Seed Science Research

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Short Communication

Cite this article: Daibes LF, Borghetti F, Ferreira AG (2021). Luiz F. G. Labouriau and the dawn of seed science in Brazil. *Seed Science Research* **31**, 39–42. https://doi.org/10.1017/S0960258520000458

Received: 20 October 2020
Accepted: 1 November 2020
First published online: 7 January 2021

Key words:
cardinal temperature; germination rate; homage; plant physiology; thermal biology

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CAMBRIDGE UNIVERSITY PRESS

Luiz F. G. Labouriau and the dawn of seed science in Brazil

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Abstract

Luiz Fernando Gouvêa Labouriau (1921–1996) was a pioneer plant biologist who made significant contributions to plant physiology, mostly by bringing seed germination into a thermobiological context. His studies have set the foundations of seed science in Brazil and keep inspiring researchers until now.

In 2021, we celebrate 100 years of the birth of Luiz Fernando Gouvêa Labouriau (1921–1996; Fig. 1), a pioneer plant biologist who set the basis of seed science in Brazil. His brilliant scientific career probably began at the age of 17, when he 'discovered' mathematics and spent 1 year studying the foundations of this universal language. In 1944, he graduated as an engineer at the *Escola Naval of Rio de Janeiro*, Brazil. However, instead of pursuing a career as a navy engineer, Labouriau dedicated his life to Science, working in different research institutions throughout his life, including the *Museu Nacional* and the *Jardim Botânico do Rio de Janeiro*. From 1954 to 1957, he worked on his PhD at the prestigious *California Institute of Technology*, considerably improving his knowledge on the physiology of plant development. His thesis brought significant contributions to the understanding of fern morphogenesis (Labouriau, 1958). Back at the *Jardim Botânico do Rio de Janeiro*, Labouriau was one of the first plant biologists to draw attention to germination studies in Brazil, addressing ecophysiological questions regarding the natural regeneration of the Cerrado (Labouriau et al., 1963), thus bringing seed science as a new discipline within the spectra of plant physiology in Brazil.

In the early 1960s, Labouriau was invited to develop ecophysiological studies at the *Instituto de Botânica de São Paulo*, where he advised and/or collaborated with several young researchers, many of whom came to be outstanding plant physiology professors of several Brazilian universities. Among them, we cite Walter Handro, Gil M. Felippe, Ivany F. M. Válio, Sonia M. C. Dietrich, Alfredo G. Ferreira and more than a dozen fellows. Labouriau was a very energic man, so in addition to being head of the laboratory, he was highly active in obtaining funds to support his research. He got an old bus from the Institute, repaired it, and set up a 'moving-lab', which allowed visitations and field expeditions to Cerrado areas. At that time, Labouriau worked in the Institute alongside Maria Lea Salgado-Labouriau, his wife, who studied pollen grains and spores in collaboration with Therezinha Melhem. From 1973 to 1986, Labouriau lived in Venezuela, where he continued his studies on plant physiology at the *Instituto Venezolano de Investigaciones Científicas*. Upon returning to Brazil, he founded the *Laboratório de Termobiologia* at *Universidade de Brasília*, the fifth lab founded by him – as he mentioned once, which is still in full operation.

Throughout his career, Labouriau applied his robust knowledge of mathematics, statistics and thermodynamics to pave a new way of looking at seed germination. In a series of papers, Labouriau and collaborators described the effects of temperature on seed germination kinetics of several species, including *Vicia graminea* (Labouriau, 1970, 1972), *Pereskia aculeata*, *Calotropis procera* and *Dolichos biflorus* (Dau and Labouriau, 1974; Labouriau and Valadares, 1976; Labouriau and Pacheco, 1978), as well as tomato and salvia (Labouriau and Osborn, 1984; Labouriau and Agudo, 1987). However, two papers could be considered as iconic, in which Labouriau (1970, 1972) addressed the temperature-dependence of seed germination rate under a thermodynamic perspective, using *V. graminea* as a model. Briefly, Labouriau showed that the use of the enthalpy of activation could reveal much more about the physiological mechanisms that control seed germination than, for example, the use of the Q_{10} coefficient and of activation-energy approaches (Labouriau, 1978; Labouriau and Labouriau, 1991).

Going indepth in the science of thermodynamics, his theoretical approaches revealed that protein thermo-denaturation affects the germination limits at extreme temperatures, and that germination would be diffusion-limited (i.e. by the seed tegument) only at circum-optimum germination temperatures (Labouriau, 1972, 1978). In line with such results, his studies also

https://doi.org/10.1017/S0960258520000458 Published online by Cambridge University Press

Fig. 1. (A) Young Labouriau working in the laboratory. (B) Labouriau being awarded a medal around 1985.

formalized the existence of cardinal temperatures for germination (i.e. T_{base} and T_{ceiling} – where germination below or above these limits would be arrested) as well as the optimum temperature or temperature range (T_{opt}), where germination would reach its maximum values of germinability and/or rate (Labouriau, 1972). From then on, Labouriau spent years experimentally testing his theories. Employing original approaches, such as the use of deuterium oxide in seed germination studies, he corroborated that seed germination is limited by thermo-denaturation of proteins near T_{ceiling} (Labouriau, 1977b) and near T_{base} (Labouriau, 1980) and that germination would be diffusion-limited only within the optimum temperature range for germination (Labouriau and Osborn, 1984).

His pioneer studies approached seed germination as a ‘thermobiological’ problem (Labouriau, 1978) a few years before thermal-time models became popular (Garcia-Huidobro et al., 1982; Covell et al., 1986). Recently, such models have been used to describe the thermal dependence of germination in a more general sense (Alvarado and Bradford, 2002; Bewley et al., 2013). Apart from thermal- and hydrothermal time concepts, the use of thermodynamic tools proposed by Labouriau contributed to a better understanding of thermal dependence of germination, employed to address physiological questions (e.g. Borghetti and Labouriau, 1994; Santos and Cardoso, 2001; Borghetti and Ferreira, 2004; Cardoso, 2009). The development of Labouriau’s ideas was contemporary with emerging approaches that put the regeneration niche at the core of vegetation dynamics (Grubb, 1977). Thus, the theoretical framework he developed provided fundamental information on the physiology and ecology of seeds and influenced the formulation of hypotheses linking regeneration niche (germination thermal breadth) to the distribution range of many tropical species of Brazil (e.g. Ranieri et al., 2012; Marques et al., 2014).

Labouriau’s most popular book (Labouriau, 1983) was a landmark in the Brazilian literature of seed physiology where he adapted and improved germination indices vastly employed in the literature (Kotowski, 1926; Maguire, 1962). Hence, Labouriau developed statistical approaches for germination analysis, as reported by Ranal and Santana (2006), which were recently used in an R package that contains several germination metrics (Aravind et al., 2020). The concepts of germinability, germination time, germination rate, rate variance, synchrony of germination among others represent regeneration traits that have been increasingly used to understand seed ecology and community assembly (Jiménez-Alfaro et al., 2016; Larson and Funk, 2016; Saatkamp et al., 2019). In addition to the theoretical and statistical approaches, Labouriau also developed and assembled scientific instruments, such as the thermogradient block (Labouriau, 1977a; Labouriau and Cavalcanti, 1996). This low-cost equipment allows germination experiments to be conducted in several temperatures simultaneously. Such a thermogradient block was never patented by him and similar ones were later built, adapted and used in a series of germination experiments (Cardoso, 2010).

In one of his last papers, Labouriau (1990) drew attention to the importance of seeds to mankind, both as a source of food production and for its ecological relevance. Positioning seed germination in a centre-stage, the paper also symbolized the long and successful trajectory of his career in the field of plant physiology. For this, he was honoured in book publications by many Brazilian seed experts in the years following his death (Ferreira and Borghetti, 2004; Santana and Ranal, 2004). In 1996, the year Labouriau left us, a brief summary of his biography and contributions was published by his former student, Dr. Walter Handro, as a tribute to celebrate his legacy to plant physiology and seed science (Handro, 1996). A lot has changed as science in Brazil has advanced substantially, the number and quality of published papers have increased, and new challenges are being tackled, mostly regarding climate change, habitat fragmentation and the lack of basic knowledge regarding the seed germination of native species that could potentially be used for restoration. Most studies on seed germination of native species are concentrated in a small number of research centres and knowledge gaps in the understanding of seed germination of Brazilian ecosystems remain open (Ribeiro et al., 2016). However, we are confident that several studies of seed science, including seed ecology, physiology and development, have found and will always find roots within the history of this passionate scientist, who keeps inspiring current and, hopefully, future researchers.

Acknowledgements. We thank Prof. Victor J. M. Cardoso for all the shared knowledge and inspiration. We also thank Talita Zupo for the English review and Kaire Nardi for improving the quality of the figures.

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