SHORT COMMUNICATIONS

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Detecting European Rabbit (*Oryctolagus cuniculus*) Disease Outbreaks by Monitoring Digital Media

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ABSTRACT: Digital media and digital search tools offer simple and effective means to monitor for pathogens and disease outbreaks in target organisms. Using tools such as Rich Site Summary feeds, and Google News and Google Scholar specific key word searches, international digital media were actively monitored from 2012 to 2016 for pathogens and disease outbreaks in the taxonomic order Lagomorpha, with a specific focus on the European rabbit (*Oryctolagus cuniculus*). The primary objective was identifying pathogens for assessment as potential new biocontrol agents for Australia's pest populations of the European rabbit. A number of pathogens were detected in digital media reports. Additional benefits arose in the regular provision of case reports and research on myxomatosis and rabbit haemorrhagic disease virus that assisted with current research.

Key words: Biological control agent, detection, emerging disease, open-source intelligence, *Oryctolagus cuniculus*, pathogen, reporting.

Australia has benefited enormously from the two exotic biocontrol diseases, myxomatosis and rabbit haemorrhagic disease, for its introduced pest rabbit (*Oryctolagus cuniculus*) populations. Agricultural benefits have been estimated to be about AU53 billion from myxomatosis alone (1950–95), and an additional AU17 billion since 1995 from the combination of myxomatosis and the introduction of rabbit haemorrhagic disease virus (RHDV), the second biocontrol agent (Cooke et al. 2013). In addition, although their economic value has never been calculated, substantial environmental benefits have accrued, including suppression of predatory pest cat (*Felis catus*) and red fox (*Vulpes vulpes*) populations (Read and Bowen 2001; Holden and Mutze 2002), native plant recruitment (Mutze 2016), and native fauna recovery (Pedler et al. 2016). Development of genetic resistance to each biocontrol in turn allowed some recovery in Australian rabbit populations (Fenner et al. 1953; Mutze et al. 2014), leading to ongoing rabbit damage (Cooke 1988; Bird et al. 2012) and to the continued need for additional rabbit biocontrols.

Myxomatosis was first detected as cross-species infection from the tapeti, or Brazilian cottontail (*Sylvilagus brasiliensis*) into European rabbits that had been translocated to Uruguay for medical research (Fenner and Fantini 1999). Although detected as an epizootic disease in domestic rabbits, RHDV is suspected to have also originated as a cross-species infection (Esteves et al. 2015). In a modern context, disease outbreaks are often first reported in published papers in scientific journals or in digital media, with "significant epidemiological events" and listed diseases notified by member countries of the World Organisation for Animal Health (OIE) and posted on its website. Disease reporting of this type can offer a simple means to identify new pathogens for biological control of rabbits. To detect such reports, Wildlife Health Australia—formerly the Australian Wildlife Health Network—adapted their program for monitoring open-source intelligence (Yu and Madoff 2004; Wilson and Brownstein 2009) to also detect international reports of rabbit disease and rabbit pathogens. Here we describe this monitoring program and the results of 4 yr (2012–16) of monitoring for rabbit diseases. Wildlife Health Australia used three techniques to monitor digital media from 2012 to 2016: 1) Using a Rich Site Summary (RSS) feeder (Beged-Dov et al. 2000), a number of RSS feeds were scanned, comprising 195–252 sources (approximately 12,000–18,200 articles scanned each month). An RSS feed allows users to access updates to online web-based content in a standardized

format, with the ability to keep track of many different websites in a single place (e.g., a RSS feed aggregator). The number of RSS feeds increased over the project period and included: 73–86 scientific journals, 48–74 Australian specific feeds (e.g., feeds from Australian government, nongovernment, university websites), 30–32 science specific news feeds, 30–44 international wildlife and wildlife disease websites and news feeds, 9–10 specific Google News key word RSS feeds specific to this project (see upcoming text), and a number of general news RSS feeds. 2) Using Google News and Google Scholar, specific key word searches were undertaken (Table 1). 3) Other website-specific searches were conducted by manually reading news, media, and conference proceedings which were not searchable via other methods. These included: International Union for Conservation of Nature lagomorph specialist group web pages, World Rabbit Science Association, World Rabbit Congress, and OIE's World Animal Health Information System email alerts.

Results of monthly searches were collated by country and topic. A country wasn't associated with articles that were basic science (i.e., if the article was not a disease report from free-ranging wildlife or laboratory-associated animals from a country). We reviewed reports of novel pathogens for those considered to be worth further consideration as potential biocontrol agents (e.g., agents were virulent, likely to be host-specific to *O. cuniculus*, humane, self-disseminating, socially acceptable). We filtered results to avoid over-reporting of diseases known to be zoonotic (e.g., *Francisella* sp. or herpesvirus).

Between 2012 and 2016, 356 rabbit disease items were detected, comprising 17–39 items a month and from 80–89 items per year that were assessed as relevant to the related search criteria. Calicivirus-related items were the most frequently detected (n=139), followed by myxoma virus, ectoparasites, and helminths. Articles were from 50 countries, primarily Australia, Europe (mainly Spain, Italy, and Portugal), and the US. The predominance of articles from Australia reflected inclusion of 48–74 Australian-specific feeds. The search method also enabled the detection of rabbit disease items from countries for which *O. cuniculus* is not native or is not a significant pest issue, including the Russian Federation, Saudi Arabia, and a number of African countries.

Of the 356 rabbit disease items, 1) 299 were from a scientific publication, with 52 of these being related to zoonoses noted as unusual or interesting reports, and 31 considered of specific interest to *O. cuniculus* biocontrol objectives; 2) 26 were from a news report, with two being zoonoses; 3) 25 were reports of a disease outbreak (e.g., an OIE report), with 16 being of an outbreak, eight being an outbreak update, and one being a summary report; and 4) six were university theses. During the 2012–16 study period, only one report of a substantial wild rabbit mortality event outside of the established range of RHDV was detected (ProMED-mail 2012). This was a mortality event in rabbits in Villanova, Missouri, US in native *Sylvilagus floridanus* (not *O. cuniculus*), and also reports of additional animal deaths suspected to be due to a toxin.

Five pathogen reports for *O. cuniculus* were extracted and subject to further review: 1) astrovirus rabbit/TN/2009/USA, detected in a domestic rabbit colony near Johnson City, Tennessee, US (Stenglein et al. 2012); 2) *Staphylococcus aureus* Sp17, a highly virulent rabbit strain, detected in a Spanish rabbit farm (Német et al. 2015); 3) a novel bocaparvoviruses found in rabbit farms in northern Italy (Lanave et al. 2015); 4) a novel picornavirus species, rabbit01/2013/HUN, found in two rabbit farms in Hungary (Pankovics et al. 2016); and 5) a zoonotic nematode, *Thelazia callipaeda*, found in two dead wild *O. cuniculus* in north-eastern Portugal (Gama et al. 2016). None of these were considered to be a likely new rabbit biocontrol agent. Leporid herpesvirus-4 (Jin et al. 2008a, b), nominated in an earlier review (Henzell et al. 2008), remains of interest and will be monitored. The likelihood of detecting a new potential rabbit biocontrol for Australia during the limited search years in this project was low. However, given the significant

TABLE 1. Specific key word searches undertaken in Google News and Google Scholar to detect outbreaks of disease in the European Rabbit (*Oryctolagus cuniculus*). Search term results were returned as a single Rich Site Summary (RSS) feed, with each RSS feed viewed using a RSS feed aggregator called Feedly (DevHD 2008).

Search engines	
Google News searches[a,b]	Google Scholar alerts[a]
Rabbit AND disease	Wildlife AND Australia
Rabbit AND mortality	Surveillance AND emerging AND biodiversity AND disease
Wildlife AND disease	Lagomorph AND disease OR mortality OR outbreak OR dead
Rabbit AND Eimeria	Oryctolagus OR Sylvilagus AND disease
Lagomorpha AND disease	Oryctolagus OR Sylvilagus AND outbreak OR mortality
Lagomorpha AND Eimeria	Abrantes[c] AND rabbit OR Oryctolagus OR Sylvilagus
Rabbit AND herpesvirus	Boag[c] AND rabbit OR Oryctolagus
Lagomorpha AND virus	
Lagomorpha AND mortality	
Lagomorpha AND dead	
Outbreak	
Endangered	
Rabbit AND disease AND mortality AND eimeria AND herpesvirus AND astrovirus	
Lagomorph AND disease AND mortality AND virus AND dead AND Eimeria	

[a] The default search logic in all Google searches is: "AND".

[b] Google News key word searches were conducted using the RSS feeder.

[c] Rabbit disease researchers of particular interest: Joana Patrícia da Silva Abrantes, CIBIO–InBIO, Universidade do Porto, Campus de Vairão, Rua Padre Armando Quintas, 4485-661 Vairão, Portugal; Brian Boag, The James Hutton Institute, Invergowrie, Dundee DD2 5DA, Scotland, UK.

potential economic, environmental, and social benefits of a new biocontrol agent, such a deliberate search strategy to detect potential new agents was considered worthwhile given the low costs compared to potential benefits. A routine, strategic approach is warranted to monitor lagomorph diseases for detecting potential new rabbit biocontrol agents. Incorporation of additional key words for other significant pest species (e.g., *Vulpes vulpes*, *Felis catus*, *Rhinella marina*) could magnify the scope and potential benefits of the process at marginally increased cost.

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