting academic associations and professorial unions (Yamamoto et al., 2012). In general, critics of academic productivism argue that it is dangerous for a professor's career and health (in terms of stress derived from excessive work) and ultimately, for science itself (Yamamoto et al., 2012).

We believe that many critics of academic productivism rely on incorrect concepts regarding SSM, which we will elucidate below. In our opinion, criticism of productivism is welcome if it improves the way scientific research is carried out; however, arguments in favour of the SSM should not be presented to justify unproductive careers. In addition, criticism of academic productivism is no longer relevant for Brazilian scientists in several fields. For example, the area of ecology and limnology at the National Council for Scientific and Technological Development (CNPq) and the area of biodiversity at the Coordination for the Improvement of Higher Education Personnel (CAPES), are no longer assessing only the number of publications, but are adopting multi-metric methods to evaluate scientists and graduate programmes, which include the researcher *H* index and journal impact factors.

Productive researchers in developed countries in the field of ecology and evolution were once publishing approximately ten papers a year but are currently publishing 20-40 papers a year (Fischer et al., 2012). The average Brazilian scientist does not come close to publishing as many papers and is considered extremely productive when producing 5-10 papers per year. For example, to apply for a productivity grant from CNPq in the field of ecology and limnology, a scientist must have published at least five papers in the previous five years (www.cnpq.br). While a researcher with such low productivity will rarely (if ever) receive the grant in Brazil, a quick search of the CNPq website reveals that most researchers who receive such grants publish less than 10 papers per year (see www.cnpq.br). This supports our suggestion that even when producing slow science, the average Brazilian researcher should still be publishing at a much higher rate. The problem lies in the high number of Brazilian researchers publishing less than five papers a year, with most of the research not exerting any influence, as indicated by the limited number of citations the papers receive. This issue is twofold: Brazilians are publishing a limited number of papers, but at the same time these research papers lack the level of impact that they should have as proposed by the SSM.

We believe a misinterpretation of the SSM is reaching many countries, especially in the Southern Hemisphere (Loyola, 2013); however, there is a possibility that our views might be biased towards Brazil. The fundamental misunderstanding of the SSM is that it does not advocate slowing the process of scientific activity; rather, it demands that scientists work even harder to reach the highest standards in science. The SSM stresses that the impact

of publishing matters, diversification of disciplines is important, and primarily, that scientists need time to read, think and fail (see http://slow-science.org). We could not find any passages in the SSM that advocated slowing down the process of scientific discovery. Thus, we feel that the term 'slow science' would be better interpreted as "deep science" because the type of science proposed by the SSM relates to a limited number of influential investigations working towards theoretical advances.

Taking the above considerations into account, we conclude that developing countries should not slow down the pace of scientific discovery as many are arguing but instead produce both 'fast science' and 'slow science' (deep science) simultaneously. These countries require that young, enthusiastic generations produce research to justify their rapid growth in the sciences (Marques, 2012). However, expecting all young scientists to produce influential papers is unrealistic. It is also important to avoid pressuring young scientists to do only influential research because they might end up forgoing writing papers or find an unscrupulous path to publishing through fraud (Beautification…, 2006). One suggestion is for senior scientists to stimulate younger scientists to grow step-by-step throughout their careers by increasing the depth of their scientific inquiries. For example, in areas such as physics and chemistry, scientists between 30 and 40 years old produce the most influential papers (Jones and Weinberg, 2011).

The question remains as to the best method of combining these apparently opposing views of science in developing countries. We believe that Alon (2009) has indirectly suggested a solution for addressing these conflicting views. Summarising Alon's suggestion, 'deep science' should be conducted by hard projects, such as long-term laboratory projects guided by senior scientists that usually result in a significant gain of knowledge, such as the Long-Term Ecological Research programs (LTER, Brazil), which are supposed to address important issues whose answers would never appear in a short time scale. In contrast, some easier and more simple activities provide smaller gains of knowledge (we interpret it as solving puzzles in normal science, *sensu* Kuhn, 1996) and could offer a more proper focus for beginning students. Post-docs could occupy an intermediary position between these two extremes. While recognising that solving puzzles is perhaps more appropriate for young researchers, we also recognise that there are brilliant young students capable of making great contributions; thus, lab leaders and mentors should always be aware of potential young talent. We emphasise that solving puzzles is still very important in tropical countries, especially in the field of ecology where knowledge is poorly developed compared to temperate regions and where there are still amazing quantities of undescribed species and unexplored ecosystems. We believe that a lab in which students and senior researchers are producing pieces of science while maintaining an awareness of the 'big picture' could provide a healthy atmosphere to boost creativity and productivity.

In conclusion, we should not struggle against slow or fast science; both sides highlight an important aspect of how scientists work and how scientific knowledge is generated. In fact, scientists in developing countries should remain focused and aware of cutting edge science, independent of how fast or slow they are performing their own research. Otherwise, these researchers will always lag behind those from developed nations. Perhaps an important building block to success exists in scientific groups that contain broad expertise collaborators who strive to find answers to big questions in great detail. In such a group, young and senior scientists would have a place, and both simple (fast science) and deep (slow science) questions could be answered.

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