



ORIGINAL ARTICLE

A survey on the use of rugs in Australian horses

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The practice of horse rugging has important implications for horse welfare and performance, but in Australia, rugging practices have not been properly documented. The objective of this study was to obtain an understanding of Australian horse rugging practices. An online survey reviewed the management of 2659 Australian horses over 12 months. Of the reported horses a total of 84.8% were rugged, although most owners (69.5%) indicated that they were unsure whether horses needed to be rugged at all. Rugging was felt by 59.8% of owners to be a requirement for horses in competition. Riding and competition were significantly associated with the use of rugs. Nearly all respondents (89.0%) felt that 'over-rugging' was a concern. However, 4.8% of owners would use up to 4 rugs at any one time on their horse and 21.4% of horses were still rugged in temperatures above 20°C in Australia. Many Australian horse owners (42.8%) also believe that horses feel cold if they are not rugged. Anthropomorphism when it comes to rugging horses cannot be justified as the horse has a much wider thermoneutral zone (TNZ) than humans. Australian climate, owner opinions, equestrian discipline and whether a horse is used for riding influence Australian horse rugging practices. However, current practices are based on limited available research and are not necessarily to the benefit of the horse. The major limitation was that the survey likely attracted respondents who are interested in the topic creating a self-selection bias.

Keywords horse (*Equus caballus*); rugging; thermoneutral zone; thermoregulation; welfare

Abbreviations BOM, Bureau of Meteorology; FEI, Fédération Equestre Internationale; LCT, lower critical temperature; TNZ, Thermoneutral zone; UCT, upper critical temperature

Aust Vet J 2023;101:9–26

doi: 10.1111/avj.13219

The first fitted horse rug or blanket was manufactured in 1857 by Troy Woolen Mills in New Hampshire.¹ Rugging is prevalent worldwide with reported use is as high as 97%.^{2,3}

Rugs have been used on horses with the goal of providing warmth and protection from the elements,³ although there are many other argued purposes. Rugs have been demonstrated to reduce exposure to cold temperatures.⁴ Modern horse rugs range from cotton and

mesh type rugs often used in hot ambient conditions, to heavy woollen and canvas rugs which claim to provide warmth and repel water. Whilst some recent preliminary studies have begun to investigate rugs^{4–7} and determine a horses' preference for wearing rugs,⁸ no definitive evidence exists for the benefits of rugging. Additionally, dissemination of this research to the general equestrian community has been poor.³

Thermoregulation in the horse is tightly controlled.⁹ The internal body temperature is maintained between 37 and 38.5°C.¹⁰ Within a range of ambient temperatures known as the 'thermoneutral zone' (TNZ) the horse maintains a balance of heat loss and production with minimal to no energy expenditure. There is therefore an upper (UCT) and lower critical temperature (LCT).¹¹ The UCT for horses is between 20 and 30°C.¹² The LCT for the horse is below 5°C¹¹ in those not accustomed to a cold winter, or as low as –15°C, in mature quarter horses outdoors in winter in Canada.¹³ The human TNZ is much higher, between 26°C as the LCT and 33°C for the UCT.^{14–16} Horses will start to feel the cold at much lower temperatures than humans and naturally grow a thicker winter coat¹⁷ which leads to the question of whether horse rugs are really required for domesticated horses at all.

Australia's climate is unique and geographically variable, but compared to Europe, is generally warmer with a milder winter. Recent data suggests that by 2050, some European cities will experience similar climates to Australian cities because of global warming.¹⁸ The Australian horse population is not only distinct, but represents a unique opportunity to study rugging practices. The primary aim of this study was to report on current Australian horse rugging, clipping and management practices. We hypothesised that rugging would be prevalent in Australia and influenced by horse-related factors (e.g. shelter and clipping), owner-related factors (including equestrian discipline and time spent overseas) and climate. We further hypothesised that Australian horse owners' attitudes and practices regarding rugging would align with the limited current research that is available. The overall aim was to provide clarity and a better understanding of rug use in Australia.

Materials and methods

Outline of survey

An online survey was offered to Australian horse owners and carers. The survey was approved by the University of Sydney Human Research Ethics Committee (HREC) project number 2020/490.

Respondents were over 18 years of age and had owned or cared for a horse within the prior 12 months in Australia (i.e. July 2019–September 2020). Each respondent answered the questions about

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one particular horse they owned or cared for. The survey was opportunistic in acquisition of responses.

Survey design

Online survey designer Redcap, provided by the University of Sydney, was used to generate the survey of 69 fields in 5 sections utilising skip logic. It was distributed to respondents through social media, and was available via an online website developed for the project (<https://australianhorserugging.weebly.com/>). Respondents were directed to this website for further information. The survey was open for 9 weeks from mid-July 2020 to mid-September 2020, drawing data from the prior 12 months.

The survey comprised:

Part 1: horses demographics including the postcode in which they were kept, housing and food provision, coat length and clipping practices.

Part 2: details of how the horse was rugged, changes in wet weather, factors determining application of additional rugs, the maximum number of rugs that would be applied at one time and the temperature above which all rugs were removed.

Part 3: owner practices regarding rugging during and after exercise and the possible use of different types of 'therapy' rugs.

Part 4: opinion-based questions answered on a likert scale. These included: benefits of rugging, use of rugs on geriatric horses, influence of rugging and clipping the hair coat on exercise recovery, negative effects of rugging and the situation of 'over rugging'.

Part 5: owner demographics with specific questions regarding involvement in equestrian professions, country of birth and whether significant time had been spent living overseas.

Most questions in the survey were closed, but several questions included a free text box for respondents to provide further details, or an alternative answer. Most questions were multiple choice and allowed multiple responses. It was clearly indicated in the question whether one or more answer was allowed. Not all questions were compulsory. Incomplete questionnaires were still accepted into the data analysis.

Climate data

Postcode location of each horse was used to classify the horses into climate zones. These climate zone were obtained from the Australian Building Codes Board website (<https://www.abcb.gov.au/resource/map/climate-zone-map-australia>)¹⁹ which is based on data from the Bureau of Meteorology (BOM) (Refer to Appendix 1 for complete details). A total of eight climate zones are included as depicted (Figure 1). These climate zones are assigned using climate data including but not limited to mean temperatures, rainfall, humidity and wind.

Statistics

Horse age was categorised as <12 months, 1–2, 3–5, 6–10, 11–15, 16–20, 26–30 and >30 years. Owner age was categorised as 18–29, 30–39, 40–49, 50–59, 60–69, 70–79 and >80 years. All other variables, except free-text responses, were categorical and selected from a drop-down list. Categorical variables were summarised and reported as number in the numerator, denominator and percent. Associations between categorical variables were assessed using a

chi-square test, or Fisher's exact test if a predicted cell frequency was <5. Statistical significance was set at $P < 0.05$. Data were analysed using R²⁰ and RStudio statistical software²¹ and the packages summary tools,²² gmodels,²³ ggplot2²⁴ and R Commander²⁵ were used.

Results

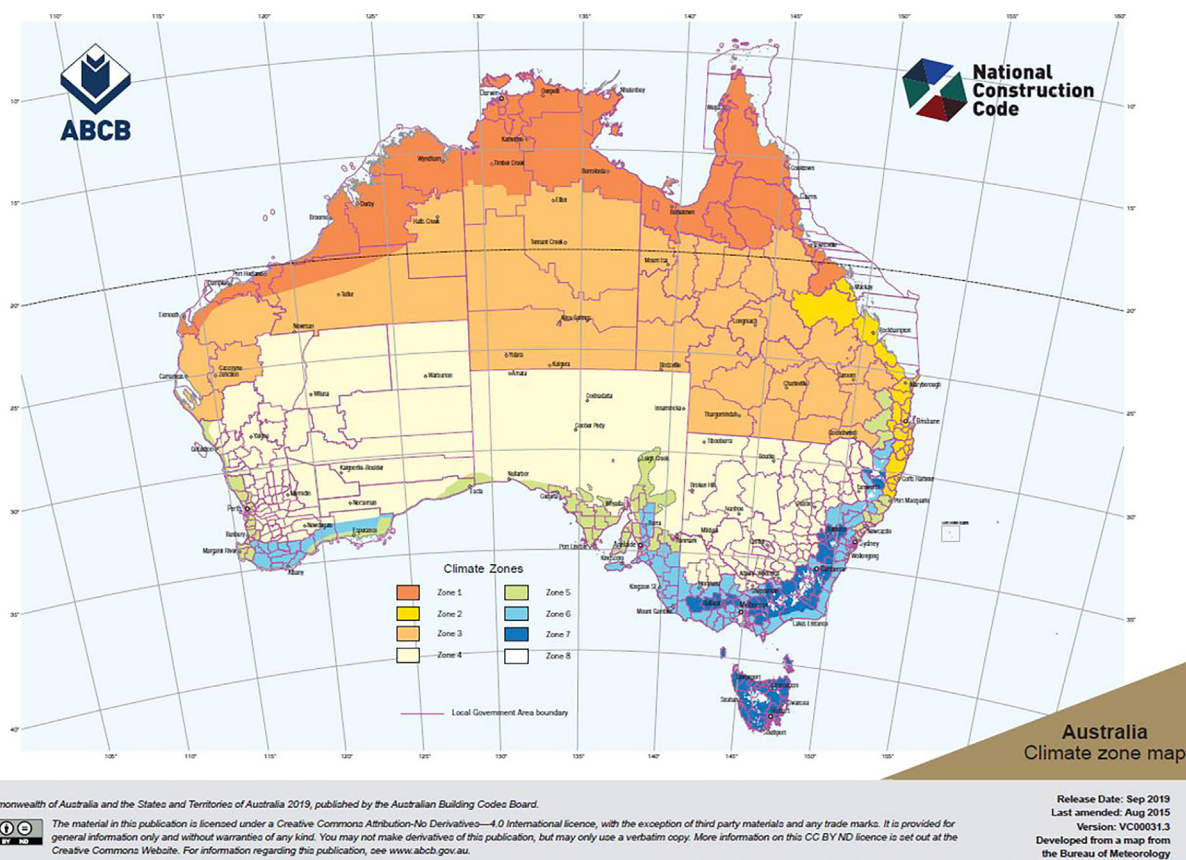
Demographics

The number of responses obtained was 2659, and 88.4% (2351/2659) were completed leaving 11.6% of surveys incomplete (308/2659). Demographic data (Table 1) were consistent with previous recent Australian surveys.^{26,27} A total of 27.2% (722/2659) respondents had lived overseas with 61% (1623/2659) not having lived overseas. Respondents that had lived overseas were significantly more likely to have used a rug on their horse in the past 12 months ($P = 0.02$) (refer to Appendix 2 for complete country of origin data of the respondents). The practice of clipping the hair-coat was also significantly associated with having lived overseas ($P = 0.015$). Living overseas was not significantly associated with an increased likelihood of using four or more rugs ($P = 0.16$). Most respondents were from the eastern states of NSW (1266/2659, 47.6%), Victoria (535/2659, 20.1%) and Queensland (268/2659, 10.1%). However, all states were represented- South Australia (201/2659, 7.6%), Western Australia (197/2659, 7.4%), Tasmania (82/2659, 3.1%), Australian Capital Territory (55/2659, 2.1%), Northern Territory (12/2659, 0.5%) and 1.6% (43/2659) of data was missing. The majority of respondents were amateurs (1824/2659, 68.6%), 9% (239/2659) derived a primary income from horses and 11% (292/2659) deriving a secondary income (304/2659, 11.4% of data missing).

The survey was over-represented by geldings (1636/2659, 61.5%), 33.1% (881/2659) being mares and entire males making up 4.3% (115/2659) of horses studied. All age categories of horses were represented- <12 months (5/2659, 0.19%), 1–2 (24/2659, 0.9%), 3–5 (276/2659, 10.4%), 6–10 (889/2659, 33.4%), 11–15 (752/2659, 28.3%), 16–20 (374/2659, 14.1%), 21–25 (202/2659, 7.6%), 26–30 (75/2659, 2.8%) and >30 years (35/2659, 1.3%). Most horses had a moderate to average coat (1770/2659, 66.6%), followed by light/fine (551/2659, 20.7%), and heavy (303/2659, 11.4%) with data missing from 1.3% (35/2659).

Management of horses

Most horses were housed in groups and were provided pasture and supplemental feed (2217/2659, 83.4%), with just 5.3% (140/2659) having only pasture access, and 10.2% (271/2659) having no pasture access (30/2659, 1.1% missing data) (Table 2). Over 75% of horses were never clipped at all (2024/2659, 76.1%), and 20.6% (547/2659) were clipped in winter only. Just 1.0% (26/2659) were clipped year-round, and 1.2% (32/2659) were clipped in summer (30/2659, 1.1% missing data). A variety of clip types were reported with the most common being a full clip (320/2659, 12.0%), followed by hunter (126/2659, 5.0%), trace (69/2659, 3.0%), blanket (53/2659, 2%), Irish (19/2659, 1.0%) bib (7/2659, 0.3%) and strip (6/2659, 0.2%). There was a statistically significant difference between horses that were clipped and rugged (565/576, 98.1%), compared to those unclipped and rugged (1686/1911, 88.2%, $P < 0.01$). Rugs were infrequently used in exercise (57/2659, 2.1%) with data missing from 27.3% of



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|--|--|
| Zone 1 - high humidity summer, warm winter | Zone 5- warm temperate |
| Zone 2- warm humid summer, mild winter | Zone 6- mild temperate |
| Zone 3- hot dry summer, warm winter | Zone 7- cool temperate |
| Zone 4- hot dry summer, cool winter | Zone 8- alpine |

Figure 1. Australian Climate Zone Map from the Australian Building Codes Board depicting the location of the climate zones used in the study.¹⁹

surveys (725/2659). Therapy rugs were also uncommon, not used by 76.9% (2044/2659) of respondents, with magnetic rugs used by 3.3% (88/2659), ionic by 0.7% (18/2659) and just 1 respondent (0.04%) using both (508/2659, 19.1% of data missing).

Frequency and types of rugs used

In the 12 months prior to completing the survey, 84.8% (2254/2659) of respondents used a rug on their representative horse with only 6.4% not providing an answer. Only 8.9% of respondents did not use a rug on their horse at all in the last 12 months. Winter nights were the most common time of year for horses to be rugged (2156/2659, 81.1%), followed by autumn nights (1926/2659, 72.4%), spring nights (1854/2659, 69.7%), autumn days (1709/2659, 64.3%), summer nights (1,654/2659, 62.2%), spring days and winter days (both 1630/2659, 61.3%) and finally summer days (1589/2659, 59.8%). Spring days were the most common time to leave horses without a

rug (843/2659, 31.7%), followed by summer nights (825/2659, 31.0%), autumn days (762/2659, 28.7%), summer days (660/2659, 24.8%), spring nights (625/2659, 23.5%), autumn nights (547/2659, 20.6%) and lastly winter days (529/2659, 19.9%).

The maximum rugs applied at any one time by respondents ranged from one to six rugs. The most common maximum number of rugs applied at once was two rugs (906/2659, 34.1%), followed by three (616/2659, 23.2%), one rug (561/2659, 21.1%) and four rugs (128/2659, 4.8%). However 1.1% of respondents reported using up to five rugs on their horse at once (28/2659) with four people reporting using up to six rugs (0.2%). A wide range of specific rug types were used by owners, and this varied based on time of day and season (Figures 2 and 3). The temperature at which all rugs were removed was most commonly above 15 degrees Celsius (748/2659, 28.1%), followed by over 20 degrees (446/2659, 16.8%) and over 10 degrees (439/2659, 16.5%). However, some horse owners never

Table 1. Respondent demographics at the time of survey completion

Variable	Grouping	n/N (%)
Respondent age group	18–29	607/2659 (22.8)
	30–39	400 (15.0)
	40–49	522 (19.6)
	50–59	572/2659 (21.5)
	60–69	208 (7.8)
	70–79	46 (1.7)
	80+	1 (0.0)
	Missing	303/2659 (11.4)
Country of birth	Australia	2043/2659 (76.8)
	United Kingdom	146/2659 (5.5)
	New Zealand	37/2659 (1.4)
	Germany	20/2659 (0.8)
	South Africa	17/2659 (0.6)
	United States of America	15/2659 (0.6)
	Scotland	8/2659 (0.3)
	The Netherlands ^a	8/2659 (0.3)
	Missing	315/2659 (11.9)
Continent in which respondents lived overseas (other than country of birth)	Europe, North America	456/2659 (17.2), 111/2659 (4.2)
	South America	3/2659 (0.1)
	Russia	3/2659 (0.1)
	Asia	43/2659 (1.6)
	Africa	24/2659 (0.9)
	Oceania	70/2659 (2.6)
	Missing/Not applicable	1949 /2659 (73.3)
	Equestrian-related industry from which income is derived	Racing, Stablehand
Coaching/breaking	175/2659 (6.6)	
Veterinary	38/2659 (1.4)	
Rescue	0/2659 (0.0)	
Agistment	74/2659 (2.8)	
Farriery	12/2659 (0.5)	
Therapy	24/2659 (0.9)	
Sales	18/2659 (0.7)	
Nutrition	7/2659 (0.3)	
Other	92/2659 (3.5)	
Missing/Not applicable	2129/2659 (80.1)	

^a For complete date regarding country of origin please refer to Appendix 2.

removed all the rugs from their horse (187/2659, 7.0%), and many did not remove their horses' rugs until the temperature was above 25 degrees (164/2659, 6.2%), 30 degrees (134/2659, 5.0%), 35 degrees (70/2659, 2.6%) and over 40 degrees (15/2659, 0.6%).

Most horses were hosed after exercise (62%). Most respondents then reapplied a rug before the coat was dry (24%), whilst 20% waited until the coat was dry before reapplying the rug and 11% of respondents did not apply a rug at all. A specific sweat rug was used by 7% of respondents to assist drying post-exercise. Just 8% of horses were

Table 2. Housing of horses during the survey period including wet weather management practices

Variable	Grouping	n/N (%)
Shelter	Trees	1326/2659 (49.9)
	Open shelter	85/2659 (3.2)
	Stable	58/2659 (2.2)
	3-sided shelter	310/2659 (11.7)
	None	69/2659 (2.6)
	Missing	35/2659 (1.3)
	Combinations	
	2 types	723/2659 (27.2)
	3 types	51/2659 (1.9)
	4 types	2/2659 (0.1)
Winter day housing	Group	1460/2659 (54.9)
	Alone	1143/2659 (43.0)
	Stabled	26/2659 (1.0)
	Missing	30/2659 (1.1)
Winter night housing	Group	1254/2659 (47.2)
	Alone	923/2659 (34.7)
	Stabled	452/2659 (17.0)
Summer day housing	Group	1466/2659 (55.1)
	Alone	1111/2659 (41.8)
	Stabled	43/2659 (1.6)
Summer night housing	Group	1297/2659 (48.8)
	Alone	978/2659 (36.8)
	Stabled	343/2659 (12.9)
Additional management practices when wet weather develops	Missing	41/2659 (1.5)
	Nothing changes	677/2659 (25.5)
	Move into stable/shelter	211/2659 (7.9)
	Apply rug	1396/2659 (52.5)
	Shelter and/or rug	185/2659 (7.0)
	Nothing or rug	13/2659 (0.49)
	Nothing or shelter	3/2659 (0.1)
Missing	173/2659 (6.5)	

not hosed after exercise, but their coat was dry before a rug was reapplied. Finally, 2% of respondents did not wait for sweat to dry before rugging post exercise.

Riding and competition

Most horses were ridden (78.0%) and used in competition (46.3%). Most horses were in moderate exercise (Table 3). A difference was observed in terms of use of a rug between ridden and not-ridden horses. A significantly higher proportion of the un-rugged horses were also not ridden (not ridden: 21.2%, 113/532 vs ridden 6.3%, 123/1958, $P < 0.01$). There was also a statistically significant difference between horses in competition that were rugged (91.9%, 1132/1232) and those that were not rugged (1.1% 30/2659). Of horses that did not compete (31.5%, 838/2659), 83.4% (699/838) were rugged, and 11.1% (93/838) were not rugged. Competing and

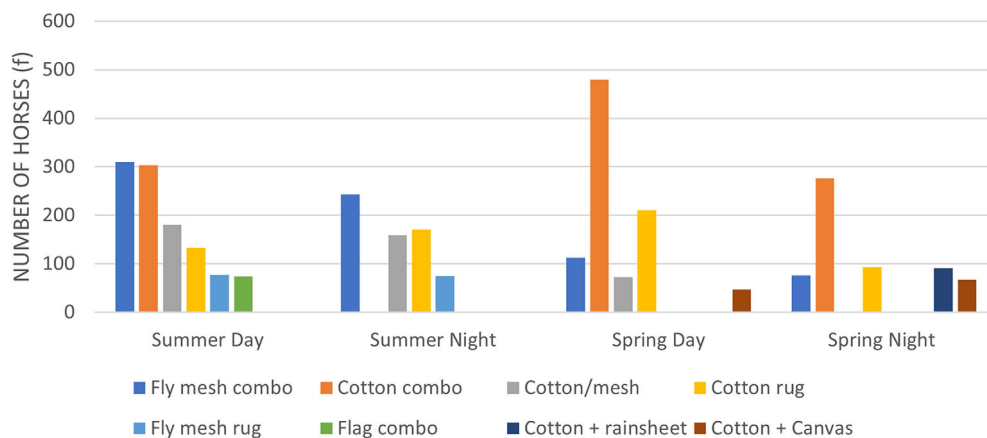


Figure 2. Most common spring and summer rugs and combinations of rugs used by respondents by day/night and season.

riding was significantly associated with rugging ($P < 0.001$). Significantly more horses who were clipped were ridden (97.2%, 588/605) compared to those who were not ridden (2.8%, 17/605, $P < 0.01$).

Rugging practices varied based on the competitive discipline a horse was involved in (Table 4). Specific competitive disciplines were significantly more likely to use a rug than others. Endurance horses were the most likely to not be rugged (14.6%, 6/41), which was significantly more when compared to dressage (0.9%, 3/325, $P < 0.001$), 'dressage_other' (1.9%, 2/103, $P = 0.008$), eventing (1.2%, 3/246, $P < 0.001$) and showjumping (0.6%, 1/179, $P < 0.001$). Western horses were more likely to be rugged than dressage horses (96.1%, 49/51 vs 93.2%, 303/325, $P = 0.049$) and showjumping horses (92.7%, 166/179, $P = 0.03$), however, being a racehorse was significantly associated with an increased likelihood of using a rug (100%, 13/13, $P = 0.02$) comparatively. Pony club horses were more likely to be left without a rug than dressage horses (5.4%, 3/56 vs 0.9%, 3/325, $P = 0.02$) and showjumping horses (0.6%, 1/179, $P = 0.02$). All other discipline comparisons were not significant.

The maximum number of rugs applied at any one time was also significantly different for certain disciplines. Show horses were significantly more likely to have a maximum of four or more rugs applied (41.4%, 41/99), compared to any other discipline: dressage (11.6%, 35/302), 'dressage_other' (7.4%, 7/94), western (6.1%, 3/49), showjumping (10.3%, 17/165), eventing (9.6%, 22/228), pony club (3.8%, 2/52), endurance (0/33) and 'other' (0/36, $P < 0.001$), polo (0/15, $P = 0.002$) and racing (0/13, $P = 0.004$) but also including 'showing_other' (17.4%, 4/23, $P = 0.03$). There was also a significant difference between 'showing_other' horses and pony club horses ($P = 0.046$) and endurance horses ($P = 0.01$). Showjumping and dressage horses were significantly more likely to use a maximum of four or more rugs compared to the 'other' horses ($P = 0.044$ and $P = 0.03$ respectively).

Rugging and climate

Horses originated from a wide range of climate zones (Table 5). Climate zone influenced the use of rugs by respondents with horses in

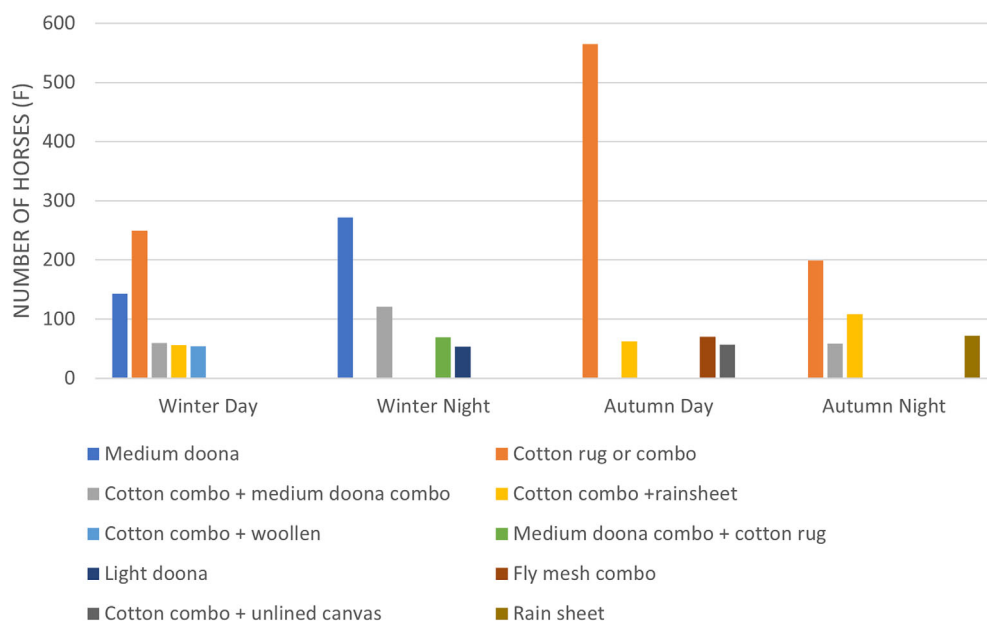


Figure 3. Most common winter and autumn rugs and combinations of rugs used by respondents by day/night and season.

Table 3. Riding and competition data for horses and owners reported in the survey including work level of horses

Variable	Grouping	n/N (%)
Was your horse competitive?	Competitive	1232/2659 (46.3)
	Non-Competitive	838/2659 (31.5)
	Missing	589/2659 (22.2)
Was your horse ridden?	Ridden	2074/2659 (78.0)
	Not Ridden	559/2659 (21.0)
	Missing	26/2659 (1.0)
Work level of horse	Light exercise	624/2659 (23.5)
	Moderate exercise	864/2659 (32.5)
	Heavy work	459/2659 (17.3)
	Very heavy	126/2659 (4.7)
	Missing/NA	586/2659 (22.0)
	Primary competitive discipline horse ridden in	Dressage
Dressage_other ^a		103/2659 (3.9)
Showing		112/2659 (4.2)
Showing_other ^b		25/2659 (0.9)
Western		51/2659 (1.9)
Showjumping		179/2659 (6.7)
Eventing		246/2659 (9.3)
Pony Club		56/2659 (2.1)
Polo		17/2659 (0.6)
Racing		15/2659 (0.6)
Endurance		41/2659 (1.5)
Other ^c		40/2659 (1.5)
Missing/Not applicable		1449/2659 (54.5)

^a Dressage_other: horses that primarily compete in dressage, but also compete in another discipline.

^b Showing_other: horses that primarily compete in showing, but also compete in another discipline.

^c Other: pleasure, adult riding club, driving, vaulting, jousting, inter-schools, hunting, working equitation.

certain zones being significantly more likely to use a rug compared to other climate zones. A total of 27.3% (9/33) of zone 1 horses were always un-rugged which is significantly higher than those in zones 4 (6.9%, 13/188), 5 (8.2%, 49/599), 6 (9.2%, 85/928), 7 (7.8%, 17/218, $P < 0.001$) as well as zone 2 (12.1%, 29/246, $P = 0.02$) and zone '7&8' (11.2%, 22/197, $P = 0.01$). Similarly, climate zone 3 had more horses that were never rugged (20.6%, 7/34) than zones 4 and 5 ($P = 0.01$), as well as 6 ($P = 0.03$) and 7 ($P = 0.02$). Horses in climate zone '5&8' were significantly more likely to be unrugged (33.3%, 3/9) when compared to zones 4 ($P = 0.005$), 5 ($P = 0.007$), 6 ($P = 0.01$), 7 ($P = 0.008$) and zone '7&8' ($P = 0.046$). All other comparisons were not significant. The climate zone in which the horse was located did not influence whether the horse had a maximum of three or less or four or more rugs applied ($P > 0.05$ for all comparisons).

Opinions of respondents

The opinions of respondents regarding rugging and associated management were determined using a likert scale (Figure 4). Most respondents (69.5%) felt the equestrian community was unsure

about whether rugs should or should not be used and various reasons why we should or should not use rugs were reported. The most common contributing factors causing uncertainty regarding rugging are summarised below:

- Strong owner beliefs/opinions about what was 'right and wrong'
- The competitive discipline the owner was involved in
- Climate variability in Australia and the horse's geographical location
- Overwhelming variety of opinions in the community causing confusion
- Lack of knowledge or education about possible negative effects of rugging

Factors that usually influenced the rug purchased by an owner were fit (1933/2659, 72.7%), denier/waterproofing (1598/2659, 60.1%) and cost (1225/2659, 46.1%) followed by warmth (1041/2659, 39.2%), brand (422/2659, 15.9%), appearance (185/2659, 7.0%) and other claims (95/2659, 3.6%) with data missing or not applicable from 14.8% (393/2659). Possible consequences of leaving horses without a rug or of applying too many rugs, as well as reasons why rugs should be used were varied (Supporting Information File 1).

Discussion

This survey confirms the hypothesis that rugging is common in Australia, as has been found in other parts of the world.³ It was practised by 84.8% of Australian horse owners although nearly 70% of respondents felt some uncertainty about whether rugs should or should not be used in Australia. The higher than expected number of responses indicates substantial interest in this topic in Australia. Many Australian horse owner perceptions and common practices are not in line with the horses' natural thermoregulation.

Climate considerations

There is limited data in the literature regarding the benefits or consequences of using different types of rugs particularly in warm climates.^{4-8,28} The climate in Australia during the surveyed period was consistently warmer than the 1980s or 1990s.¹⁹ Most horses were located in the east of Australia, as noted in previous surveys.²⁷ Zone 1 horses (i.e. humid summer and warm winter) and zone 3 (i.e. hot dry summer, warm winter) were significantly less likely to have a rug on than most other zones (zone 2, 4, 6, 7, '7&8') with cooler winters. The horse's TNZ is 5 to 20–30°C^{11,29} therefore leaving horses without a rug in zone 1 and zone 3 is best practice based on the average seasonal temperatures. However, many other horses in zone 1, 2 and 3 still had a maximum of four or more rugs applied. Zone '7&8' respondents were the most likely to use a maximum of four or more rugs (8.4%) which may be appropriate given these are climates with cooler winters and the alpine regions of Australia, however, the effect of multiple rugs has not been evaluated.

Some horses were never without a rug (7.0%) and a significant proportion of horses did not have rugs removed until the temperature was $>30^{\circ}\text{C}$ (8.2%). Given the UCT is 20–30°C,^{12,29} horses that are healthy, unclipped, provided with shelter and acclimated to the climate should not require a rug until the temperature dips below 5°C, and may overheat if a rug is used in conditions over 20°C.

Table 4. Horses grouped into competitive discipline, and as having been rugged or always un-rugged

Competitive discipline	Rugged n/N (%)	Un-rugged n/N (%)	≤3 max rugs n/N (%)	≥4 max rugs n/N (%)
Dressage	303/325 (93.2)	3/325 (0.9)	267/302 (88.4)	35/302 (11.6)
Dressage_other ^a	94/103 (91.3)	2/103 (1.9)	87/94 (92.6)	7/94 (7.4)
Showing	100/112 (89.3)	3/112 (2.7)	58/99 (58.6)	41/99 (41.4)
Showing_other ^b	23/25 (92.0)	1/25 (4.0)	19/23 (82.6)	4/23 (17.4)
Western	49/51 (96.1)	2/51 (3.9)	46/49 (93.9)	3/49 (6.1)
Showjumping	166/179 (92.7)	1/179 (0.6)	148/165 (89.7)	17/165 (10.3)
Eventing	229/246 (93.1)	3/246 (1.2)	206/228 (90.4)	22/228 (9.6)
Pony Club	52/56 (92.9)	3/56 (5.4)	50/52 (96.2)	2/52 (3.8)
Polo	15/17 (88.2)	1/17 (5.9)	15/15 (100)	0/15 (0)
Racing	13/15 (86.7)	0/15 (0)	13/13 (100)	0/13 (0)
Endurance	34/41 (82.9)	6/41 (14.6)	33/33 (100)	0/33 (0)
Other ^c	36/40 (90.0)	2/40 (5.0)	36/36 (100)	0/36 (0)

Note: Horses also categorised as having had a maximum of 3 or less or 4 or more rugs applied at any one time. N = total horses in the competitive discipline.

^a Dressage_other: horses that primarily compete in dressage, but also compete in another discipline.

^b Showing_other: horses that primarily compete in showing, but also compete in another discipline.

^c Other: pleasure, adult riding club, driving, vaulting, jousting, interschools, hunting, working equitation.

Interestingly, 42.8% of respondents indicated that horses without a rug would feel cold. The human TNZ is higher than the horse and so this anthropomorphism may negatively impact horse welfare. Comparing the TNZ to current and forecast weather would be a better guide for rugging. It is important also to note that supplemental feeding in horses is associated with an increase in heat production and metabolism by up to 10%–20%.³⁰ Supplemental feed in addition to pasture was provided by 83.4% of horse owners and this likely further diminishes the need for rugging in Australia.

Many Australian horse owners are rugging horses in conditions that are too warm, with 21.4% leaving rugs on in temperatures over 20°C. Padalino et al found that cotton rugs alone cause an increase in surface and rectal temperature in horses.⁵ However, Padalino et al used a common cotton/polyester blend rug, and not a mesh rug which could have influenced the outcome. Some of the most common reasons why owners reported using a rug on their horse provide insight as to why the rugs were never removed by some owners. Protecting from insects and rain were the two most common

Table 5. Horses categorised by climate zone in which they were located and whether they were rugged or never rugged, and whether they had a maximum of 3 or less or 4 or more rugs applied at any one time

Climate zone	Total horses n/N (%)	Rugged n/N (%)	Un-rugged n/N (%)	≤3 max rugs n/N (%)	≥4 max rugs n/N (%)
1	36/2659 (1.4)	24/33 (72.7)	9/33 (27.3)	22/22 (100)	0/22 (0.0)
2	246/2659 (9.3)	210/239 (87.9)	29/239 (12.1)	195/205 (95.1)	10/205 (4.9)
3	36/2659 (1.4)	27/34 (79.4)	7/27 (20.6)	24/26 (92.3)	2/26 (7.7)
4	205/2659 (7.7)	175/188 (93.1)	13/188 (6.9)	159/170 (93.5)	11/170 (6.5)
5	630/2659 (23.7)	550/599 (91.8)	59/599 (8.2)	490/532 (92.1)	42/532 (7.9)
6	985/2659 (37.0)	843/928 (90.8)	85/928 (9.2)	747/814 (91.8)	67/814 (8.2)
7	233/2659 (8.8)	201/218 (92.2)	17/218 (7.8)	183/193 (94.8)	10/193 (5.2)
8	0/2659 (0)	-	-	-	-
4 & 5 ^a	2/2659 (0.1)	1/1 (100)	0/1 (0)	1/1 (100)	0/1 (0)
5 & 6 ^a	3/2659 (0.1)	3/3 (100)	0/3 (0)	3/3 (100)	0/3 (0)
5 & 8 ^a	10/2659 (0.4)	6/9 (66.7)	3/9 (33.3)	6/6 (100)	0/6 (0)
6 & 7 ^a	8/2659 (0.3)	7/8 (87.5)	1/8 (12.5)	7/7 (100)	0/7 (0)
6 & 8 ^a	12/2659 (0.5)	11/12 (91.7)	1/12 (8.3)	11/11 (100)	0/11 (0)
7 & 8 ^a	204/2659 (7.7)	175/197 (88.8)	22/197 (11.2)	153/167 (91.6)	14/167 (8.4)
6, 7, 8 ^a	6/2659 (0.2)	6/6 (100.0)	0/6 (0.0)	5/5 (100)	0/5 (0)

Note: N = total horses in the specific climate zone.

^a Several locations reported by respondents were on the border of two climate zones, meaning the region experiences a combination of the listed climates. Refer to Figure 1 for location of climate zones.

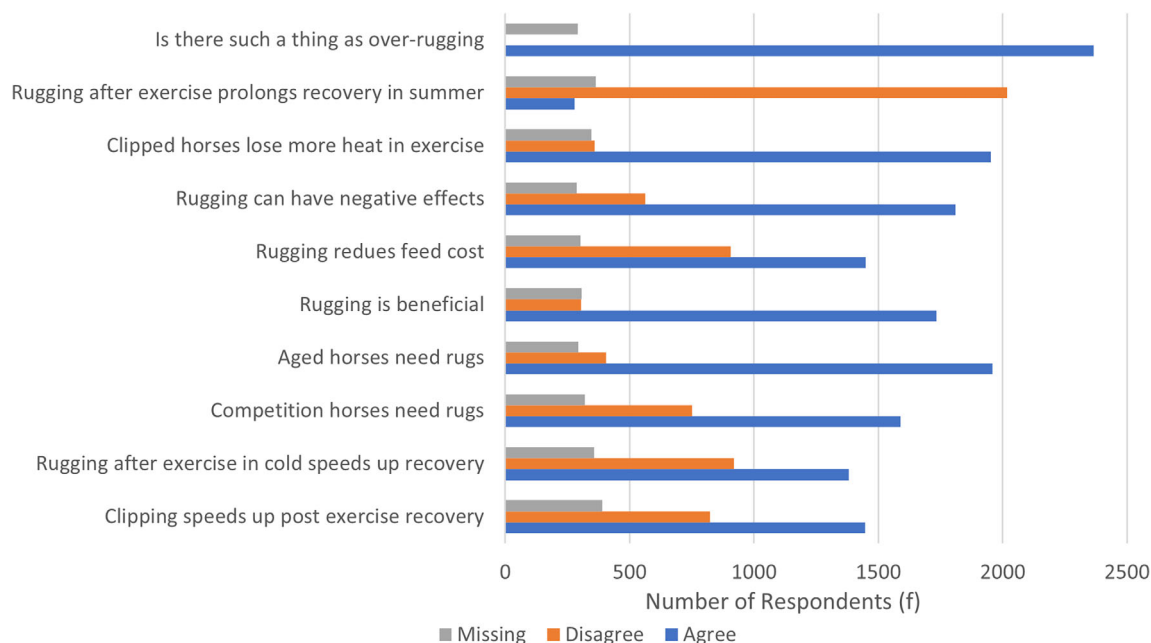


Figure 4. Respondent's level of agreement (likert scale) to statements related to rug use. Strongly agree and agree are grouped as are strongly disagree and disagree. (N = 2659).

responses. Insect activity is highest in summer. Therefore, rugging to protect from insects is likely to occur in the warmest time of year.³¹ Whilst a mesh rug with zebra-striped and checked pattern have been demonstrated to deter flies,³² further research is needed to ensure these rugs do not cause a detrimental increase in surface and rectal temperatures in horses. A large percentage (47.6%) of respondents also used rugs to keep horses clean, as has been identified by Hartmann et al. This is a concern of owners, not of horses.

The provision of a rug does not remove the need for shelter in cold conditions. In Norway where the ambient temperatures ranged from -8.7 to 8.1°C , a rug (200 g polyfill doona/quilt) was not enough to protect horses from inclement weather and shelter use increased.⁷ Whilst the climate in Norway is far colder than even Australian winters, temperatures do still drop below the horses TNZ in Australia. For the horses provided shelter in Australia applying rugs in inclement weather may not be necessary and may not be sufficient without shelter provision as well. In this survey, when wet weather arrives, most respondents applied a rug (52.5% to their horse), with just 7.0% applying a rug and moving into shelter. It is concerning that 2.6% of horses in the current survey were not provided with any form of shelter. Shelter is also needed for hot conditions to assist cooling as previously described. According to the Prevention of Cruelty to Animals Act (POCTAA) 5 freedoms,³³ provision of shelter is legally required for domesticated horses.

Effect of equestrian discipline on rugging

There was a significant association with equestrian discipline and rugging practices in Australia as hypothesised. Endurance riders were the most likely to leave their horse without a rug on. Riders competing in western disciplines were most likely to use a rug at any time. Show horses were by far the most likely to have a maximum of

4 or more rugs on at any one time. The impact of applying multiple rugs on this has not been studied. However, potential known adverse effects of rugging include chaffing, rubbing, and pressure sores which is amplified in clipped horses.^{3,34} Applying more rugs does not halt winter coat development, which is related to extended photoperiod.³⁵ Rugs were used by 19.4% of owners to help keep a horse's coat short. We therefore reject the hypothesis that rugging horses will stop winter coat development which is common owner belief. We suggest that transfer of evidence-based knowledge to the equestrian community is poor.

Demographics and owner opinions

Being a professional was significantly associated with an increased likelihood of using a maximum of four or more rugs ($P = 0.02$). Previous studies have demonstrated that young equestrians are influenced by what they see on social media posted by professionals.³⁶ The practices and opinions of professional equestrians within the Australian community probably shapes the rugging practices of amateurs. Many of those rugging practices are not in line with our understanding of the TNZ in the horse.

The most frequently identified factors influencing the purchase of rugs were fit, denier and cost. The high cost of rugs should deter anything but evidence-based use. Owners also reported that colour, and other manufacturing claims influenced their choice of rug. Rug manufacturers are likely to be a driving force behind rug practices in Australia.

Rugging, clipping and their relationship to exercise

As horses commence exercise, there is an increase in heat production, lost via the same mechanisms as those in resting horses (convection, conduction, radiation and evaporation).³⁷ Conduction is the

loss of heat directly from molecule to molecule, and the magnitude of heat loss or whether it occurs at all, is determined by the gap in temperature of those two molecules. In horses this is influenced by thickness of the hair coat and is more efficient in certain areas of the body because of the surface area to mass ratio.³⁸ The practice of haircoat clipping is common in ridden horses² and clipping decreases signs of overheating in horses exercising in a cool climate,³⁹ and clipped horses experience enhanced heat loss.⁴⁰ Most respondents (73.4%) agreed that clipping increases heat loss via the skin.⁴⁰

Just over half (54.4%) of Australian horse owners felt that clipping increased the speed of post-exercise recovery. Clipping has been found to improve recovery in cold conditions. Unclipped horses (winter coats) had elevated rectal temperatures and respiratory rates during and after exercise compared to when clipped.³⁹ In correlation with this horses that were ridden were more likely to be clipped ($P < 0.01$). Clipped horses may require rugs during non-training time as they lack the natural protective and thermoregulatory properties of a haircoat such as piloerection.⁴⁰

Exercise specific rugs are used mainly in winter during warmup.³ During exercise internal body temperature rises. As rugs have an insulating effect even in resting horses, rugging in exercise reduces the ability to lose heat.^{12,39} Based on average ambient temperatures, the use of exercise rugs in most of Australia is unnecessary and may cause overheating. Despite this, 2.1% of Australian horse owners reported using one at some time. Exercise rugs are suggested to only be used if the ambient temperature is under 5°C and only utilised in the initial few minutes of warmup in Australia.

Limitations of the survey

It is not possible to determine an exact response rate to the survey as there is no specific or detailed data regarding the horse population in Australia. However, Australia is estimated to have over 1 million domesticated horses and an estimated 400,000 horse owners,⁴¹ meaning 0.7% of the population was sampled. Whilst this population meant we could achieve some statistical significance, it is only a small sample of the population and results may not be able to be generalised based on this. The survey was not sent directly to potential respondents but marketed opportunistically through social media channels. The number of respondents may have been higher if the survey had it been sent to specific groups. However, this could introduce selection bias depending on the method of distribution. This may have also attracted participants who were already principally interested in the topic of rugging and are therefore biased by self-selection.⁴² Participants could have been biased in selecting which horse they answered for, perhaps one that they believe was receiving the highest standards of care.⁴³ However, this strategy was chosen to try to reduce participant fatigue due to copious data entry required from a large number of questions.⁴⁴

Future directions for research

Future research should be controlled and the investigated physiological data of horses rugged under different conditions (i.e. single compared to multiple rugs, warm compared to cold conditions), utilising the Australian horse rugging and management profiles were

outlined. Such data would direct best practice strategies and regulations for rugging in Australia and potentially worldwide. Rugs that can determine skin surface temperature, sweating and increases in respiratory rate may be useful in the future to help owners monitor the effect of a rug particularly when the weather is variable. Some such devices are already on the market^{45,46} however, may be cost prohibitive particularly for multi-horse properties and owners. Without established physiological cut-offs and parameters utilising the TNZ as a guide, their use is limited. Given the popularity of horse rugging, understanding if rugs are beneficial or harmful for horses in the uniquely variable Australian climate is needed.

Conclusions

The practice of horse rugging in Australia is common and routine. The specific rugs used, and timing of their application appears to be influenced by equestrian discipline, owner beliefs, owner demographics and the Australian climate. However, owners largely base rugging decisions on anecdotal information and anthropomorphism. Australian horse owners may be rugging horses when it is too hot. There is substantial interest and concern regarding use of rugs and the possible role 'over rugging' in Australian horse welfare which should encourage future clinical investigation. Use of rugs in healthy, unclipped horses that have shelter access, in temperatures over 5°C (for non-alpine acclimatised horses) is not in agreement with science. More accessible resources based on an understanding of the importance of the TNZ and practical guidelines are critical to assist owners rugging horses in Australia.

Acknowledgments

The survey would not have been possible without the generosity of horse owners who gave their time to complete the survey. We were overwhelmed by the positive response to the survey and are extremely grateful for each person's time and engagement. Open access publishing facilitated by The University of Sydney, as part of the Wiley - The University of Sydney agreement via the Council of Australian University Librarians.

Conflict of interest and sources of funding

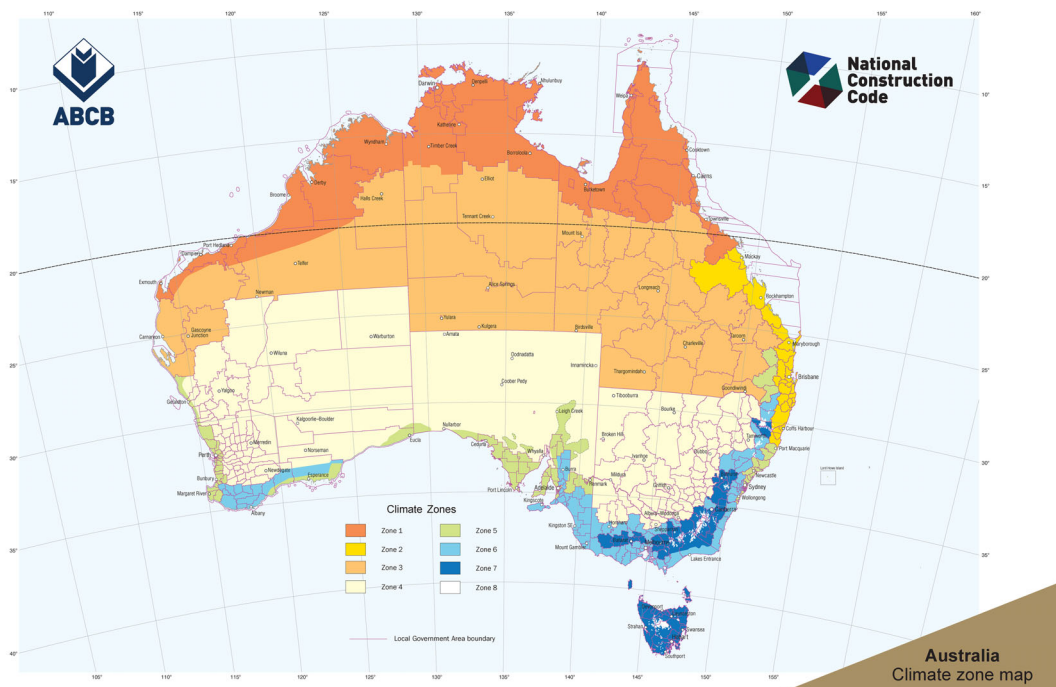
The authors declare no conflicts of interest for the work presented here. The University of Sydney provided funding for the data analysis as part of the Masters of Veterinary Science funding for the first author.

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APPENDIX 1



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Release Date: Sep 2019
 Last amended: Aug 2015
 Version: VC00031.3
 Developed from a map from the Bureau of Meteorology

Australia

Climate zone map

Table 1 NCC climate zones for thermal design: Australia

State or Territory	Location	Climate zone
Australian Capital Territory	Canberra	7
New South Wales	Albury	4
New South Wales	Armidale	7
New South Wales	Batemans Bay	6
New South Wales	Bathurst	7
New South Wales	Bega	6
New South Wales	Bellingen Shire – Dorrigo Plateau	7
New South Wales	Bellingen Shire – Valley & seaboard	2
New South Wales	Bourke	4
New South Wales	Broken Hill	4
New South Wales	Byron Bay	2
New South Wales	Cobar	4
New South Wales	Coffs Harbour	2
New South Wales	Dubbo	4
New South Wales	Goulburn	7
New South Wales	Grafton	2
New South Wales	Griffith	4

Version history

This version:

Last amended: Aug 2015

Release date: Sep 2019

Version: VC00031.3

Details of release: Table included for web content accessibility purposes (WCAG) and styling aligned with NCC 2019 branding.

Previous version:

Last amended: Aug 2015

Version: VC00031.3

Climate zone map: Australia

State or Territory	Location	Climate zone
New South Wales	Ivanhoe	4
New South Wales	Lismore	2
New South Wales	Lord Howe Island	2
New South Wales	Moree	4
New South Wales	Newcastle	5
New South Wales	Nowra	6
New South Wales	Orange	7
New South Wales	Perisher Smiggins	8
New South Wales	Port Macquarie	5
New South Wales	Sydney East	5
New South Wales	Sydney West	6
New South Wales	Tamworth	4
New South Wales	Thredbo	8
New South Wales	Wagga Wagga	4
New South Wales	Williamtown	5
New South Wales	Wollongong	5
New South Wales	Yass	6
Northern Territory	Alice Springs	3
Northern Territory	Darwin	1
Northern Territory	Elliot	3
Northern Territory	Katherine	1
Northern Territory	Renner Springs	3
Northern Territory	Tennant Creek	3
Queensland	Birdsville	3
Queensland	Brisbane	2

Climate zone map: Australia

State or Territory	Location	Climate zone
Queensland	Bundaberg	2
Queensland	Cairns	1
Queensland	Cooktown	1
Queensland	Cunnamulla	3
Queensland	Gladstone	2
Queensland	Hervey Bay	2
Queensland	Hughenden	3
Queensland	Longreach	3
Queensland	Mackay	2
Queensland	Mount Isa	3
Queensland	Normanton	1
Queensland	Rockhampton	2
Queensland	Roma	3
Queensland	Southport	2
Queensland	Toowoomba	5
Queensland	Townsville	1
Queensland	Warwick	5
Queensland	Weipa	1
South Australia	Adelaide	5
South Australia	Bordertown	6
South Australia	Ceduna	5
South Australia	Cook	4
South Australia	Elliston	5
South Australia	Kingscote	6
South Australia	Leigh Creek	5

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Page 3

Climate zone map: Australia

State or Territory	Location	Climate zone
South Australia	Lobethal	6
South Australia	Loxton	5
South Australia	Naracoorte	6
South Australia	Marree	4
South Australia	Mount Gambier	6
South Australia	Murray Bridge	6
South Australia	Oodnadatta	4
South Australia	Port Augusta	4
South Australia	Port Lincoln	5
South Australia	Renmark	5
South Australia	Tarcoola	4
South Australia	Victor Harbour	6
South Australia	Whyalla	4
Tasmania	Burnie	7
Tasmania	Bicheno	7
Tasmania	Deloraine	7
Tasmania	Devonport	7
Tasmania	Flinders Island	7
Tasmania	Hobart	7
Tasmania	Huonville	7
Tasmania	King Island	7
Tasmania	Launceston	7
Tasmania	New Norfolk	7
Tasmania	Oatlands	7
Tasmania	Orford	7

Climate zone map: Australia

State or Territory	Location	Climate zone
Tasmania	Rossarden	7
Tasmania	Smithton	7
Tasmania	St Marys	7
Tasmania	Zeehan	7
Victoria	Anglesea	6
Victoria	Ararat	7
Victoria	Bairnsdale	6
Victoria	Ballarat	7
Victoria	Benalla	6
Victoria	Bendigo	6
Victoria	Bright	7
Victoria	Colac	6
Victoria	Dandenong	6
Victoria	Echuca	4
Victoria	Geelong	6
Victoria	Hamilton	7
Victoria	Horsham	6
Victoria	Melbourne	6
Victoria	Mildura	4
Victoria	Portland	6
Victoria	Sale	6
Victoria	Shepparton	4
Victoria	Swan Hill	4
Victoria	Traralgon	6
Victoria	Wangaratta	7

Climate zone map: Australia

State or Territory	Location	Climate zone
Victoria	Warrnambool	6
Victoria	Wodonga	6
Western Australia	Albany	6
Western Australia	Balladonia	4
Western Australia	Broome	1
Western Australia	Bunbury	5
Western Australia	Carnarvon	3
Western Australia	Christmas Island	1
Western Australia	Cocos Island	1
Western Australia	Derby	1
Western Australia	Esperance	5
Western Australia	Exmouth	1
Western Australia	Geraldton	5
Western Australia	Halls Creek	3
Western Australia	Kalgoorlie-Boulder	4
Western Australia	Karratha	1
Western Australia	Meekatharra	4
Western Australia	Northam	4
Western Australia	Pemberton	6
Western Australia	Perth	5
Western Australia	Port Hedland	1
Western Australia	Wagin	4
Western Australia	Wyndham	1

For further information, refer to the National Construction Code (NCC) or the relevant State/Territory climate zone map available from the ABCB website (abcb.gov.au).

APPENDIX 2

Table of complete country of origin data for respondents

Country of origin	n/N (%)
Australia	2043/2659 (76.8)
United Kingdom	146/2659 (5.5)
New Zealand	37/2659 (1.4)
Germany	20/2659 (0.8)
South Africa	17/2659 (0.6)
United States of America	15/2659 (0.6)
Scotland	8/2659 (0.3)
The Netherlands	8/2659 (0.3)
France	6/2659 (0.2)
Denmark	5/2659 (0.2)
Finland	5/2659 (0.2)
Belgium	4/2659 (0.2)
Austria	3/2659 (0.1)
Russia	3/2659 (0.1)
Sweden	3/2659 (0.1)
Switzerland	3/2659 (0.1)
Ireland	2/2659 (0.1)
Malaysia	2/2659 (0.1)
Belize	1/2659 (0.04)
Bulgaria	1/2659 (0.04)
Hong Kong	1/2659 (0.04)
Japan	1/2659 (0.04)
Kenya	1/2659 (0.04)
Latvia	1/2659 (0.04)
New Guinea	1/2659 (0.04)
Norway	1/2659 (0.04)
Papua New Guinea	1/2659 (0.04)
Poland	1/2659 (0.04)
Singapore	1/2659 (0.04)
Wales	1/2659 (0.04)
Zimbabwe	1/2659 (0.04)
Missing	315/2659 (11.9)

Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site: <http://onlinelibrary.wiley.com/doi/10.1111/avj.13219/supinfo>.

Supplemental File 1. Table 1. Chi square contingency table p value, comparing disciplines regarding whether rugs were or were not used in the 12 months prior to the survey.

Table 2. Chi square p value comparing disciplines by maximum rugs used. Maximum rugs applied grouped into categories: 3 or less, 4 or more.

Table 3. Chi square p value results comparing climatic zones to whether horses were rugged or never rugged.

Table 4. Reasons respondents reported for buying and using rugs, possible negative impact of rugs, consequences of not rugging or using too many rugs and reasons why rugs should be used in Australia n/N (%).

(Accepted for publication 4 November 2022)