

Macquarie–Yaegl Partnership: Community Capability Strengthening Through Western and Indigenous Science*

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The rich customary knowledge possessed by Indigenous people from around the world has provided intellectually stimulating academic research opportunities and has been a successful avenue for healthcare and drug discovery as well as commercial native foods, flavours, fragrances, nutraceuticals, cosmetics, and agricultural products. When conducted with benefit sharing and reciprocity as core agenda, such research can provide community capability strengthening and immense rewards for both the Indigenous people and the academic research team involved, as well as benefiting potentially many others. This account shares my experiences as a natural products and medicinal chemistry academic, of working with Australian Aboriginal Elders, most notably from Yaegl Country of northern New South Wales, on investigating their bush medicines. Together we have facilitated the recognition and preservation of Yaegl Country customary knowledge and through initiation of a science leadership program, the National Indigenous Science Education Program, we have promoted educational attainment and STEM engagement in Australian Aboriginal youth. While this account is authored as my own personal statement of the Macquarie–Yaegl partnership, I am indebted to the Yaegl Aboriginal Elders and other Australian Aboriginal people I have worked with, and my university, school and community collaborators, my research team and student volunteers, who have all enabled the outcomes described in this account to be realised, and have made the experience so rewarding. I am also thankful to the Royal Australian Chemical Institute for the recognition of the value of this work through the award of a 2019 Royal Australian Chemical Institute Citation.

Manuscript received: 12 August 2020.

Manuscript accepted: 23 September 2020.

Published online: 30 October 2020.

Introduction

We all aspire to make valuable contributions to society, and in the chemistry profession there are many ways that these contributions can be made. For me, as a natural products and medicinal chemistry academic having had the privilege to work in respectful partnership with Australian Aboriginal people on bush medicines, I have been able to contribute towards tangible community benefits in ways that I never initially anticipated, and in ways that have been immensely rewarding and educational for myself, my research group, and coursework students I teach. In sharing the experiences and opportunities I have had working alongside Australian Aboriginal people as First Nations scientists, I hope this will inspire other chemists to be able to truly contribute to community capability strengthening through collaborations with Australian Aboriginal and other Indigenous peoples.

The rich customary (traditional and contemporary) knowledge possessed by Indigenous cultures from around the world is a proven resource for drug discovery and the provision of commercial native foods, flavours, fragrances, nutraceuticals, cosmetics, and agricultural products.^[1–4] This knowledge additionally finds applications within the ecotourism industry and is an important cultural, historical, and educational resource.^[5,6] Many natural products and medicinal chemists have tapped into

this rich customary knowledge as part of their research programs, and this has provided intellectually stimulating research opportunities that can also be a means to two-way exchange of knowledge and skills and reciprocal benefit sharing.

Australian Aboriginal people have one of the longest living cultures in the world^[7] and have a deep knowledge of their flora and fauna that has evolved over thousands of years.^[8] Much of this knowledge has been underexplored in a ‘Western scientific’ sense, and like much Indigenous knowledge worldwide, Australian Aboriginal knowledge is being eroded and is in critical danger of being lost forever.^[3,9] The World Health Organisation (WHO)^[10] and Federal government of Australia^[11] have acknowledged that the maintenance of Indigenous peoples’ customary knowledge is a priority area. Australia’s Biodiversity Conservation Strategy 2010–2030 mandates that managing this priority area should include ‘recording, ongoing development and intergenerational transfer of Indigenous knowledge’ and be done through Indigenous ‘employment, partnership and participation’ and the two-way transfer of scientific knowledge that ‘actively supports its maintenance and use’.^[11]

The Yaegl Aboriginal people are the traditional custodians of the coastal regions of Yamba, Iluka, and Maclean in northern New South Wales.^[12] The first people to reside there were the Yaygir tribe and hence the neighbouring national park was

*Joanne F. Jamie is the recipient of the 2019 RACI Citation Award.

named Yuragyir and was where the name Yaegl was derived from. Yaegl Country also includes parts of the Clarence River such as Ul Gundahi Island located off the township of Maclean. The Yaegl community have experienced significant erosion of their customary (traditional and contemporary) knowledge due to the premature death of Elder knowledge custodians in the early 2000s. It is through this urgent need of the Yaegl Elders to document and preserve their knowledge that led to the partnership with Macquarie University.

In early 2004, the Yaegl Elders (through Deidre and Michael Randall) contacted Macquarie University ethnobotanist Associate Professor James (Jim) Kohen for assistance to document and preserve their customary knowledge. Associate Professor Kohen had taught Yaegl community members at Macquarie University, and had built a relationship of trust with them. I had also just commenced a research relationship with Jim and medical microbiologist Associate Professor Subramanyam (Subra) Vemulpad (also from Macquarie University), due to our joint interests in customary medicinal plants. Together, we established the Indigenous Bioresources Research Group (IBRG), with the aim to preserve Indigenous medicinal customary knowledge and conduct chemical and biological investigations of biota (mainly plants) aligned with their customary uses. Following initial meetings with Deidre and Michael, organised through the Yaegl Local Aboriginal Land Council, Jim, Subra, and myself commenced ethnobotanical documentation of Yaegl medicinal plant knowledge, and some chemical and biological investigations of a selection of the Yaegl medicinal plants, following the explicit requests of Yaegl Elders for this study and with human research ethics approval. Our collective initial objective was to document Yaegl medicinal plant knowledge and support this knowledge with Western science.

In October 2004, the partnership objectives were expanded at a landmark gathering in Yarrowarra, northern New South Wales, designed to further develop the plant research. With Yaegl and Bundjalung Elders and other community members at this meeting, along with Jim, Subra, and myself and Law and Indigenous studies academics, we discussed processes to ensure collegial respectful research partnerships. This led subsequently to changing Macquarie University's ethical protocols and development of collaborative agreements that ensured that research on Indigenous knowledge systems had Indigenous peoples recognised as equal research partners and capability strengthening and reciprocal benefit sharing was core to the research.^[13] It was also the stepping stone to the development of a multi-award winning education program, the National Indigenous Science Education Program (NISEP, nisep.org.au, 2005) to empower Indigenous secondary school students to be leaders of science events and in turn become role models for other Indigenous youth, and the award-winning River of Learning Cultural Immersion Program (2010) that respectfully embeds Yaegl knowledge into the curriculum at Maclean High School.^[14]

Results and Discussion

Following the requests by Yaegl Elders for us (Kohen, Vemulpad, and me) to assist in the documentation and preservation of their knowledge and subsequent chemical and biological investigations, we obtained human research ethics approval from Macquarie University (HE27FEB2004-R02750) to undertake working with the Yaegl community. We were struck by the limitation of the ethics process treating Indigenous

peoples as research subjects rather than research partners, despite these custodians of cultural knowledge bringing an enormous wealth of biota knowledge and outstanding community networks that have been accumulated through their life experiences. This led to us initiating a project, funded by a Macquarie University Vice-Chancellor's grant, to develop processes for ensuring academic researchers adopt best ethical practices to work in truly collaborative partnerships with Indigenous communities (within Australia and internationally).

An integral stage in the development of a collegial respectful and reciprocal benefit sharing partnership with the Yaegl Elders (and ultimately with other Indigenous communities) was a two-day workshop that we held in October 2004, in Yarrowarra, northern New South Wales, co-hosted by the Yaegl Local Aboriginal Land Council. Bringing together community members from Yaegl and Bundjalung Countries, and science and law academics from Macquarie University, we discussed what Kohen, Vemulpad, and I could provide as scientists to the project, protection of customary intellectual property, and community capability strengthening opportunities. It was this meeting that was the catalyst for subsequent workshops with representatives from Indigenous communities from across Australia, including Yaegl Country and including Indigenous lawyers, Macquarie University law and science academics, and staff from the Macquarie University Human Research Ethics Committee and Contracts teams, that enabled modification of Macquarie University ethical protocols such that Indigenous peoples were able to be recognised as equal research partners and the development of collaborative research partnership agreements between Macquarie University and Yaegl Country Elders, as well as with other communities that I have worked with in Alice Springs and Chungtia Village (Nagaland, India).^[13,15,16] These collaborative agreements have protection and preservation of Indigenous knowledge and capability strengthening opportunities for the Indigenous partners as key components, as well as recognition of their very significant contribution to the research, including as coauthors of research publications and presentations. While such partnerships may seem obvious, this was extremely unusual for academia when we initiated the first collaborative agreements. Now such collaborative agreements are an essential part of our human research ethics approval process for researching with Indigenous knowledge holders. These agreements are also aligned with best ethical practice protocols for working with Indigenous peoples, including the National Health and Medical Research Council guidelines for research with Australian Aboriginal and Torres Strait Islander peoples,^[17] and the Convention on Biological Diversity and Nagoya Protocol for access to natural resources.^[18]

Our first face-to-face interviews and documentation studies with the Yaegl Elders to aid preservation of their medicinal plant knowledge (ethnobotanical studies) were conducted over 2004 and 2005, with 19 Elders interviewed, leading to discussions on 32 medicinal plants. This was followed by chemical and biological investigations of medicinal plant parts topically applied as customary medicines for treatment of sores, wounds, and skin infections. This research provided the first comprehensive study of Yaegl medicinal plants, leading to the conservation of knowledge of 54 medicinal plant preparations and the understanding of biological properties and bioactive compounds aligned with the customary uses of these previously underexplored plants.^[12,19–21] With the Yaegl Elders and the Macquarie research team (IBRG), we have so far coauthored five refereed scientific papers on the Yaegl medicinal plants.^[12,19–22]

This research is ongoing, in partnership with the Elders. The research work with the Yaegl Elders has been showcased in the *ABC Message Stick Caring for Country* series and *Catalyst*, on *ABC Radio National Drive*, and in the national newspaper, *The Australian*, amongst other media.

Extending from the ethnobotanical studies, the Elders requested for us to develop a handbook together that could showcase their local bush foods and medicines. This resulted in the Yaegl Medicinal and Plant Resources Handbook (2011), which is coauthored by Yaegl Elders and the IBRG.^[23] The Handbook is being used for ecotourism and education purposes, and through selling it at the local museum and art gallery and national events such as the Indigenous Science Experience (see more later), it provides an income to assist with education programs for Yaegl and other Aboriginal youth. This handbook has become a highly valued resource for schools for their incorporation of Australian Aboriginal and Torres Strait Islander peoples' knowledge and perspectives into curriculum, and it has been recommended as a useful resource by the Australian Curriculum, Assessment and Reporting Authority (ACARA) and the NSW Government Department of Education, including for the chemistry curriculum. Following the success of this handbook, we are in discussion on an updated edition that we anticipate will also incorporate local language.

The 2004 Yarrawarra meeting was significant in its initiation of robust ethical protocols for respectful university–Indigenous community partnerships, which was its core aim, but it had other unexpected positive outcomes reaching even beyond us and the Yaegl Community, that came from an icebreaker session and listening and responding to community needs. Macquarie University chemical education researcher (and my husband), Dr Ian Jamie, also attended this Yarrawarra meeting. Together with Subra, we presented hands-on science activities as icebreakers as we knew there would be community members present that we had not previously met and we wanted to make them more comfortable for the serious workshop discussions ahead. The icebreaker activities included writing on paper with betadine and watching the purple drawing disappear when rubbed with lemon juice (redox), seeing the expanding power of dry ice, making slime, and placing hands on agar plates and seeing how many 'bugs' were visible by the next day. This icebreaker session led to the Elders talking about their deep concerns for their youth, especially their lack of completion of High School. They asked us 'Can you help us help our youth?' 'Indeed, can you make them leaders of science activities like you have just shown us... and can you show them what university is like?'. This was before Closing the Gap was openly discussed, and we were shocked by the revelation of the scale of educational inequality faced by their youth, including the fact that most were not encouraged to go beyond year 10. As a collaborative force, Subra, Ian, and I and the Yaegl Elders initiated in 2005 an education program now known as the National Indigenous Science Education Program (NISEP) to empower Indigenous secondary school students from low socioeconomic status regions as leaders of science events, so they gain the confidence and motivation to stay in school, pursue higher education, and take positive employment pathways.^[24] This began in 2005 with school students from Maclean High School (on Yaegl Country) and Casino High School (Bundjalung Country), both of which we have continued to work with ever since.

Right from its inception, we chose as NISEP leaders not only students who are keen to pursue learning, but also those students who have been identified within the schooling system as being

disengaged, and/or lacking confidence. Starting in Yaegl and Bundjalung Countries, but now with a much wider reach, NISEP annually empowers around 200 Indigenous secondary students as leaders, with them presenting practical everyday science activities to around 2000 junior students, peers, family, and the wider public. This includes as part of school events where the NISEP student leaders (years 8–12) present science activities to junior students (years 5–7), university events (most notably the Macquarie Science Experience), and community events including the Indigenous Science Experience.^[24] Along with the NISEP secondary student leaders, Yaegl Elders and a growing number of other cultural knowledge holders present at NISEP events including the annual Indigenous Science Experience where they showcase Indigenous and Western science to school students and the public during National Science Week.^[24,25] Examples of activities the NISEP secondary student leaders demonstrate include the classical interactive science activities such as elephant's toothpaste, making slime, non-Newtonian properties of ooblek, redox reactions with betadine and vitamin C, acid–base reactions with turmeric, and expansion and density properties with dry ice. They also include yarning on bush foods and medicinal plants used by Australian Aboriginal people and showing soap making using bush medicines, Aboriginal tool making, the physics of spear throwing, among others, where the NISEP student leaders work alongside Australian Aboriginal Elders and Indigenous STEM outreach providers. With COVID-19, in 2020, some of the student leaders learnt to share and demonstrate Western and Indigenous science online. The national showcasing of the positive achievements of the young and the Elder science and cultural knowledge holders has enabled the Macquarie–Yaegl partnership to provide benefits far beyond Yaegl Country and aided Closing the Gap.

NISEP student leaders are also given information on STEM study and career options by academics and students who also tell them about their experiences. This breaks down access barriers by giving students the information and confidence they need to pursue STEM based careers. As an example, in 2017 we welcomed former NISEP student leader William Frazer into a Bachelor of Science (major in chemical and biomolecular sciences) with a Bachelor of Laws at Macquarie University.^[26]

To help facilitate NISEP (and other STEM engagement activities), I have developed a Macquarie University course, Engaging the Community in Science, which provides us with a wonderful cohort of university student volunteers that assist in the training of NISEP students and running of activities, and sharing of personal stories, contributing to NISEP's sustainability and impact. Fig. 1 provides an overview of NISEP's program.

When we began NISEP in 2005, the gap between Indigenous and non-Indigenous people in education attainment was very high, but even today despite so much exposure towards Closing the Gap, the need to address the gap Indigenous people face in education attainment cannot be underestimated.^[27] In 2018–2019, 66 % of Australian Indigenous people aged 20–24 had achieved a Year 12 or equivalent level of education compared with 89.1 % for non-Indigenous people.^[27] Indigenous students also remain significantly underrepresented within higher education in Australia. In 2016, just 1.7 % of university enrolled students self-identified as Indigenous (compared with Indigenous peoples making up 3.1 % of the Australian working age population).^[28,29] Furthermore, Indigenous employment lags well behind that for the non-Indigenous, at 47 % compared with 72 % respectively. Given that a strong education can lead to

The National Indigenous Science Education Program (NISEP) – The Student Leader Experience

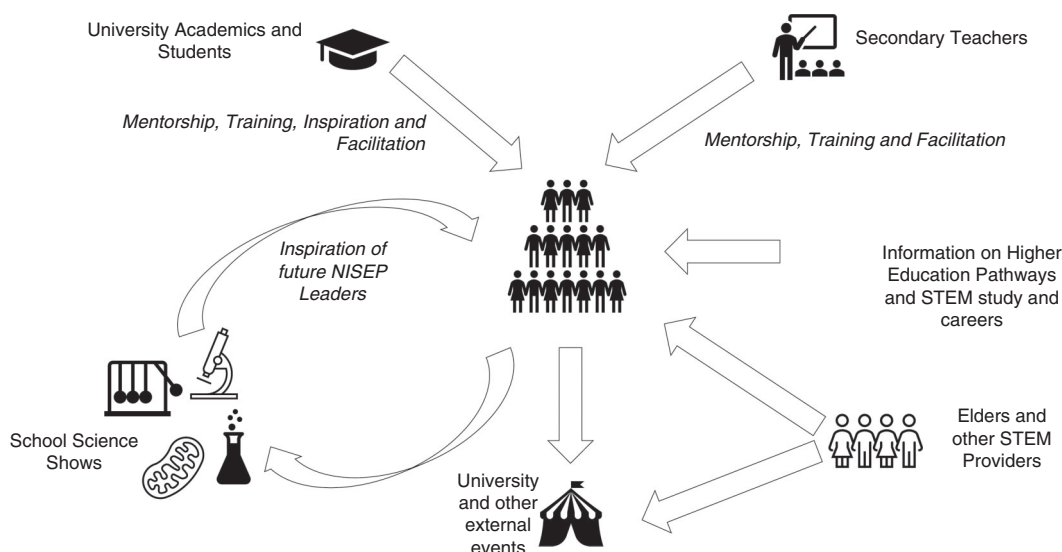


Fig. 1. The National Indigenous Science Education Program (NISEP) provides secondary school students (NISEP student leaders) leadership and role model opportunities as part of school, university, and community science events. NISEP students are supported by university academics, school staff, Aboriginal Elders, and science, technology, engineering, and mathematics (STEM) providers, in training, mentoring, and facilitating their involvement in these events. NISEP student leaders are also provided information on higher education and STEM study and career pathways.

increased societal outcomes, e.g. in health and employment, and lower incarceration rates, it is imperative to address such education gaps.

Aboriginal and Torres Strait Islander people are significantly underrepresented in science and more broadly STEM careers, reflecting their low participation in higher education programs. NISEP engages with its student leaders throughout years 7 to 12 (year 7 as participants and years 8–12 as leaders), providing science events that build their confidence, skills, and educational aspirations over time. We give them roles of responsibility and trust as integral members of our events, giving them the confidence to excel in science. We also incorporate the voices of Aboriginal Elders and community members, science academics, school staff, Indigenous and science outreach providers, and the students themselves, ensuring we are inclusive and culturally respectful.

We provide our partner schools in rural/regional areas with resources and NISEP personnel to facilitate STEM activities they cannot normally access. We also cover costs for student leaders to travel to capital cities for STEM events so as to remove barriers to inclusion. Through events such as the Indigenous Science Experiences,^[25] which engage with primary schools with high Indigenous populations and local Indigenous communities, NISEP student leaders become role models for other youth. Showcasing the vast STEM knowledge of Aboriginal Elders at these high-profile events gives our NISEP student leaders, Elders, and community members a sense of pride, demonstrates the importance and relevance of Indigenous peoples' STEM knowledge, and promotes respect and inclusion in the wider community. As we move towards a more science-based, technology-enriched society, it is also important that we equip students with science and more broadly STEM skills, allowing them to pursue STEM based careers and contribute to the development of Australia's economy. For example, PricewaterhouseCoopers (PwC) has estimated that changing 1 % of

Australia's workforce into STEM-related roles would add \$57.4 billion to GDP.^[30]

Evaluation of data of over a decade (Macquarie University Human Research Ethics approvals HE27JUL2007-R05361, 5201200891, and 5201800357) indicates that NISEP provides transformative and effective attitudinal changes. NISEP helps Indigenous students to see STEM as an achievable calling and show their peers that Australian Aboriginal and Torres Strait Islander people can connect with STEM. Anonymous evaluations of our student leaders ($n \sim 1000$) show that 9 in 10 found being a leader a good or inspiring experience; 8 in 10 had an increased interest in science; and over 6 in 10 had an increased desire to go on to year 12 or higher education. School staff also indicated, 2–3 months after NISEP events, that 8 in 10 of the student leaders demonstrated improved motivation, teamwork, and/or enthusiasm for learning and 7 in 10 increased concentration and/or completed schoolwork (see Supplementary Material for further information). These findings are very significant given some of the leaders were initially identified as shy or disengaged and given how critical it is to close the gap between Indigenous and non-Indigenous youth educational outcomes. Focus group interviews (independent of NISEP and IBRG staff) show the involvement of Aboriginal Elders within NISEP has created a greater connection of Indigenous youth to their local culture and provided an enormous sense of pride for both the Elders and youth. NISEP also has wider benefits, with university staff and student volunteers learning STEM engagement skills and giving back to the community, audiences being exposed to broad aspects of STEM, and school staff being able to expose their students to a wider range of STEM activities.

The blueprint provided by the Yaegl community has allowed NISEP to be implemented by Charles Sturt University in collaboration with Wiradjuri Elders. In 2019, the NISEP partners of Macquarie University, Charles Sturt University, and Yaegl Country were awarded the inaugural Australian Museum

Eureka Prize for STEM Inclusion. We are growing NISEP to ensure that the wonderful legacy of the Macquarie–Yaegl partnership endures, to enable more Australian Aboriginal youth to benefit nationally, and are encouraging more universities to be involved so we can facilitate NISEP's greater reach in a sustainable manner.

Building on the bush medicine research, I and the Macquarie team have been proud to have a role in the development of the award-winning River of Learning Cultural Immersion Program that incorporates cultural excursions on Yaegl Country and embeds Yaegl knowledge into the curriculum for Year 7 students at Maclean High School.^[14] Having run annually since 2010, this program has engaged with over 2000 students.^[31] In 2016, the program was awarded a Nanga Mai Award for its outstanding commitment to increasing understanding of Aboriginal culture, and in 2019 it received the national Reconciliation Australia Narragunnawali Award for exceptional commitment to reconciliation in education.^[32] The River of Learning program is an exemplar for other schools to respectfully embed Australian Aboriginal and Torres Strait Islander knowledge into their curriculum.

Yaegl Elders have stated that acknowledgement of their valuable cultural knowledge and the dissemination of the research findings in refereed journals and media stories, and as part of the River of Learning and NISEP events, has empowered them, making them (in their own words) 'visible and important in the community' and 'aided reconciliation', and has been critical in their success (2015) in two native title claims (7th & 8th successful claims in NSW). Having their knowledge respectfully shared, and them being centre stage, has also led to unprecedented interest in Yaegl cultural knowledge and heightened awareness of the value of Australian Aboriginal wisdom nationally and internationally.

The Macquarie–Yaegl partnership has also provided economic and other community benefits. Aunty Rosemary Vesper conducts bush soap workshops, incorporating knowledge from the scientific investigations, and sells her soaps. Yaegl woman, Deborah Breckenridge, is employed by Macquarie University as a cultural advisor for the medicinal plant research and NISEP. Uncle Ron Heron received an Honorary Doctorate at Macquarie University (2014) for his leadership in the Macquarie–Yaegl partnership, across the medicinal plant research, NISEP, and the River of Learning programs.

The involvement of Indigenous peoples as equal partners in research that recognises the value of their culture increases their self-worth and identity and can contribute to their health, well being, and social inclusion. We have seen very clear evidence of this with our Yaegl Elders partners, who acknowledge that our joint projects have provided a real sense of ownership and pride that has contributed to their mental health and desire to interact with scientists. It is a partnership that is contributing to Closing the Gap and is providing rich rewards for all of us involved.

Conclusion

The Macquarie–Yaegl partnership has developed through us listening to and respecting each other and acting so that real change happens that fosters two-way exchange of knowledge, skills, and capability strengthening. When this partnership began it was rare for Australian universities to acknowledge Australian Aboriginal people (or any Indigenous people) as partners in research or education initiatives. We worked with Macquarie's Human Research Ethics Committee, Indigenous

lawyers, and other community representatives to improve protocols and develop collaborative agreements that recognise Indigenous peoples as true research partners rather than research subjects. The outcome of this is that the Yaegl Elders are among the few Australian Aboriginal or Torres Strait Islander groups to be given authorship status on scientific publications. By listening to the Yaegl community, this approach also led to the development of the only leadership program for Indigenous students of its kind in Australia (NISEP) and embedding of Yaegl culture into Maclean High School's curriculum.

Australian universities are finally recognising Indigenous Australians, for instance through implementing Reconciliation Action Plans. There are a growing number of successful Australian university–Indigenous community research and education partnerships now. I believe the Macquarie–Yaegl partnership provides an exemplar for universities to address reconciliation and hope that the Macquarie–Yaegl partnership is also an inspiration for fellow chemists to provide tangible benefits to community.

Supplementary Material

Further data on evaluation of the National Indigenous Science Education Program are available on the Journal's website.

Conflicts of Interest

The author declares that there are no conflicts of interest.

Acknowledgements

I would like to acknowledge first and foremost the Yaegl Aboriginal Elders, along with Elders from Bundjalung and Wiradjuri Countries, for their generosity in sharing their knowledge and their deep commitment to keeping their culture alive and their passion in educating youth and the public. I would like to especially acknowledge Dr Uncle Ronald Heron, Aunty Carmel Charlton, Aunty Judith Breckenridge, Aunty Rosemary Vesper and Aunty Lenore Parker. I also acknowledge Deborah Breckenridge as our Yaegl Cultural Liaison Officer and Northern Rivers NISEP coordinator, and Noline Kapeen, CEO Yaegl Local Aboriginal Land Council. Special thanks go to Emeritus Associate Professor James Kohen for introducing us to the Elders of Yaegl and Bundjalung Countries, and to him and Associate Professor Subramanyam Vemulpad as Co-Directors with me of the Indigenous Bioresources Research Group (IBRG). I am especially grateful to the Macquarie National Indigenous Science Education Program (NISEP) team, Dr Ian Jamie and Subramanyam, who co-direct NISEP with me, and for Dr Emma Barnes as NISEP Program Manager. I am proud of the Charles Sturt University and Wagga Wagga NISEP and IBRG collaborations, including with Associate Professor Paul Prenzler, Dr Russell Barrow, Dr Danny Bedgood and Colette Geier, and all our school partners, with special note for the contributions of Andrew Ford, Wayne Rice, Angela Froud, Liz Parry, Vivian Lambeth, Aleasha Lyons and Nim Weerakoon. Thanks also goes to all my past and present research team for the IBRG, including Dave Harrington, Dr Joanne Packer and Dr Nynke Brouwer, who were involved in formative stages of the Yaegl partnership, including NISEP, and to all my other past and present NISEP team including (but not limited to) Joshua Wilson, Renee Cawthorne, Erin Rozgonyi and Kaisarun Akter, all the wonderful Macquarie University staff and students who have contributed to building the confidence of the NISEP student leaders and running of NISEP events, and to the fantastic NISEP secondary student leaders. This work was supported by grants from the National Health and Medical Research Council [grant number 488504], [grant number 1028092] and Macquarie University PhD scholarships for the medicinal plant research. For the National Indigenous Science Education Program (NISEP), I acknowledge financial support from the Australian Government Department of Industry, Innovation, Science, Research Tertiary Education (DIISRTE) Inspiring Australia' Unlocking Australia's full potential' scheme [UL010076] and Department

of Education, Higher Education Participation and Partnerships Program (HEPPP) schemes, through Macquarie University's LEAP (Learning, Education, Aspiration, Participation) program and a HEPPP 2014 National Priorities Pool grant. Further small grants supporting NISEP events include from Coca Cola Australia Foundation and St George Foundation, along with annual National Science Week grants from DIISRTE. I wish to also acknowledge funding through Macquarie University's Vice Chancellor Grant Scheme, that initiated best ethical practices for working with Indigenous peoples. Finally, I thank the Royal Australian Chemical Institute for the 2019 Citation Award.

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