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Characterization of the epidemiology of bat-borne rabies in Chile between 2003 and 2013

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ABSTRACT

Rabies is a zoonotic disease of great impact to public health. According to the World Health Organization, the country of Chile is currently declared free from human rabies transmitted by dogs. An epidemiological characterization and description was conducted using rabies data from 2003 to 2013 held by the National Program for Prevention and Control of Rabies from the Ministry of Health, consisting of bats samples reported as suspect and samples taken by active surveillance (bats brain tissue). Spatial autocorrelation analysis was performed using Local Indicators of Spatial Association (LISA) statistics, particularly Moran's I index, for the detection of spatial clusters. Temporal descriptive analysis was also carried out. Nine hundred and twenty-seven positive cases were reported, presenting an average of 84 cases per year, mainly originated from passive surveillance (98.5%), whilst only 1.5% of cases were reported by active surveillance. Global positivity for the study period was 7.02% and 0.1% in passive and active surveillance respectively. Most of the cases were reported in the central zone of Chile (88.1%), followed by south zone (9.1%) and north zone (2.8%). At a regional level, Metropolitana (40.6%), Valparaíso (19.1%) and Maule (11.8%) regions reported the majority of the cases. *Tadarida brasiliensis* (92%) presented the majority of the cases reported, with viral variant 4 (82%) being most commonly diagnosed. Only two cases were detected in companion animals. The central zone presented a positive spatial autocorrelation (Moran's I index = 0.1537, 95% CI = 0.1141–0.1933; *p-value* = 0.02); north and south zones returned non-significant results (Moran's I index = 0.0517 and −0.0117, 95% CI = −0.0358–0.1392 and −0.0780–0.0546, and *p-values* = 0.21 and 0.34 respectively). The number of rabies cases decreased between May and August (late fall and winter) and tended to increase during the hot season (December to March), confirmed with the evidence from Autocorrelation analysis and the Ljun-Box test (X^2 = 234.85 and *p-value* < 0.0001). Knowledge of animal rabies epidemiologic behaviour becomes relevant when designing prevention and control measures and surveillance programs. This is especially important considering the high impact to Public Health of this disease and that wildlife rabies in bats remains endemic in Chile.

1. Introduction

Rabies is a zoonotic disease caused by an RNA virus from the family Rhabdoviridae, genus *Lyssavirus*, which has a case fatality rate in humans of near 100% if prophylactic measures are not implemented within a short time following exposure (Hampson et al., 2008; Dubovi and MacLachlan, 2011). Worldwide, rabies causes around 60,000 human deaths annually, 95% of which are from rural areas from Asia and Africa (WHO, 2016). In endemic regions, this disease is of major public health importance, not only due to the high case fatality rate, but also because it is potentially preventable if health education and immunization approaches are used. Due to the presence of the virus in both humans and animal hosts (with human infection almost invariably due to contact with infected animals) and its severity, control of rabies has been considered to be

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Table 1
Total number of samples and positivity percentage per year, from active and passive surveillance, of animal rabies in Chile, between the years 2003 and 2013.

Year	Active surveillance		Passive surveillance	
	Samples	Positivity (%)	Samples	Positivity (%)
2003	1,657	1 (0.06)	1,187	74 (6.23)
2004	1,966	5 (0.25)	1,319	81 (6.14)
2005	1,840	0 (0.00)	1,483	104 (7.01)
2006	1,528	0 (0.00)	1,329	110 (8.27)
2007	1,781	0 (0.00)	1,203	87 (7.23)
2008	1,571	3 (0.19)	1,192	80 (6.71)
2009	810	0 (0.00)	963	51 (5.29)
2010	977	2 (0.2)	1,082	60 (5.54)
2011	758	0 (0.00)	963	81 (8.41)
2012	418	2 (0.47)	1,096	92 (8.39)
2013	500	1 (0.2)	1,191	93 (7.80)
Total	**13,806**	**14 (0.10)**	**13,008**	**913 (7.02)**

Table 2
Number of cases of animal rabies in Chile, by animal reservoir and species, between the years 2003 and 2013.

Animal reservoir	Species	N° of cases
Bat	*T. brasiliensis*	856
	Lasiurus cinereus	37
	Histiotus macrotus	14
	Lasiurus borealis	9
	Myotis chiloensis	9
Dog	*Canis familiaris*	1
Cat	*Felis catus*	1
Total		**927**

Table 3
Number of cases of animal rabies in Chile, by rabies virus variants detected in positive bats between the years 2008 and 2013.

Viral variants detected on bats	N° of cases
3	2
4	381
5	1
6	28
8	1
9	2
H. macrotus	4
Not typified	46
Total	**465**

Table 4
Moran's I index, 95% confidence intervals and *p-value* for the three macro-zones.

Zone	Moran's I	Confidence interval (95%)		*p-value*
		lower	upper	
North	0.0517	−0.0358	0.1392	0.21
Central	0.1537	0.1141	0.1933	0.02
South	−0.0117	−0.078	0.0546	0.34

particularly amenable to a "One Health" strategy which integrates human and veterinary approaches (WHO, 2016).

Within Chile, rabies was considered endemic in domestic dog population until the late 1960s, when the National Program for Prevention and Control of Rabies was implemented by the Ministry of Health (MINSAL, from its Spanish acronym). The program consisted of monitoring activities of the disease in order to keep the country free of human and canine rabies and to an early establishment of necessary control measures. It comprised passive surveillance through reports of suspect animal rabies cases submitted by the population, public health offices and private clinics reports about dog bite events; and active surveillance through random sampling of susceptible animal populations (MINSAL, 2013). This program was highly effective, and resulted in a decrease in the number of human cases related to canine variants until the year 1972, when the last case was reported (Favi and Durán, 1991). Since 1985 the relevance of insectivorous bats as reservoirs of rabies has become clear. Testing for rabies positive bats belonging to the species *Tadarida brasiliensis* (among other species) became systematic and allowed characterization of the epidemiologic patterns of rabies in Chile, recognizing endemic infection in Chiropterans of Chile and prompted the surveillance of the agent in this and other species (Favi et al., 2011). In August 2013, a case of rabies encephalitis was confirmed in humans, linked to a 24-year-old male from the region of Valparaiso with a history of suspected stray dog bite; Situation that did not happen in Chile since 1996, not being able to identify the viral variant involved (ISP, 2013).

This study aims to analyse and characterize the evolution of the epidemiology of bat-born rabies in Chile during the period 2003–2013. Considering the number of cases per region and commune, animal reservoir involved, type of report (active or passive surveillance) and viral variant and to describe spatial and temporal patterns of bat cases as evidence and support for policy makers.

2. Materials and methods

2.1. Source population

For this study, secondary data sources were used, corresponding to the archives of the National Program for Prevention and Control of Rabies from MINSAL. In the case of active surveillance samples correspond to bats sampled directly from their colonies by MINSAL staff or other known reservoirs related to human bites (mainly dogs), in the case of passive surveillance, samples correspond to public reports of suspicious bats presence. This data source contained details of all positive cases, defined as brain samples positive to direct immunofluorescence (DI), from sampled animals, analysed by the Instituto de Salud Pública de Chile (ISP; Chilean Institute of Public Health), national reference laboratory in the diagnosis of rabies (ISP, 2013).

2.2. Target population

From these records, all available data was collected from positive cases between 2003 and 2013 and then consolidated recording: official registration number of the case, date of diagnosis, region and commune of occurrence, positive animal reservoir (dog, cat or bat), origin of the sample (active or passive surveillance) and the viral variant, the latter being registered since 2008. In terms of a definition of commune, there is no official definition in terms of dimensions or population ranges. This because there are 346 communes in Chile and with substantial differences between them. Normally the idea of a commune corresponds to a territory around an important urban nucleus, but not always happens in this way. There are communes of mostly rural characteristics without any defined urban nucleus, on the other side we have large conurbations divided in multiple communes, e.g. the city of Santiago de Chile, that have 36 communes. When describing communes in Chile by surface, it can be observed mean of 5,795.4 km^2, with ranges of 7.0 km^2–49,924.1 km^2 (Indepencia and Natales surface respectively); by population, it can be observed a mean of 49,850 habitants, with ranges of 332 habitants to 805,000 habitants (Ollagüe and Maipu population respectively); and by human population density (measure in habitants per km^2), it can be observed a mean of 862.62 habitants per km^2, with ranges of from 0.02 habitants per km^2 to 14,218.14 habitants per km^2 (Rio Verde and Lo Espejo population density respectively) (INE, 2017).