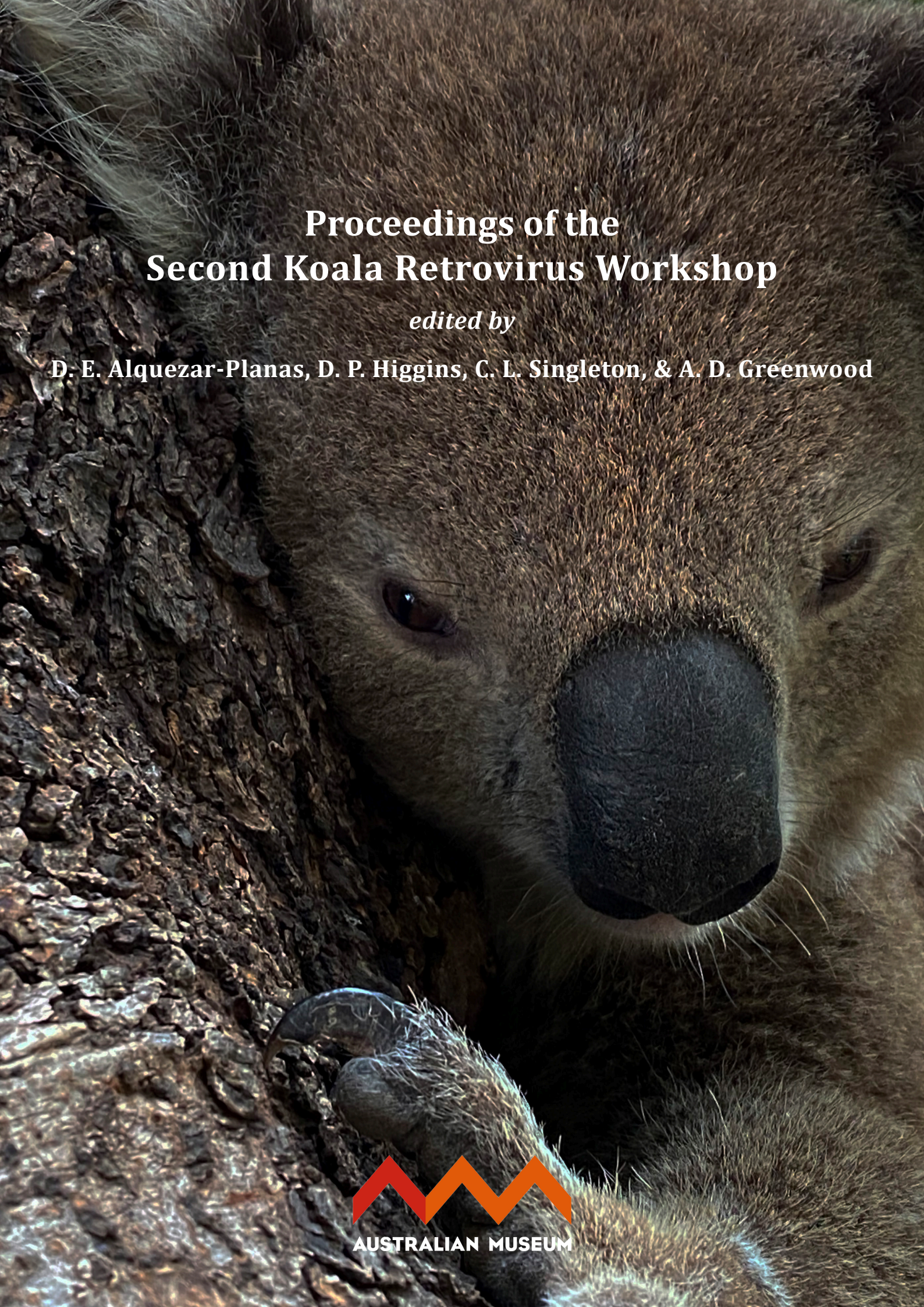
Proceedings of the Second Koala Retrovirus Workshop

edited by

D. E. Alquezar-Planas, D. P. Higgins, C. L. Singleton, & A. D. Greenwood



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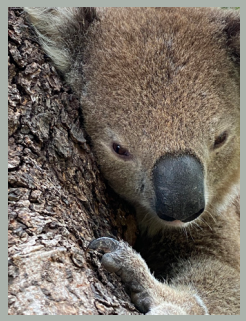

Cover photo
by Damien P. Higgins

A series of peer-reviewed papers, edited by David E. Alquezar-Planas, Damien P. Higgins, Cora L. Singleton, & Alex D. Greenwood, and a discussion summary, from the *Second Koala Retrovirus Workshop* held online, 25–27 May 2021. Published 21 June 2023, in *Technical Reports of the Australian Museum Online* number 38, ISSN 1835-4211 (online).

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Preface to the Second Koala Retrovirus Workshop Online 25–27 May 2021

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Abstract. In 2013, the first Koala Retrovirus Workshop was held in San Diego, bringing together biology and veterinary specialists to assess and discuss the state of knowledge on koala retrovirus (KoRV) and to form professional bridges and networks. Tremendous progress has been made in the years following the San Diego meeting, in large part due to ongoing international collaborations that were fostered to study KoRV. This volume presents peer-reviewed papers from most of the oral presentations and discussions held during the Second Koala Retrovirus Workshop in 2021. Unfortunately, the COVID-19 pandemic forced the workshop into an online only format. Despite this limitation, three days of discussions based on workshop presentations highlighted current knowledge and important information gaps, culminating in suggested ways forward, all summarized in this volume.

Since characterization of the koala retrovirus (KoRV) in 2000 (Hanger *et al*., 2000) and the discovery that it represents the only accessible model of the process of genome colonization (Tarlinton *et al*., 2006), molecular techniques have advanced to a state where full genomes of koalas and huge numbers of individual koalas in both healthy and diseased states can be examined (Greenwood *et al*., 2018). At the same time, a growing body of research supports association of KoRV with disease manifestations in koalas (Legione *et al*., 2017; Waugh *et al*., 2017; Fabijan *et al*., 2019; Quigley *et al*., 2019; Butcher *et al*., 2020; Saker *et al*., 2020; McEwen *et al*., 2021; Blyton *et al*., 2022). In the 10 years since the first Koala Retrovirus Workshop (2013), enormous strides have been made in understanding KoRV. However, the workshop clearly demonstrated that several knowledge gaps remained which precluded implementation of effective management strategies to support koala conservation efforts. This has become an increasingly urgent need. Koala population decimation following the major fires across much of the koala's Australian range in 2019–2020 highlighted the vulnerability of koala populations, brought about by decades of habitat reduction and fragmentation. As of February 2022, the Australian Government listed the combined koala populations across Queensland, New South Wales, and the Australian Capital Territory as endangered.

During this three-day workshop, invited speakers reviewed historical knowledge and presented recent discoveries in KoRV biology, with topics covering KoRV

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genetic diversity and distribution, KoRV-associated diseases, anti-retroviral processes, the origins of KoRV, and new models for retroviral germline invasion. Scientists in many fields including: veterinarians, ecologists, and population managers, all contributed to discussions on KoRV status and the impacts this has on koala health, the challenges faced with managing koala populations (wild and captive) as well as maintaining fit for purpose zoological collections that will enable ongoing foundational research. Over three days following the presentations, discussion sessions focused on KoRV foundational biology and applied management of zoo and wild koala populations to consolidate knowledge, achieve consensus, and identify contrasting perspectives. Discussion summaries for the three-day workshop are also published in this series (Greenwood *et al*., 2023), outlining what we know, what we still do not know, and what we need to know about KoRV. We hope this will serve as a useful guide for current and future KoRV researchers to continue advancing our understanding KoRV and its impacts on koalas.

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References

Blyton, M. D. J., M. Pyne, P. Young, and K. Chappell. 2022. Koala retrovirus load and non-A subtypes are associated with secondary disease among wild northern koalas. *PLoS Pathogens* 18(5): e1010513.
https://doi.org/10.1371/journal.ppat.1010513

Butcher, R. G., L. M. Pettett, J. Fabijan, E. Ebrahimie, M. Mohammadi-Dehcheshmeh, K. N. Speight, W. S. J. Boardman, P. S. Bird, and D. J. Trott. 2020. Periodontal disease in free-ranging koalas (*Phascolarctos cinereus*) from the Mount Lofty Ranges, South Australia and its association with koala retrovirus infection. *Australian Veterinary Journal* 98(5): 200–206.
https://doi.org/10.1111/avj.12919

Fabijan, J., D. Miller, O. Olagoke, L. Woolford, W. Boardman, P. Timms, A. Polkinghorne, G. Simmons, F. Hemmatzadeh, D. J. Trott, and N. Speight. 2019. Prevalence and clinical significance of the Koala retrovirus in two South Australian koala (*Phascolarctos cinereus*) populations. *Journal of Medical Microbiology* 68(7): 1072–1080.
https://doi.org/10.1099/jmm.0.001009

Fabijan, J., N. Sarker, N. Speight, H. Owen, J. Meers, G. Simmons, J. Seddon, R. D. Emes, R. Tarlinton, F. Hemmatzadeh, L. Woolford, and D. J. Trott. 2020. Pathological findings in retrovirus-positive koalas (*Phascolarctos cinereus*) from northern and southern Australia. *Journal of Comparative Pathology* 176: 50–66.
https://doi.org/10.1016/j.jcpa.2020.02.003

Greenwood, A. D., Y. Ishida, S. P. O'Brien, A. L. Roca, and M. V. Eiden. 2018. Transmission, evolution and endogenization: lessons learned from recent retroviral invasions. *Microbiology and Molecular Biology Reviews* 82(1): e00044-17.
https://doi.org/10.1128/MMBR.00044-17

Hanger, J. J., L. D. Bromham, J. J. McKee, T. M. O'Brien, and W. F. Robinson. 2000. The nucleotide sequence of koala (*Phascolarctos cinereus*) retrovirus: a novel type C endogenous virus related to gibbon ape leukemia virus. *Journal of Virology* 74(9): 4264–4272.
https://doi.org/10.1128/JVI.74.9.4264-4272.2000

Greenwood, Alex D., David E. Alquezar-Planas, Philippa A. McKay, Baptiste Mulot, Geoffrey W. Pye, Amy Robbins, Cora L. Singleton, Rachael E. Tarlinton, and Damien P. Higgins. 2023. 2023. Synthesis of discussions of the Second Koala Retrovirus Workshop, 2021. In *Proceedings of the Second Koala Retrovirus Workshop*, ed. D. E. Alquezar-Planas, D. P. Higgins, C. L. Singleton, and A. D. Greenwood. *Technical Reports of the Australian Museum Online* 38: 53–82.
https://doi.org/10.3853/j.1835-4211.38.2023.1842

Legione, A. R., J. L. S. Patterson, P. Whiteley, S. M. Firestone, M. Curnick, K. Bodley, M. Lynch, J. R. Gilkerson, F. M. Sansom, and J. M. Devlin. 2017. Koala retrovirus genotyping analyses reveal a low prevalence of KoRV-A in Victorian koalas and an association with clinical disease. *Journal of Medical Microbiology* 66(2): 236–244.
https://doi.org/10.1099/jmm.0.000416

Quigley, B. L., S. Phillips, O. Olagoke, A. Robbins, J. Hanger, and P. Timms. 2019. Changes in endogenous and exogenous koala retrovirus (KoRV) subtype expression over time reflects koala health outcomes. *Journal of Virology* 93(18): e00849-19.
https://doi.org/10.1128/JVI.00849-19

Sarker, N., J. Fabijan, H. Owen, J. Seddon, G. Simmons, N. Speight, J. Kaler, L. Woolford, R. D. Emes, F. Hemmatzadeh, D. J. Trott, J. Meers, and R. E. Tarlinton. 2020. Koala retrovirus viral load and disease burden in distinct northern and southern koala populations. *Scientific Reports* 10(1): 263.
https://doi.org/10.1038/s41598-019-56546-0

Tarlinton, R. E., J. Meers, and P. R. Young. 2006. Retroviral invasion of the koala genome. *Nature* 442: 79–81.
https://doi.org/10.1038/nature04841

Waugh, C. A., J. Hanger, J. Loader, A. King, M. Hobbs, R. Johnson, and P. Timms. 2017. Infection with koala retrovirus subgroup B (KoRV-B), but not KoRV-A, is associated with chlamydial disease in free-ranging koalas (*Phascolarctos cinereus*). *Scientific Reports* 7(1): 134.
https://doi.org/10.1038/s41598-017-00137-4