



# Q fever in an endemic region of North Queensland, Australia: A 10 year review



Pirathaban Sivabalan <sup>a,\*</sup>, Apoorva Saboo <sup>a</sup>, James Yew <sup>a</sup>, Robert Norton <sup>b</sup>

<sup>a</sup> Mackay Base Hospital, Australia

<sup>b</sup> Townsville Hospital, Australia

## ARTICLE INFO

### Article history:

Received 12 February 2016

Received in revised form 22 February 2017

Accepted 3 March 2017

Available online 4 March 2017

## ABSTRACT

**Background:** Q fever is a zoonotic infection caused by *Coxiella burnetii*. Endemic Q fever has long been recognised in north Queensland, with north Queensland previously acknowledged to have the highest rate of notification in Australia. In this retrospective study, we reviewed the demographics and exposure of patients diagnosed with Q fever in an endemic region of north Queensland, to identify trends and exposure factors for the acquisition of Q fever.

**Methods:** A retrospective study looking at patients in the region that had tested positive for Q fever by case ascertainment between 2004 and 2014. This involved both a chart review and the completion of a patient questionnaire targeting demographics, clinical presentation, risk factors and outcomes.

**Results:** There were 101 patients with a positive Q fever serology and/or PCR that were identified in the region of north Queensland that was studied, between 2004 and 2014. The cohort was residents of Mackay Hospital and Health Service. Of these, 4 patients were excluded and 63 patients successfully completed a questionnaire on demographic and risk factors.

Out of the 63 patients, the highest prevalence was in the patients residing in the coastal region of Proserpine (42/100,000 people per year) followed by the Whitsundays region (14.8/100,000 people per year). A significantly higher proportion of patients were reportedly exposed to macropods (69.8%) and possums (66.7%) as compared to cattle (23.8%). A trend between increased cases of Q fever infection and high seasonal rainfall was noted.

**Conclusions:** In this endemic region of north Queensland, exposure to wildlife and seasonal rainfall may be substantial exposure factors for the development of Q fever. The region studied is a popular tourist destination. An understanding of risk factors involved can help practitioners who see residents or returned travelers from the region, with an undifferentiated fever.

Crown Copyright © 2017 Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

## 1. Introduction

Q fever is a zoonotic infection caused by *Coxiella burnetii*, an obligate intracellular gram-negative bacterium. Q fever was first reported in the 1930s, being simultaneously identified in Montana in the United States of America as well as in Queensland, Australia [1]. In 2011, more than half of the Q fever notifications within Australia originated from Queensland. In the same year, north Queensland had the highest rate of Q fever notifications in Australia at an incidence of 3.5/100,000. This is more than double the national average incidence of 1.6/100,000 [2].

The Mackay Hospital & Health Service (MHHS) delivers public hospital and health services to an area in north Queensland. The catchment services a population of approximately 180,000 [3]. This region is

known for industries such as mining, farming and cane-cultivation, as well as its diverse wildlife fauna. In the period of 2004–2014, the average incidence of Q fever cases recorded in the MHHS region was 5.6/100,000 per year, which was marginally greater than the incidence of 5.3/100,000 per year recorded in the region further north that is serviced by the Townsville Hospital and Health Service [4]. This incidence is almost four times higher than the Australian national average. In addition, the actual incidence may be underestimated, as a significant number of people affected by Q fever are either mildly symptomatic or asymptomatic, and are therefore unreported [5]. Traditionally, Q fever has been related to livestock, especially cattle in Australia, and therefore livestock-related occupations have been deemed to be a risk factor [6]. However, studies such as Banazis et al. (2009), have shown that Australian wildlife carry *C. burnetii*. The study highlights that 33.5% of western grey kangaroo serum samples tested positive for *C. burnetii* antibody-ELISA and 12.25% of the tested western grey kangaroos had positive *C. burnetii* DNA (via polymerase chain reaction (PCR) testing) detected in faecal samples [7]. Tozer et al. (2012) revealed *C.*

\* Corresponding author at: Department of Medicine, Mackay Base Hospital, Queensland, Australia.

E-mail address: [pirathaban.sivabalan@health.qld.gov.au](mailto:pirathaban.sivabalan@health.qld.gov.au) (P. Sivabalan).

<sup>1</sup> Present address: 207/435 Coronation Drive, Auchenflower, QLD, 4066.

*burnetii* can be readily detected in the environment, both in animals and their products as well as soil and dust [8]. This study was able to elucidate PCR evidence in wildlife urine and faecal samples as well as soil and dust samples. Another wildlife seroprevalence study performed by Cooper et al. (2012) revealed 30.4% macropods were positive for *C. burnetii* by serology, followed by bandicoots (23.9%) and possums (10.7%) [9–11]. Furthermore *C. burnetii* has been isolated from ticks, particularly in the kangaroo-habituating *Amblyomma triguttatum* [12, 13]. The demonstration of evidence of previous serological exposure to *C. burnetii* as well as DNA in body fluid samples supports the suggestion that wildlife may be potential reservoirs for humans. As well as wildlife, a correlation between rainfall and incidence of Q fever has also been previously documented [14]. Q fever was previously associated with dry, dusty and windy conditions as illustrated in the French study by Tissot-Dupont et al. [15] However, a recent study in North Queensland by Harris et al. (2013) demonstrated that there was clear correlation with rainfall, with the highest number of cases occurring 3 months after peak rainfall. It was postulated that increased rainfall attracted increased numbers of wildlife due to the increase in vegetation associated with wet season and the subsequent drier period potentially resulted in the aerosolization of the pathogen [14].

With a high incidence of Q fever and being an integral area for wildlife in Queensland, the MHHS region provides an ideal study location to further evaluate exposure risk factors for Q fever. The primary aim of this epidemiological study was to investigate exposure risk factors for developing *C. burnetii* infection, and in particular the effect of wildlife and rainfall on the prevalence of Q fever. This study assessed the exposure to wildlife such as macropods, possums and bandicoots, and how they compared with exposure to livestock in the transmission of Q fever. Correlation between the number of cases and rainfall was also examined, given the previous seasonal incidence reported by Harris et al. The secondary aims of this study were to identify any predisposing conditions or lifestyle factors that increase the risk for acquiring Q fever, and to examine the geographical distribution of Q fever in the region.

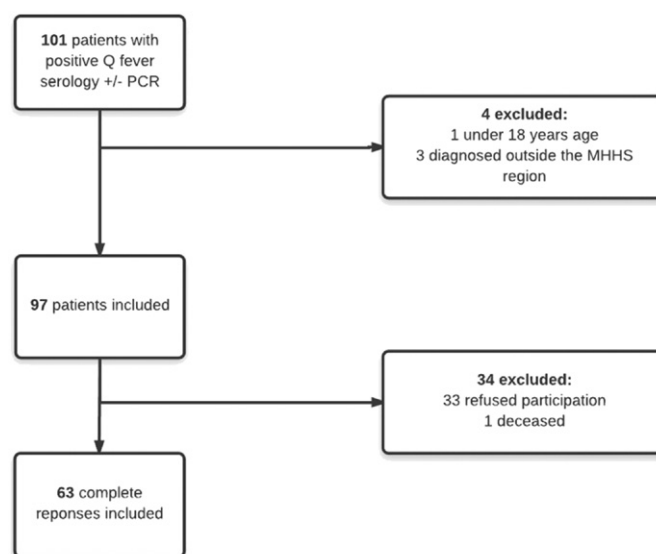
## 2. Methods

### 2.1. Study population

Data for patients over 18 years of age whom were identified as having positive serological or molecular diagnosis for Q fever infection in the region, from 2004 to 2014 was obtained. This was defined as an elevated single Q Fever Phase I and/or Phase II IgG titer, elevated Phase II IgM titer or seroconversion in paired sera tested in parallel by enzyme-linked immunosorbent assay (ELISA), complement fixation tests (CFT) and/or detection of *C. burnetii* by polymerase chain reaction (PCR). Q fever is a notifiable disease in Australia and positive patient data is registered by the Communicable Diseases Unit. Ethics approval was sought from the Townsville Human Research Ethics Committee (HREC/14/QTHS/55). All participants were contacted via phone and sent an information pack with the questionnaire with a consent form to return. The information included the background, objective and methods of the study and supplied with contact numbers of the researchers.

#### 2.1.1. Patient questionnaire and data collection

A questionnaire was designed to obtain the following information from patients with proven Q fever: patient location at time of diagnosis, the area of the patient's residential property, the presence of fencing on the patient's residential property, pre-existing medical conditions, lifestyle factors, occupation and treatment received for Q fever. Moreover, patient exposure to wildlife, cattle, horses, and sheep was ascertained. Respondents were given the option to mention if they were exposed to other animals to encompass as many exposure sources as possible. Season of diagnosis was based on patient's recollection of symptoms and/or timing of diagnosis. Questionnaires were administered via post to residential addresses, and a reminder phone call was made to those



**Fig. 1.** Flowchart of patients who met inclusion and exclusion criteria in study population with positive Q fever serology and/or PCR. A total of 63 patients included in study analysis and 38 excluded as above.

who had not completed the questionnaire one month after distribution. Addresses and contact numbers were provided by the public health unit. Not all affected patients could be contacted, due to a change in address, or contact number. Fig. 1 highlights the inclusion and exclusion criteria for this study, and process of participant recruitment. A total of 101 patients with a positive serology and/or PCR were identified in the Mackay Hospital Health Service District. Four patients were excluded as three were diagnosed outside the MHHS district, and one was currently under the age of 18 years. Rainfall data was collected from Australian Government Bureau of Meteorology [16].

### 2.2. Data analysis

All data was analyzed using International Business Machines Statistical Package for Social Science (IBM SPSS Statistics Data Editor, United States of America (USA)) and Microsoft Excel (Microsoft Office, United States of America (USA)). Univariate analysis of the variables was performed. Rainfall data was analyzed with Spearman's Rho correlational analysis [17]. The mapping of hotspots geographically was performed online on GmapGIS [18].

## 3. Results

Of the 97 patients included in this study, 63 (64.9%) participants responded. The mean age of patients was 46 years with the majority (34.9%) in ages 45–54 years as highlighted below (Table 1). A male predominance was also noted of 77.8% of the participants. Of the 63 completed questionnaires, 2 (3.2%) identified themselves as Indigenous Australian. Within the MHHS region, the highest average annual Q fever incidence was observed in the coastal areas of Proserpine (42/

**Table 1**  
Age categories of participants.

Age (years)	Number of respondents (n)	Percentage (%)
<24	6	9.5
25–34	7	11.1
35–44	15	23.8
45–54	22	34.9
55–64	9	14.3
65–74	3	4.8
>75	1	1.6

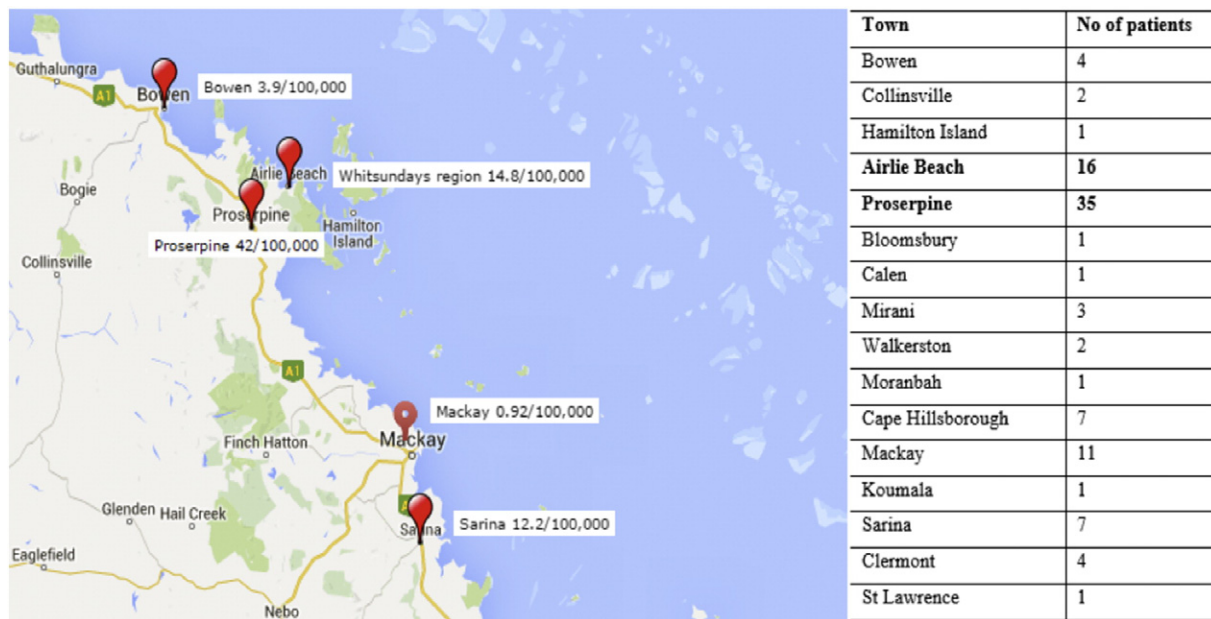


Fig. 2. Geographical representation of the study participant residences with the major areas of the Mackay Hospital Health Service [18].

100,000 people per year) followed by the Whitsunday Islands (14.8/100,000 people per year) as highlighted in Fig. 2.

Comparison between the mean season rainfall (mm) and number of cases is illustrated in Fig. 3. While a trend was noted with the highest number of Q fever cases diagnosed in summer (26 cases), followed by autumn (15 cases), coinciding with the highest mean seasonal rainfall, this was not significant ( $r = 0.8$ ,  $p = 0.2$ ). Similarly, no significant correlation was identified between the number of cases and yearly rainfall within the district ( $r$  and  $p < 0.05$ ).

More than half the participants had a property of 5001 m<sup>2</sup> or higher and approximately half the participants either had no fence or a fence with a maximum height of 0.5 m around their property. Twenty-six (41.9%) of the respondents spent more than seven hours a day on their paddock either farming or gardening. A further 17 (27.4%) had spent greater than an hour each day on their front- or backyard.

Two main exposure trends were seen in our respondents. Many of the respondents reported exposure to and direct contact with more than one group of animals (66.7% and 46% respectively). However the majority stated exposure and direct contact with macropods (69.8% and 42.9% respectively) (Tables 2, 3). Additionally, a large number of respondents (66.7%) reported observing possums in/near their property. No respondents stated exposure or direct contact with sheep albeit explicitly asked in the questionnaire. By comparison, fewer respondents reported exposure to and direct contact with cattle (23.8% and 30.2% respectively). Furthermore, the Mackay region has approximately 10.2% of cattle found in Queensland with the highest in the Mt. Isaac/Nebo

region consisting of 500,000 cattle. The Bowen/Whitsunday regions (including Proserpine) have approximately 320,000 cattle. Breakdown of participant's occupation is displayed in Table 4 with majority of participants having occupations outside the traditionally regarded high risk occupations such as cattle, cane farming, veterinarians, abattoir workers or wildlife carers. An important finding in this regard was that 10 (15.9%) participants were landscapers by profession, and this may be a previously under-recognised high-risk profession.

Sub-analysis of the Proserpine respondents revealed 86.4% of diagnoses were male, with a mean age of 53.5 years. A diagnosis of Q fever was made in 54.5% of the cases in summer. In addition, 54.5% of respondents had a property size greater than or equal to 5001 m<sup>2</sup>, and 59.1% had no fences. Furthermore, 68.4% of this subset were exposed to both macropods and possums, whilst only 27.3% of respondents were exposed to cattle.

Meaningful data collection of chronic Q fever within our respondents was unable to be obtained. This was due to the inconsistency in responses due to recall bias and subjective interpretation of the word chronicity amongst participants.

#### 4. Discussion

In this retrospective study, the demographics, exposure factors, social and lifestyle factors of 63 out of 97 patients diagnosed with Q fever in Mackay Hospital and Health Service were examined and reported. The study had a high survey response rate of 64.9%. The mean age at time of diagnosis of the respondents was 46 years. This is similar to the median diagnosis age of 47 years previously reported in a Q fever epidemiological article based in a Dutch study [19]. Two of the 63 respondents (3.2%) identified themselves as Indigenous Australians. A previous study examining the seroprevalence of *C. burnetii* in Australian

Relationship between seasonal rainfall and incidence of Q fever

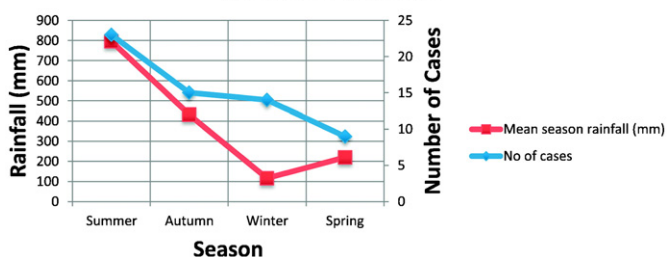


Fig. 3. Relationship between timing of Q fever diagnoses and average seasonal rainfall in Mackay Hospital Health Service.

Table 2

Exposure factor observed near/within their property by patients.

Observation of exposure factor in/near property	Number of respondents (n)	Percentage (%)
Macropods	44	69.8*
Possum	42	66.7
Cattle	15	23.8
Cane farm	31	49.2

\* Number does not add up to 100% as many cases included multiple exposure factors.

**Table 3**  
Exposure factors associated with direct contact with animals.

Direct contact with exposure factors	Number of respondents (n)	Percentage (%)
Macropods	27	42.9*
Possum	13	20.6
Cattle	19	30.2
Bandicoot	15	23.8
Horse	16	25.4

\* Number does not add up to 100% as many cases included multiple exposure factors.

dogs (Shapiro et al., 2015) revealed dogs from Aboriginal communities were 2.8 times more likely to be seropositive than dogs from other populations, possibly increasing the possible risk of transmission in the Indigenous population [20]. However, within our study, apart from the location of diagnosis, no other similarities, statistically significant or otherwise were noted within the two Indigenous patients in our cohort.

*C. burnetii* can survive harsh conditions in the environment [14]. The authors speculate that, when wildlife encroach on domestic properties and excrete *C. burnetii* in that environment, such proximity may increase the probability of transmitting the pathogen to the human occupiers of the property. Indeed, more than half the patients who participated in the survey had a property greater than or equal to 5001 m<sup>2</sup>. In rural areas, such as Proserpine, large properties either are or border to farmlands, native forests, or billabongs. A larger property size increases grazing pastures, which can be utilised as food thus attracting more wildlife. The increase in wildlife will increase the degree of faecal contamination of the soil with *C. burnetii* thus increasing the inoculum size overall available for infection. In addition, approximately half the participants either had no fence or a fence with a maximum height of 0.5 m around their property. Minimal fencing allows for a greater probability of wildlife entering these properties. More than 40% of the respondents spent more than seven hours a day on their paddock either farming or gardening. Lack of fencing on large properties, in combination with 69.8% and 66.7% of respondents observing macropods or possums in and/or near their properties indirectly indicates that wildlife is common in this area. Consequently, it could be presumed the likelihood of wildlife-to-human transmission is likely to be amplified.

The study by Harris et al. delineates a clear seasonal correlation with acute Q fever cases [14]. The study outlined a peak in acute Q fever cases in 3 months following the peak in rainfall in February. It postulated that an increase in wildlife numbers and drier conditions seen immediately following the wet season may explain the seasonal peak of acute Q fever cases in humans within Townsville. In Queensland, the calving season for the beef cattle industry occurs towards the end of the wet season when pasture biomass is highest. The prevailing winds in the area tend to come from the northeast, attributable to the ocean, although they may originate from the south or southeast in the mornings. However, currently there are only a few cattle properties immediately surrounding Townsville. As such, an aerosol route of spread of Q fever from farms carried on prevailing winds seems a less probable cause of notifications observed in the current study. High rainfall seasons also contribute to increased population numbers of macropods and other

**Table 4**  
Occupational breakdown of participants.

Occupation	Number of respondents (n)	Percentage (%)
Cattle farmer	7	11.1
Cattle farmer/wildlife carer	1	1.6
Wildlife Carer	1	1.6
Cane farmer	1	1.6
Abattoir worker	3	4.8
Landscaper	10	15.9
Vet	0	0
Other	40	63.5

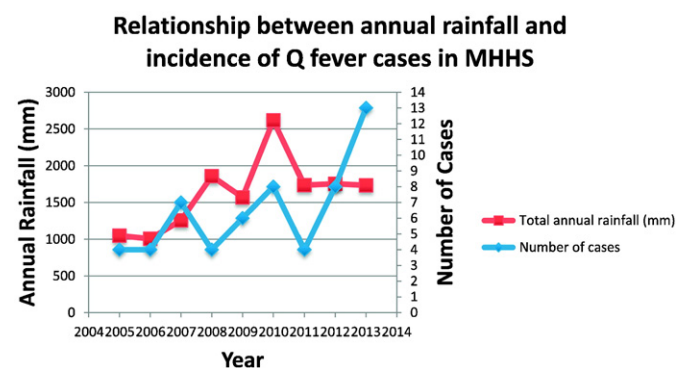
wildlife. While not statistically significant, a trend in seasonal peak was also identified in our study with correlation to seasonal rainfall. The majority of the Q fever cases in this study were reported in summer followed by autumn. These were also the two seasons with the highest mean rainfall across the region. The trend shown in Fig. 3 suggests that the highest reduction in Q fever cases follows 3 months after the lowest mean seasonal rainfall. A difference was observed in the relationship between rainfall and the clinical presentation of cases, in the Townsville and Mackay regions. The peak of cases in the former was approximately 2–3 months after the peak of rainfall, whereas in this study it was observed concurrently with rainfall. The reason for this discrepancy is unclear. The bulk of the cases in this study were from the Proserpine region. This region is part of the wet tropics whereas the Townsville region is in the dry tropics [16]. The patterns of land utilisation would also be different. In the Townsville region, there has been recent utilisation of bushland for residential properties. It was postulated that this encroachment has led to native mammals coming to paddocks where the rainfall has resulted in new grass growth. This would occur after the rain, as the Townsville region is dry between wet seasons with little native grass. In the Proserpine area, this may occur much sooner due to the persistence of grass over periods of diminished rainfall. It is acknowledged that wind information would have been useful adjunctive information; however wind information was not available (Fig. 4).

The highest incidence of Q fever was reported in Proserpine, which is historically known for cane farming, tourism and wildlife. The Proserpine statistics further confirm exposure factors for the acquisition of Q fever as being middle aged, male, ownership of large properties with no fences, being exposed to native wildlife, and the season of summer. Furthermore, the Mt. Isaac/Nebo region consisted of a larger number of cattle compared to the Bowen/Whitsundays region; however the Bowen/Whitsundays region had much higher rates of Q fever compared to the Mt. Isaac/Nebo region.

The secondary outcomes of this study were identifying occupational, social and lifestyle factors which might contribute to the development of Q fever. Our study illustrates that occupational risk profile for Q fever may not be restricted to industries associated with livestock, veterinarians, abattoir workers or wildlife carers as highlighted in Table 4. This suggests that vaccination coverage may have been effective in previously known high-risk occupations but may need to extend to other at-risk sectors such as landscapers.

Other variables including past medical history and Q fever treatment were difficult to ascertain from the questionnaires as many participants could not remember their treatment. Limited correlations with comorbidities, such as pre-existing cardiorespiratory diseases, gastrointestinal diseases and diabetes were found.

The present study has limitations. Firstly, it is a retrospective study and therefore is affected by recall bias from patients completing the questionnaire. Secondly, this was not a case controlled study. Thirdly, although this study has a high participation rate of 64.9%, it is still a small



**Fig. 4.** Relationship between annual rainfall and incidence of Q fever cases in MHHS \*Note: 2004 and 2014 left out as data collected from June 2004 till June 2014.



sample size of 63 participants and definitive conclusions may not be confidently drawn, providing moreover a foundation for further prospective research in this area. Lastly, goats and companion animals were not explicitly explored within the patient questionnaire.

Q fever is an important condition not only in North Queensland, but also throughout Australia and globally. Chronic Q fever infection is a condition with a high morbidity and manifestations such as endocarditis, hepatitis, aortic aneurysms and osteomyelitis. This study suggests that wildlife exposure may represent an important exposure factor for the acquisition of Q fever in our region. Although not statistically significant, exposure to heavy seasonal rainfall may also play a role in the acquisition of Q fever in our health district. Not only does this study provide a platform for further larger studies, it also highlights the lack of association of Q fever with the animal husbandry in the Mackay Hospital and Health Service catchment. Clinicians should therefore have a low threshold to consider Q fever when faced with a compatible clinical syndrome with appropriate risk factors and in the absence of other more traditional risk factors such as livestock exposure. As vaccination against Q fever is available, the knowledge of as many at-risk populations as possible will only aid further in progressing the prevention of this disease.

### Acknowledgements

We thank Dr. Jennifer Banks and Dr. Venkat Vangeaveti (Research Support Officers, James Cook University) for assistance with statistical analysis as well as the Private Practice Trust Fund of Mackay Base Hospital for funding this research. Furthermore we would like to thank Department of Agriculture, Fisheries and Forestry (DAFF) and Wildnet for providing data in regards to cattle numbers and wildlife demographics within the Mackay Health District.

### References

- [1] H. Roest, et al., Clinical microbiology of *Coxiella burnetii* and relevant aspects for the diagnosis and control of the zoonotic disease Q fever, *Vet. Q.* 33 (3) (2013) 148–160.
- [2] National Notifiable Diseases Surveillance System. Department of Health and Ageing. (<http://www9.health.gov.au/cda/Source/CDA-index.cfm>). 2014 (updated). (Accessed March 2014).
- [3] Australian Bureau of Statistics. Mackay: Region Data Summary. ([http://stat.abs.gov.au/itt/r.jsp?RegionSummary&region=312&dataset=ABS\\_NRP9\\_ASGS&geoconcept=REGION&datasetASGS=ABS\\_NRP9\\_ASGS&datasetLGA=ABS\\_NRP9LGA&regionLGA=REGION&regionASGS=REGION](http://stat.abs.gov.au/itt/r.jsp?RegionSummary&region=312&dataset=ABS_NRP9_ASGS&geoconcept=REGION&datasetASGS=ABS_NRP9_ASGS&datasetLGA=ABS_NRP9LGA&regionLGA=REGION&regionASGS=REGION)). 2014 (updated). (Accessed 4th December 2014).
- [4] Epidemiology, Surveillance and Research Unit. Communicable Disease Branch, Queensland Health, 2011. Herston, Queensland.
- [5] M. Maurin, D. Raoult, Q fever, *Clin. Microbiol. Rev.* 12 (1999) 518–553.
- [6] M. Garner, et al., A review of Q fever in Australia 1991–1994, *Aust. N. Z. J. Public Health* 21 (1997) 722–730.
- [7] M. Banazis, et al., A survey of Western Australian sheep, cattle and kangaroos to determine the prevalence of *Coxiella burnetii*, *Vet. Microbiol.* 143 (2010) 337–345.
- [8] S. Tozer, et al., Potential animal and environmental sources of Q fever infection for humans in Queensland, *Zoonoses Public Health* 61 (2014) 105–112.
- [9] A. Cooper, et al., Serological evidence of *Coxiella burnetii* infection in beef cattle in Queensland, *Aust. Vet. J.* 89 (2011) 260–264.
- [10] A. Cooper, et al., Determination of *Coxiella burnetii* seroprevalence in macropods in Australia, *Vet. Microbiol.* 155 (2012) 317–323.
- [11] A. Cooper, et al., Serological evidence of *Coxiella burnetii* exposure in native marsupials and introduced animals in Queensland, Australia, *Epidemiol. Infect.* 140 (2012) 1304–1308.
- [12] N.R. Parker, J.H. Barralet, A.M. Bell, Q fever, *Lancet* 367 (2006) 679–688.
- [13] J.H. Pope, W. Scott, R. Dwyer, *Coxiella burnetii* in kangaroos and kangaroo ticks in Western Queensland, *Aust. J. Exp. Biol. Med. Sci.* 38 (1960) 17–27.
- [14] P. Harris, et al., Acute Q fever in northern Queensland: variation in incidence related to rainfall and geographical location, *Epidemiol. Infect.* 141 (5) (August 2013) 1034–1038.
- [15] H. Tissot-Dupont, et al., Wind in November, Q fever in December, *Emerg. Infect. Dis.* 10 (2004) 1264–1269.
- [16] Australian Government Bureau of Meteorology. Climate Data Online. (<http://www.bom.gov.au/climate/data/index.shtml?bookmark=136>). 2013 (updated). (Accessed 3rd December 2014).
- [17] Spearman's Rho Calculator (Correlation Coefficient) [Internet]. Socscistatistics.com. 2016 (<http://www.socscistatistics.com/tests/spearman/Default.aspx>). (Accessed 11th July 2016).
- [18] GmapGIS: Web application to draw on Google Maps; create, share, link, embed and publish interactive maps with polygons, lines, circles, markers and labels. (<http://www.gmapgis.com/>). 2013. (Accessed 24th May 2015).
- [19] T. Veenstra, et al., Risk Factors for Q Fever in the Netherlands, *Webmed Cent. Infect. Dis.* 2 (7) (2011) 1–10 <http://www.webmedcentral.com> (20th December 2014).
- [20] A. Shapiro, et al., Seroprevalence of *Coxiella burnetii* in Australian dogs, *Zoonoses Public Health* 63 (2016) 458–466.