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Carbon and Nitrogen Isotope Composition of Australasian Hair and Fingernails in a Global Context

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ABSTRACT

Rationale: The stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope composition of human bone and tissues encodes dietary information that in some circumstances can be attributed to geographical location. While there is a global dataset amounting to >4000 samples, limited data are available for the Australasian region.

Methods: One hundred and seven nail/hair samples were detergent and solvent pretreated and analysed for $\delta^{13}C$ and $\delta^{15}N$ composition, sourced from individuals normally residing in southern Australia (temperate), northern Australia (seasonal tropical) and urban Papua New Guinea (tropical). Isotope values for nails were converted to hair keratin equivalent values using accepted fractionation factors. The results were compared with each other, and with the global datasets available from Europe, Asia, Africa and the Americas.

Results: The southern Australian and Papua New Guinean data exhibit a similar mean and range to each other for both $\delta^{13}C$ and $\delta^{15}N$ values, comparable to results for some regions of Europe and Asia. The northern Australian data extends to higher $\delta^{13}C$ values than the other groups due to a greater component of carbon in the diet ultimately from a C_4 source. Vegetarians exhibit a similar range to the omnivores in $\delta^{13}C$ but tend to lower $\delta^{15}N$ values.

Conclusions: Global supply chains and industrial fertilizer use have reduced the range $\delta^{13}C$ and nitrogen $\delta^{15}N$ values in the samples in this study, as has been the case globally. The range of values observed reflects the ability of consumers to access local produce from supermarkets or local markets. The Australasian data tend to lower $\delta^{13}C$ values than the global average, indicating a dominance of carbon assimilated by C_3 photosynthesis in the diet. While similar to some European and Asian populations, $\delta^{13}C$ values are lower than from regions with a high reliance on carbon assimilated by C_4 photosynthesis, including the Americas and parts of Africa.

1 | Introduction

The stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope composition of human bone and tissues are broadly related to the diet of an individual [1, 2]. As a result of the resources available for consumption varying by geographic location, and because the food items consumed by an individual are also modulated by factors such as personal preference, wealth and/or status, sometimes expressed as differences between genders, the stable isotope composition of the human diet covers a significant range [3–6]. All human tissues archive a record of the diet of the individual over time during life, and materials, such as hair/nail keratin and bone collagen, retain a record *post-mortem* that is indicative of the diet of an individual in the weeks to years before their death [e.g. 7]. Such information is widely used in studies of human physiology, archaeology and forensic science to assess metabolism, modern/ancient diets, dietary change over time [8], as well as infer geographic location, and mobility prior to death [8–11].

The locally sourced foods consumed by prehistoric humans around the world resulted in an extremely wide range of keratin and collagen stable isotope compositions (~20‰ for δ^{13}C and ~25‰ for δ^{15}N; [12]). Much of this range is still evident in modern populations living by subsistence lifeways [12]. Gross variations in carbon isotope composition at the global scale are driven by relative changes in the proportions of foodstuffs derived ultimately from photosynthetic isotope fractionation (C_3 vs. C_4 plants on land, or plankton in the ocean), either directly (e.g. cereals, fruit and vegetables) or indirectly (e.g. meat and fish). Gross variation in nitrogen isotope composition is controlled by a combination of climate factors (primarily rainfall), the trophic level of the organisms consumed, whether the foodstuffs are derived from the terrestrial or marine environment and whether industrial fertilizers were used in the food consumed [4, 12]. Many more minor sources of variability related to climate and, for example, differences in the isotope composition of different components of both vegetation and animal tissues mean that there can be a significant range of isotope values expressed potential food items and therefore by individuals, even from relatively constrained geographic locations [8].

Whereas the modern global range of isotope values is expressed by individuals living on a subsistence diet remains large, humans from modern urban environments and from relatively wealthy countries exhibit a much smaller range (~7‰ for δ^{13}C and ~7‰ for δ^{15}N; [12]). This is due to the widespread use of low ^{15}N fertilizers produced by the Haber-Bosch process in industrial agriculture and animal husbandry and the globalization of food distribution networks that has expanded dietary options [12]. This reduced range still enables some geographical locations—aggregated by country—to be identified as distinct from others, but with considerable overlap between widely separated populations in many instances [4]. Thus, for example, individuals from European countries tend to be similar to each other and to individuals in several countries in Asia, all sharing relatively low δ^{13}C values suggestive of a dominance of C_3-sourced produce and only a ~3‰–4‰ range in δ^{15}N values. In contrast, populations from the Americas tend to have a similar range in δ^{15}N values, but distinctively higher δ^{13}C values reflective of a higher contribution of C_4-sourced produce [4]. Across all populations, vegans, and, to a presumably lesser extent, vegetarians tend to be identifiable by relatively lower δ^{15}N values as a result of not consuming nitrogen from the higher trophic levels occupied by livestock, game and fish [6, 8].

Hülsemann et al. presented the first global compilation of ~4000 carbon and nitrogen isotope composition of modern human hair and nail keratin [4]. The compilation demonstrates that some regions and countries are well represented, with a thousand or more analyses available from each of Europe and North America, and > 1000 analyses available from some Asian countries when combined with the more recent study of Kusaka et al. [13]. Other regions of the world including Africa and Oceania, are much more poorly represented, with < 100 analyses available for either, often skewed to traditional subsistence populations in those regions [4]. Here, we present a new dataset comprising 107 isotope results from individuals from urban Australia and urban Papua New Guinea (PNG), from temperate southerly latitudes to the tropical north.

We seek to determine (i) whether there are systematic differences between northern and southern Australia that relate to the large difference in climate between the two, (ii) whether there are systematic differences between the Australian and PNG populations resulting from the higher reliance on locally sourced produce in urban PNG, compared to the supermarket-dominated supply chains of urban Australia, and (iii) determine whether either population is distinct in comparison to other countries.

2 | Materials and Methods

We sourced hair and/or nail samples from 107 individuals, dominantly in 2020–2021 during the COVID pandemic, but with additional samples added opportunistically up to 2024, all samples from long-term residents of the locations assigned to them. The Australian samples were divided into tropical northern (NAUST; Queensland and Northern Territory) and temperate southern Australian (SAUST; New South Wales, Victoria and southern Western Australia) groups, with those identifying as vegetarian from either group forming a separate population (VAUST). PNG samples were obtained from students and staff at the University of Papua New Guinea in the capital, Port Moresby. All individuals confirmed their agreement for the anonymized data to be included in the study, which was provided ethics approval by James Cook University (approval number H8077).

All samples were immersed in water and detergent in an ultrasonic bath for 20 min, rinsed with distilled water and subjected to the treatment a second time. The process was then repeated twice with dichloromethane, before being dried and crushed for isotope analysis. We measured carbon and nitrogen isotope composition by elemental analysis isotope ratio mass spectrometry (EA-IRMS) using a Thermo Scientific Flash EA with Smart EA option coupled with a Conflo IV to a Delta V Plus at James Cook University's Advanced Analytical Centre. We report carbon isotope measurements as per mil (‰) deviations from the Vienna Pee Dee Belemnite (VPDB) reference standard scale for δ^{13}C and the AIR reference scale for δ^{15}N values. Uncertainty on the three standards included in every analytical sequence to correct for drift and peak amplitude variations ('USGS40 L-Glutamic Acid' δ^{13}C −26.39‰, δ^{15}N −4.52‰; 'Taipan' δ^{13}C −11.65‰, δ^{15}N + 11.64‰; and 'Chitin' δ^{13}C −20.48‰, δ^{15}N −1.04‰) were equal to or better than ±0.2‰. Nail isotope results were corrected for fractionation effects to 'hair equivalent' values using the values recommended by Hülsemann et al. [4] by adding 0.4‰ to each nail $\delta^{13}C$ value ($\delta^{13}C_{hair}$) and subtracting 0.6 ‰ from each nail $\delta^{15}N$ value ($\delta^{15}N_{hair}$). Both are reported in Table S1.

3 | Results

The results for all samples are presented in Table S1. Across all 107 samples $\delta^{13}C_{hair}$ ranged from −22.0 to −16.9 ‰, while $\delta^{15}N_{hair}$ ranged from +6.8‰ to +10.4‰. Omnivorous Australians from the southern states (SAUST; $n=14$) exhibited means for $\delta^{13}C_{hair}$ of −20.2 ± 1.1 ‰ (1σ) and for $\delta^{15}N_{hair}$ of +9.3 ± 0.6 ‰ (1σ), while the larger sample set of omnivorous Australians from the northern states (NAUST; $n=54$) exhibited means for $\delta^{13}C_{hair}$ of −19.5‰ ± 1.1‰ (1σ) and for $\delta^{15}N_{hair}$ of +9.2‰ ± 0.5‰ (1σ). Australian vegetarians, not grouped by northern or southern origin (VAUST; $n=15$), exhibited means for $\delta^{13}C_{hair}$ of −20.2‰ ± 1.1‰ (1σ) and for $\delta^{15}N_{hair}$ of +8.0‰ ± 0.7‰ (1σ).

Despite being entirely located in the humid tropics, the Papua New Guinean sample set (PNG; $n=24$) returned similar values to the SAUST samples, with means for $\delta^{13}C_{hair}$ of −20.7‰ ± 0.7‰ (1σ) and for $\delta^{15}N_{hair}$ of +8.9‰ ± 0.5‰ (1σ). Note that the PNG samples include two vegetarians (See Table S1) not separately identified due to the low sample number; these individuals were similar to the average for the broader PNG population with a mean for $\delta^{13}C_{hair}$ of −20.9‰ and $\delta^{15}N_{hair}$ of +8.7‰.

Two-sample *t*-tests of each population (Tables 1 and 2) suggest greater variance of $\delta^{15}N_{hair}$ values between sample sets than for $\delta^{13}C_{hair}$ values. $\delta^{15}N_{hair}$ values for the VAUST sample set were significantly different ($p<0.001$) from all other sample sets. $\delta^{13}C_{hair}$ was more similar between populations, though the NAUST and PNG sets differed significantly from other sample sets.

TABLE 1 | *p*-values for $\delta^{13}C_{hair}$ between different sample sets.

	NAust	SAust	VAust	PNG
NAust		0.009	0.03	< 0.001
SAust	0.009		0.93	0.045
VAust	0.03	0.93		0.133
PNG	< 0.001	0.045	0.133	

TABLE 2 | *p*-values of $\delta^{15}N_{hair}$ values between sample sets.

	NAust	SAust	VAust	PNG
NAust		0.516	< 0.001	0.071
SAust	0.516		< 0.001	0.006
VAust	< 0.001	< 0.001		< 0.001
PNG	0.071	0.006	< 0.001	

4 | Discussion

4.1 | Diet of Australians

The foodstuffs consumed at the national level are tracked annually by the Australian Bureau of Statistics [14], and from that information, we calculated the average consumption of major food categories for the period 2020–2023. Overall, ~36% of daily food intake by weight is animal (or fish)-derived, with the remainder being plant-derived. This equates to 60.2% of daily protein intake being animal (or fish, 4.1%) derived, with 38.1% of this total derived from beef, sheep or pig and 38.8% being from poultry meat and eggs. The remainder of protein intake (39.8%) comes from a wide range of plant sources, about half of which from cereals (in the form of bread, past and breakfast cereals) and unprocessed vegetables, the other half from products derived to some degree from plant matter.

Supermarkets with national and global supply chains dominate the market across Australia, with a 62% share of all food bought with two supermarket chains enjoying a 70% market share operating via large distribution centres from the major cities to the regions [15]. Food supply in Australia is therefore relatively homogeneously distributed. There are smaller local suppliers, and major supermarkets also carry a range of locally sourced food items [15]. Variations in the potential isotope composition of the food consumed by Australians will therefore largely be determined by individual preferences for particular food items and also by the choice to consume locally produced items.

Variations in carbon isotope composition are likely to be controlled by the proportion of produce ultimately derived ultimately from C_3 versus C_4 photosynthesis. Most Australian produce ultimately derives from C_3 photosynthesis, with the major C_4-derived sources being products containing cane sugar, and to a lesser degree corn. Sheep [16] and poultry [17] products are overwhelmingly of Australian origin, produced predominantly in the southern temperate states, therefore fed on dominantly C_3 pasture [18] and grains. Pig production is also dominated by the southern states, supplemented to a significant degree by imports from North America and the Netherlands [19]. Beef meat products are overwhelmingly sourced in Australia, but unlike other major meats, 60% of production comes from the northern subtropical and tropical region [20] with animals raised on C_4-dominated pasture [18], sometimes augmented by dominantly C_3 grain in feedlots prior to sale. In contrast, dairy production, also overwhelmingly of Australian origin, is dominantly from the temperate south [21].

In aggregate, then, the $\delta^{13}C_{hair}$ values of Australians are likely to be dominantly modulated by the proportion of C_4-derived vegetable matter in individual diets, the proportions of different meats consumed, and a preference (or otherwise) for locally sourced products, which may amplify or dampen the impact of the north–south gradient that exists in the balance between C_3 and C_4 pastures in the biomass consumed by herbivores. The $\delta^{15}N_{hair}$ values of Australians will dominantly reflect the proportion and type of animal-derived products in the total diet, noting that the production of the majority of crops in Australia are produced with the aid of industrial nitrogen fertilizers, with low $\delta^{15}N$ values [22].

4.2 | Diet of Papua New Guineans

There is less information on the diet of modern Papua New Guineans. Traditionally, diet was low in protein and high in carbohydrates, with the main dietary items being locally sourced root crops, fruit and vegetables along with internationally sourced rice, augmented by meat (dominantly local pig and poultry, and internationally sourced canned meat) and seafood, locally caught or tinned [23, 24]. Protein was derived from tree and root crops and/or meat and seafood depending on location. In recent decades, in urban settings, markets selling locally produced meat, fruit and vegetables, all produced with little industrial fertilizer addition, have lost market share to supermarkets, although markets remain the primary suppliers of fruit and vegetables [25]. There has been an attendant increased reliance on imported processed C_3 grain as bread and noodles and increase in the consumption of sugar in processed foods and sweetened drinks, among other factors, leading in turn to an increase in noncommunicable diseases such as cardiovascular disease and diabetes [26].

Unlike Australia, most local terrestrial foodstuffs and imported grains will have a dominant C_3 isotope composition, and this will be reflected in $\delta^{13}C_{hair}$ values, with higher values likely to reflect an increase in the consumption of foodstuffs sourced internationally, and particularly those containing cane sugar. Also unlike Australia, the $\delta^{15}N_{hair}$ values of the PNG population is likely to reflect the root, fruit and vegetables produced locally with minimal industrial fertilizer, along with seafood and meat produced either locally or imported.

4.3 | Stable Isotopes in Australasian Hair

All Australasian isotope data from this study, along with previously published data of relevance from the region are plotted on Figure 1.

The clearest systematic difference between the four Australasian populations is that the $\delta^{15}N_{hair}$ values of the vegetarian population (VAUST; coming from both northern and southern Australia) are relatively low. While there is overlap between the omnivorous (NAUST; SAUST) and vegetarian groups, most VAUST individuals have significantly lower $\delta^{15}N_{hair}$ values than all other samples in the study ($p < 0.001$; Table 2). This phenomenon has been noted before in several studies and attributed to the absence of the trophic enrichment in ^{15}N that increases the $\delta^{15}N$ values of meat and seafood products [1, 6].

The SAUST and NAUST data are similar to the previously published modern urban Australian data compiled by Hülsemann et al. [4]. While there is some overlap between the NAUST and SAUST data, and no difference in $\delta^{15}N_{hair}$ values, the $\delta^{13}C_{hair}$ values are significantly different ($p = 0.009$; Table 1). More than a third of the NAUST $\delta^{13}C_{hair}$ values are higher than −19‰ (and as high as ~−17‰), whereas the $\delta^{13}C_{hair}$ values in the SAUST population are all lower than −19‰. This contrasts with the results of a similarly continental scale study of hair from the central United States that found no patterning in either nitrogen or carbon isotopes in hair along a similarly broad environmental

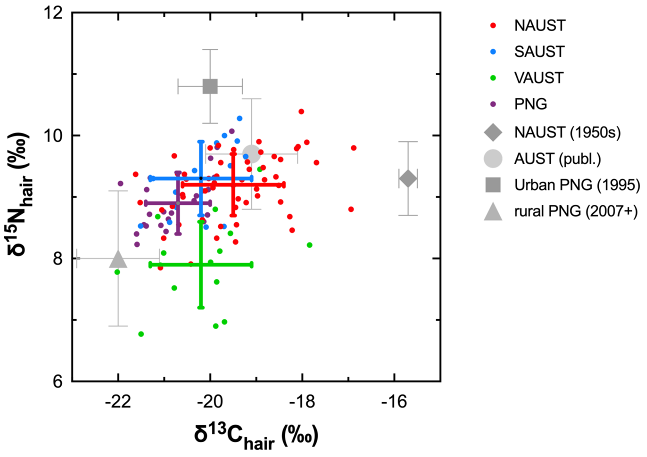

FIGURE 1 | Stable isotope composition of all samples in this study, with average analytical uncertainty shown. NAUST, northern Australia; PNG, urban Papua New Guineans; SAUST, southern Australia; VAUST, vegetarian Australians. Also shown are the means and standard deviation of the datasets for this study, for urban Papua New Guineans in 1995 ($n = 34$; [23]) and rural Papua New Guineans from 2007 and later ($n = 237$; [23]), previously published samples from 'Australia' ($n = 27$; [4]) and a northern Australian indigenous aboriginal sample set of unknown size, from samples collected in the 1950s [27].

gradient to that in this study [28]. As discussed in Section 4.1, this is likely to reflect some remaining differentiation in the source of supermarket produce nationally and the ability of Australians to 'eat locally' if they choose to do so. In temperate southern Australia, this means eating a higher proportion of C_3-derived produce. In tropical northern Australia, this means eating a higher proportion of C_4-derived produce. The majority of the NAUST samples are from individuals residing in Cairns, north Queensland, the hinterland of which supports local beef, pork, poultry, dairy and egg industries that provide products for local markets and supermarkets.

Comparison with the NAUST and SAUST data with an indigenous population (Figure 1) practicing a largely subsistence lifeway in the 1950s from coastal northern Australia, suggests that a 'fully local' diet could result in even higher $\delta^{13}C_{hair}$ values up to −15.5‰. The similar or higher range in $\delta^{15}N_{hair}$ values may be reflective of a relatively high intake of seafood, along with terrestrial grazing fauna such as kangaroos [29] and/or the impact of low ^{15}N industrial fertilizers on $\delta^{15}N_{hair}$ values of the modern Australian population, as discussed in a global context by [12].

The PNG dataset is very close in mean and range for both $\delta^{13}C_{hair}$ and $\delta^{15}N_{hair}$ values to the SAUST dataset (Figure 1). Discussion in Section 4.2 indicates a dominance of C_3-derived foods in the 'average' urban PNG diet, so the similarity in $\delta^{13}C_{hair}$ values between the two populations is unsurprising. While the penetration of internationally sourced food products into PNG has increased over the last decades, and this has led to an increase in the availability of high sugar processed foods and drink [26], this does not appear to have had a measurable impact on $\delta^{13}C_{hair}$ values, at least in the individuals in this study.

Given the lower amount of animal/seafood-derived protein in the average urban PNG diet, the similarity in $\delta^{15}N_{hair}$ values is more surprising. The similarity to the SAUST data suggests that although high ^{15}N meat/seafood consumption per capita in PNG is lower than the SAUST population, the consumption of locally sourced vegetable products that do not rely on low ^{15}N fertilizers for production is higher than the SAUST population.

The range of the urban PNG $\delta^{15}N_{hair}$ values in this study is significantly lower ($p<0.001$) than an urban PNG dataset, also from Port Moresby but collected in 1995, and lies at the upper end of the range for the rural PNG population in the same study [23]. The relatively high $\delta^{15}N_{hair}$ values recorded in the urban population in the 1995 samples are due to more than 50% of the protein intake in the that study being derived from meat and tinned fish (mackerel and tuna), the latter in particular having high $\delta^{15}N$ values (mean = +12.1‰) compared to other foodstuffs all of which all had $\delta^{15}N$ values < +10‰. The lower $\delta^{15}N_{hair}$ values recorded in our study compared to 1995 suggest that the last three decades has seen greater access to a wider range of foodstuffs, a higher proportion of which are of international origin, and produced with the use of low ^{15}N industrial fertilizers.

4.4 | Global Context

Figure 2 plots the means and standard deviations of the data from this study in the context of previously published nationally aggregated data from around the world [4, 13]. The VAUST data plot similarly to other vegetarians globally, including the populations from India/Pakistan, where a significant proportion of the population are vegetarian or consume only a limited amount of meat [30]. The SAUST and PNG data overlap with the majority of European and some Asian datasets, reflecting a dominance of C_3-sourced foodstuffs, and reliance on low ^{15}N industrial fertilizers in the food chain. The NAUST data extends to higher $\delta^{13}C_{hair}$ values that are

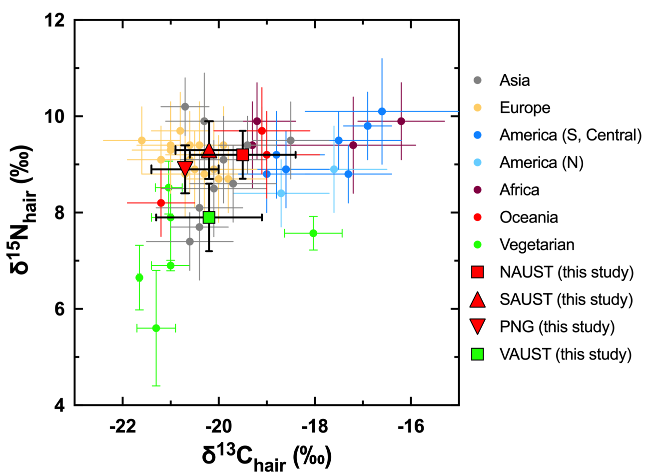

FIGURE 2 | Mean and standard deviation of the stable isotope composition of the four groups from this study samples in this study compared with other available national datasets. NAUST, northern Australia; PNG, urban Papua New Guineans; SAUST, southern Australia; VAUST, vegetarian Australians. The published datasets are mostly by country but have been grouped into broad continental scale regions, indicated by colour. The majority of data is drawn from the global compilation ($n=4002$) of Hülsemann et al. [4] but includes the more recent data from Kusaka et al. [13] for Japan ($n=1305$), South Korea ($n=32$), India ($n=21$) and Mongolia ($n=78$).

distinct from the European and some Asian (Japanese/Korean) datasets. As discussed in Section 4.3, the higher $\delta^{13}C_{hair}$ values in the NAUST data likely result from access to local products with a higher proportion of C_4 input. The relatively high $\delta^{13}C_{hair}$ values in the Korean and Japanese datasets—locations dominated by C_3 primary production—are likely due to higher consumption of seafood, and/or imported corn-fed meats [13]. The Australasian data presented here, in general, appear to remain relatively distinct from most American populations that exhibit a high reliance on corn either directly or indirectly. The Australasian data is also distinct from savanna-dominated (southern and Eastern) African populations, where there is also a high proportion of C_4-derived foodstuffs in the diet resulting in high $\delta^{13}C_{hair}$ values.

Within the broader Australia-Pacific region, the New Zealand data (means of −21.2‰ and +8.2‰; $n=12$, reported in [4]) are lower than the SAUST, NAUST and PNG means. While the New Zealand dataset is small, this is consistent with the intensive use of industrial fertilizers in all production systems in the country, including meat and dairy [31], and the local dominance of C_3 biomass. In contrast, the 'Melanesian' dataset (means of −19.0‰ and +9.2‰; $n=69$ reported in Hülsemann et al. [4]) is superficially similar to the NAUST mean. However, the data are drawn from two studies, one comparing inland and coastal populations in PNG [32] the other from a coastal village in Fiji [33]. The mean in this population is therefore the result of combining results for coastal and inland populations from widely dispersed locations, with individual samples ranging from −22‰ to −16.5‰ for $\delta^{13}C_{hair}$ values and +8.3‰ to +12‰ for $\delta^{15}N_{hair}$ values.

Overall, the new data presented here suggest that, despite the increase dominance of global food supply chains in both Australia and PNG, there remains significant heterogeneity in $\delta^{13}C_{hair}$ and $\delta^{15}N_{hair}$ values across what is a very large region (~6% of the global landmass) spanning temperate to tropical latitudes. The heterogeneity that remains is related to the availability of locally produced food products, as well as the capacity and decision of individuals to choose those local products and preference, or otherwise, for food and drinks containing cane sugar. The data presented here broadly overlap with data from developed countries in Europe and Asia but remain relatively distinct from developed countries in North America and developing countries in Central/South America and parts of Africa. We note that in many cases, there is a limited amount of data; the data that are available are likely biased to a small population group that may be distinct from other local populations, and combining datasets because they are from the same can mask significant local heterogeneity.

Two studies [11, 34] have tried to distinguish 'Australian' samples from local populations in Europe, and neither found that carbon/nitrogen isotopes provided significant discriminatory power. In the context of the much larger dataset presented here, this is not surprising. Both studies did find that additional discriminatory power was provided by also examining the hydrogen, oxygen and sulphur isotope compositions of the hair. This may have been largely fortuitous. There are either regional or national Australian isoscapes available for water isotopes ($\delta^{2}H_{rainfall}$ range −10‰ to < −58‰) [35] and sulphur ($\delta^{34}S_{sulphate}$ range −4‰ to +21‰) [36], which demonstrate the range of isotope values to be expected for these elements from Australasian hair samples is likely to be very large. Thus, while it may be possible to identify an 'Australian' as an outlier in another population, it would be difficult to assign an Australian origin to an unknown sample.

Further national sampling efforts may be able to refine regions in Australia where distinct multi-isotope signatures might be anticipated, particularly if coupled with existing national/regional isoscapes for lead [37] and strontium [38]. This approach could be used, for example, to assign a place of origin to human remains known to have originated from Australia, which may be of potential utility in repatriating unprovenanced indigenous remains currently held in institutions overseas [39].

Author Contributions

Michael I. Bird: conceptualization, data curation, formal analysis, visualization, writing – original draft, methodology, investigation, supervision, project administration, writing – review and editing, funding acquisition. **Maria Box:** investigation, writing – review and editing, formal analysis. **Rainy Comley:** investigation, writing – review and editing. **Matthew Leavesley:** conceptualization, investigation, writing – review and editing, methodology. **Naomi O'Dea:** investigation, writing – review and editing. **Christopher M. Wurster:** conceptualization, methodology, investigation, writing – review and editing.

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Conflicts of Interest

The authors declare no competing interests.

Data Availability Statement

All data are available in Table S1.

Peer Review

The peer review history for this article is available at https://www.webofscience.com/api/gateway/wos/peer-review/10.1002/rcm.10058.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.