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The relationship between the Southern Oscillation Index, rainfall and the occurrence of canine tick paralysis, feline tick paralysis and canine parvovirus in Australia

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ABSTRACT

The aim of this study was to describe the association between climate, weather and the occurrence of canine tick paralysis, feline tick paralysis and canine parvovirus in Australia. The Southern Oscillation Index (SOI) and monthly average rainfall (mm) data were used as indices for climate and weather, respectively. Case data were extracted from a voluntary national companion animal disease surveillance resource. Climate and weather data were obtained from the Australian Government Bureau of Meteorology. During the 4-year study period (January 2010–December 2013), a total of 4742 canine parvovirus cases and 8417 tick paralysis cases were reported.

No significant ($P \geq 0.05$) correlations were found between the SOI and parvovirus, canine tick paralysis or feline tick paralysis. A significant ($P < 0.05$) positive cross-correlation was found between parvovirus occurrence and rainfall in the same month (0.28), and significant negative cross-correlations (–0.26 to –0.36) between parvovirus occurrence and rainfall 4–6 months previously. Significant ($P < 0.05$) negative cross-correlations (–0.34 to –0.39) were found between canine tick paralysis occurrence and rainfall 1–3 months previously, and significant positive cross-correlations (0.29–0.47) between canine tick paralysis occurrence and rainfall 7–10 months previously. Significant positive cross-correlations (0.37–0.68) were found between cases of feline tick paralysis and rainfall 6–10 months previously.

These findings may offer a useful tool for the management and prevention of tick paralysis and canine parvovirus, by providing an evidence base supporting the recommendations of veterinarians to clients thus reducing the impact of these diseases.

Introduction

Both rainfall and the Southern Oscillation Index (SOI)[1], a standardised index based on the observed sea level pressure differences between Tahiti and Darwin, Australia, have been associated with animal disease occurrence. Ward (2002) found a correlation between the occurrence of canine leptospirosis and rainfall events recorded 3 months prior to disease diagnosis, suggesting an opportunity for targeted vaccination programmes.

The SOI is often used to predict rainfall across northern and eastern Australia (Ward and Johnson, 1996; Suppiah, 2004). A strongly negative SOI (termed El Niño) is associated with lower than average rainfall, whereas a strongly positive SOI (termed La Niña) is associated with higher than average rainfall. Ward and Johnson (1996) described an association between the SOI and bluetongue virus infection in cattle. Similarly, Martin et al. (2008) showed that climate patterns such as El Niño are associated with the occurrence of Rift Valley fever. Climate and disease associations have important implications for the management and prevention of serious disease outbreaks.

Canine parvovirus and tick paralysis are commonly diagnosed diseases in Australian small animal veterinary practice (Ling et al., 2012; Eppleston et al., 2013) that have a substantial impact on patient health and mortality as well as placing a heavy emotional and financial burden on owners. It is therefore sensible to pursue possible indicators of the occurrence of these diseases, in an effort to develop targeted prevention programmes that might include, for example, vaccination against canine parvovirus and vigilance for signs of tick paralysis.

Companion animal tick paralysis in Australia is most commonly caused by envenomation of the tick species *Ixodes holocyclus*. Left untreated, the prognosis for survival is poor to grave (Stone et al., 1983; Ilkiw et al., 1987; Atwell et al., 2001). *I. holocyclus* is a three-host tick species, with four life cycle stages: egg, larvae, nymph and

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[1] See: http://www.ncdc.noaa.gov/teleconnections/enso/indicators/soi/ (accessed 10 March 2015).

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adult (Taylor et al., 2007). The time required to complete a life cycle is variable, but has been estimated at >1 year (Ross, 1924). *I. holocyclus* is distributed along the east coast of Australia (Jackson et al., 2007) and thrives in moderate temperatures and relatively high humidity although it will succumb rapidly to desiccation in drier climates (Ross, 1924; Heath, 1979). Low vegetation and shrubbery provides an ideal microclimate for survival (Doube, 1975). The host range is wide, including various small native mammals such as rodents, bandicoots, macropods, wombats, and koalas (Doube, 1975; Jackson et al., 2007), but *I. holocyclus* may attach to any species of mammal, including domestic dogs and cats, particularly in areas where tick populations thrive (Doube, 1975).

Canine parvovirus is a commonly diagnosed cause of gastrointestinal disease in dogs across Australia and worldwide (Goddard and Leisewitz, 2010; Ling et al., 2012). A recent study estimated the case fatality rate for canine parvoviral infections in Australia to be 43% (Ling et al., 2012), and this can reach as high as 91% when the disease is left untreated (Prittie, 2004). The treatment required to decrease patient mortality is costly, time consuming and labour intensive. Anticipating higher periods of risk could be invaluable for developing preventive strategies to reduce the incidence of these two serious diseases.

Disease WatchDog[2] is an Australian national companion animal health surveillance system, launched in January 2010, that logs spatial and temporal data relating to the incidence of several companion animal diseases, including tick paralysis and canine parvovirus (Ward and Kelman, 2011; Ling et al., 2012; Eppleston et al., 2013). The system relies on registered users (veterinary personnel) reporting disease cases regularly via a web-based interface (Ward and Kelman, 2011). Users have access to real-time mapping of disease occurrences and outbreaks, and can customise output (such as maps and graphs) to suit their clinic.

The data generated by Disease WatchDog have been used to investigate risk factors for several companion animal diseases, including tick paralysis, parvovirus, feline calicivirus, and feline herpes virus (Brady et al., 2012; Ling et al., 2012; Eppleston et al., 2013; Wong et al., 2013; Brazier et al., 2014). Between its launch in January 2010 and December 2013, >4000 diagnosed cases of canine parvovirus and >8,000 diagnosed cases of tick paralysis have been reported, making this system an important tool in companion animal epidemiological research.

The objective of the present study was to describe the association between both the occurrence of tick paralysis and canine parvovirus with the SOI and rainfall.

Materials and methods

Data collection

Cases were extracted from Disease WatchDog using data entered by registered clinic staff (Ward and Kelman, 2011). For each case, the following were reported: patient details (species, age, breed, sex, neutered status, vaccination details), case details (date, disease, method of diagnosis, case outcome), and location (suburb, state, region, postcode). For our study, data were extracted for reported cases between 1 January 2010 and 31 December 2013 (48 months). Monthly SOI data were obtained[3] for the period January 2009 to December 2013, inclusive (60 months). Historical daily rainfall data (to May 2014) were also obtained for all recording stations throughout Australia[4].

Data management

Data extracted from Disease WatchDog were managed in Microsoft Excel, and only cases with a valid reported date between 1 January 2010 and 31 December 2013 inclusive were included in the study. Cases of both canine and feline tick paralyses were only included if a method of diagnosis was reported. For canine parvovirus, only cases with a reported confirmed diagnosis via testing were included; those in which outcome was listed as 'animal tested positive but not clinically affected' were excluded.

In addition to the reporting of individual cases in Disease WatchDog, cases can be reported in batches, in which one single entry can represent more than one individual. This feature allows clinics to report cases more easily, but does not capture individual patient information or individual case dates. However, case date (at a resolution of week) and case location (postcode) information are still submitted. Batch entries were therefore removed from all patient factor analyses, but were retained for time series and geographical distribution analyses (using the same inclusion criteria).

The resulting data were searched for errors and duplicate entries. Duplicates were identified as cases with identical date (within a 7-day window), clinic and patient details. Duplicates and cases with obvious errors (for example those with non-logical age data) were removed from the dataset. Case dates for each disease dataset were reclassified into month/year and season. Patient age was categorised and canine breeds were re-categorised into breed groups according to the Australian National Kennel Council[5] classification (toys, terriers, gun dogs, hounds, utility, working and non-sporting), and a further category of mixed breed was included. Case diagnosis for canine parvovirus was analysed as immuno-fluorescence, ELISA Snap test or PCR, and for tick paralysis as 'tick found', 'tick crater found' or 'clinical presentation'. Case outcome was analysed as recovered, died, euthanased or treatment ongoing.

For time series analysis, cases were summed by month. Entries with incomplete patient information (e.g. missing age, breed or sex) were still included in time series. Station recording data were sorted by start and end dates and only those that recorded data within the study period were selected. These stations were then geocoded using the station's reported latitude and longitude coordinates and an Australian postcode map (GDA 1994 coordinate system, Lambert Conformal Conic projection; ArcGIS v10. ESRI). For each postcode from which cases were reported, the closest recording station within a 20 km distance was identified by joining the station point file to the postcode polygon file (ArcGIS v10. ESRI). Recorded rainfall data within the relevant period were then extracted and average monthly rainfall calculated.

Data analysis

Frequency distributions were generated using pivot tables (Microsoft Excel) for date, sex, breed, diagnosis and survival, and descriptive statistics were calculated for age. Time series graphs were generated in Microsoft Excel for case frequency by date (month), with monthly SOI values and rainfall data overlaid for visual comparison. Maps showing the proportional number of cases were generated for each dataset (canine parvovirus, canine tick paralysis, and feline tick paralysis) using the reported locations by postcode (ArcGIS v. 10. ESRI). Cross-correlation statistics and statistical significance (95% confidence intervals, based on 48 months) were calculated to describe the relationship between cases reported each month and monthly SOI and average monthly rainfall recorded at the matching postcodes during the same month and up to 12 months previously (lags 0–12 months) (ASTSA v1).

Results

A total of 15,122 cases were extracted from the Disease WatchDog database, of which 4742 were canine parvovirus and 8417 were tick paralysis. Following application of exclusion criteria and data cleaning, a total of 2820 canine parvovirus cases, 5935 canine tick paralysis cases and 1860 feline tick paralysis cases remained for patient factor analysis and 3152 parvovirus cases, 6285 canine tick paralysis cases and 1971 feline tick paralysis cases remained for time series analysis and mapping. Fifty-eight canine parvovirus entries were removed from the dataset: 55 duplicate entries and three entries with a non-logical age entered. Eighty-six tick paralysis entries were removed from the dataset: 85 duplicate entries and one entry with a non-logical age entered.

Patient characteristics

Similar to previous studies, most canine (63%) and feline (62%) tick paralysis cases occurred during the spring months. Canine parvovirus cases were less seasonal, ranging from 32% in spring to 15% in winter. Tick paralysis cases were reported from a total of 395

[2] See: Disease WatchDog Companion Animal Disease Surveillance Centre. http://www.diseasewatchdog.org (accessed 10 March 2015).

[3] See: Australian Government Bureau of Meteorology 2014. Southern Oscillation Index Archives – 1876 to present, Commonwealth of Australia, Canberra. http://www.bom.gov.au/climate/current/soihtm1.shtml (accessed 27 June 2014).

[4] See: Australian Government Bureau of Meteorology. http://www.bom.gov.au/climate/data-services/ (accessed 27 June 2014).

[5] See: Australian National Kennel Council. www.ankc.org.au (accessed 27 June 2014).