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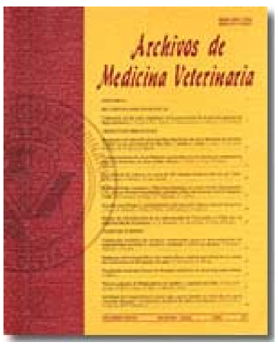

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ARTICULO ORIGINAL

Risk of introduction of Newcastle disease in Chile through import of ostriches

Riesgo de introducción de la enfermedad de Newcastle a Chile por la importación de avestruces

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Resumen

Chile ha estado libre de de la enfermedad de Newcastle del tipo PMV-1 desde 1977; por consiguiente, el objetivo del presente estudio fue evaluar el riesgo de introducción de la enfermedad de Newcastle origen, aquellos que corresponden al proceso mismo de importación y los realizados en la cuarentena en el país de destino. De acuerdo a los reportes de enfermedad en cada uno de los países exportadores de avestruces, se categorizó a los países en dos niveles: aquel donde la enfermedad de Newcastle no ha sido reportada y el de un país endémico. Las probabilidades de las entradas del modelo de simulación fueron obtenidas de fuentes bibliográficas e información sanitaria publicada por organismos de sanidad animal. Se ejecutó un análisis de sensibilidad, para lo cual se usó el coeficiente de correlación de rango a fin de identificar las variables que ejercen mayor influencia en el modelo, siendo éstas: la probabilidad de brote y la cantidad de avestruces importadas. Esta información sirvió para el diseño de cuatro escenarios que incluyeron valores extremos de la presentación de la enfermedad basados en la situación endémica, así como el uso de una mejor prueba diagnóstica. El número de avestruces positivos que ingresarían a Chile resultó fuertemente relacionado al número de brotes en el país endémico y al número de avestruces importadas del país endémico; el valor fue de 2.2 ^{x} 10^{-5}, con un límite de confianza superior del 90% de $8.5^{*}10^{-5}$ por año. El riesgo de introducción de la enfermedad de Newcastle a Chile asociado a la importación de avestruces fue muy bajo, incluso en los peores escenarios.

***Palabras claves**:* enfermedad Newcastle, avestruces, riesgo importación.

Summary

Chile has been free of Newcastle disease (ND) of type PMV- 1 since 1977. The objective of this study was to evaluate the risk of introduction of ND into Chile through importation of ostriches using a stochastic simulation model. Data for the model input were obtained from bibliographical sources and sanitary information published by animal health institutions. A scenario tree model incorporated the ND prevalence in ostriches in the exporting countries, the number of ND infected ostriches exported and the sensitivity of the tests before exportation and during quarantine in Chile. The outcome variable was the number of ND infected ostriches (per year) that enter Chile after quarantine. The model was simplified by limiting the model to two types of countries that represented countries of which Chile imported most ostriches: a ND-free country and a country where ND was endemic. The number of positive ostriches that enter Chile was strongly related to the number of outbreaks in the endemic country and the number of imported ostriches from the endemic country and amounted 2.2 ^{x} 10^{-5} with an upper 90% CI limit of 8.5 ^{x} 10^{-5} per year. The scenario tree model was a simplification of reality and the risk of introduction of ND in Chile by importation of ostriches was very low even in worse case scenarios.

***Key words**:* Newcastle disease, ostriches, import risk analysis.

INTRODUCTION

Newcastle disease (ND) is caused by an avian paramyxovirus (PMV-1 serotype). The ND strains are classified by their virulence as velogenic, mesogenic, lentogenic and asymptomatic forms (Alexander 2000). Newcastle disease virus (NDV) can infect many bird species, occurs worldwide and has a considerable economic impact on the world poultry industry (Jorgensen y col 1998).

ND was first reported in zoo ostriches in the 1950s. An outbreak of ND in commercial ostriches in Israel was reported in 1989. Of more significance were the ND infections of ostriches in southern Africa that occurred during the 1990s. These were thought to have spread from commercial domestic fowl (Verwoerd 2000). This outbreak was of particular concern because of the boom in international trade in ostriches and their products at that time (Alexander 2000).

Characterization of ND viruses isolated during outbreaks in ostriches has shown them to be indistinguishable from viruses infecting chickens in the locality. However, ND in ostriches is different from ND in poultry in that there is no respiratory involvement and thus no airborne transmission, unlike poultry ostriches show typical nervous symptoms such as not being able to lift their head, no pathological lesions in ostriches, and no carrier status (Huchzermeyer 2002). Because transmission of ND mainly occurs by direct contact and not by air, ND usually only infects a few ostriches at any one time during an outbreak and the disease does not usually cross a wire partition between groups (Huchzermeyer 2002).

The haemagglutination-inhibition (HI) test is most widely used to diagnose ND and considered the

the exporting country and in quarantine in Chile. Indirect and blocking enzyme-linked immunosorbent assay (ELISA) tests have been developed for the detection of ND antibodies in ostrich sera and have a high agreement with the HI test results (Moro de Sousa y col 2000). In addition, the ELISA tests have a higher sensitivity than the HI tests (Cadman y col 1997, Williams y col 1997).

Chile has been free of ND of type PMV-1 since 1977. However, the import of ostriches in Chile has grown during the last five years and was thought to be associated with an increased risk of introduction of ND. An introduction of ND would incur enormous economic losses for the Chilean poultry industry. In Chile, poultry is the second most important export product of animal origin after beef. Even if infection did not spread from ostriches to poultry there would be considerable economic losses as a result of export restrictions on poultry imposed by importing countries. Therefore, the objective of this study was to evaluate the risk of introduction of ND into Chile through importation of ostriches.

MATERIAL AND METHODS

Base parameters of the simulation model. Data for the model input were obtained from bibliographical sources and sanitary information published by animal health institutions. A stochastic simulation model was developed in MS EXCEL 2002 (Microsoft Corp. 1985-2001) and @RISK 4.0 (Palisade Corp. 2001). Ten thousand iterations were done with Latin Hypercube sampling. A scenario tree model incorporated the ND prevalence in ostriches in the exporting countries (population size x probability of ND outbreak x prevalence during an outbreak), the number of ND infected ostriches exported to Chile (number exported x ND prevalence in the population) and the sensitivity of the tests before exportation and during quarantine in Chile. The outcome variable was the number of ND infected ostriches that enter Chile per year after quarantine and was assumed to follow a Poisson distribution. The model was simplified by limiting the model to two types of countries from which Chile imported ostriches: 1) a ND-free country where ND had not been reported since 1975 (USDA 1992) and 2) an endemic country where ND outbreaks (in poultry) were detected every year and the last outbreak in ostriches occurred in 1998 (National Veterinary Services 2002). The input variables for the base model were based on the ND situation in the period from 1997 (when Chile started importing ostriches) to 2001. The total number of ostriches imported in Chile per year was obtained from the Servicio Agrícola y Ganadero (SAG) and ranged from 34 ostriches in 1998 to 689 in 2001. About 70% of the imports came from ND-free countries and 30% from ND endemic countries. The import data did not follow any pattern and were thus assumed to follow a uniform distribution (NDfree country: min. 34 max. 689; endemic country: min. 0 max. 558).

The ostrich population size in the exporting countries was obtained from national agricultural databases. The data were sparse for the ND-free country and varied little in the endemic country and thus the population size was assumed to follow a Uniform distribution (ND-free country: min. 350,000 max. 700,000; endemic country: min. 1,677,518 max. 1,965,204).

The probability of a ND outbreak (per year) in the exporting countries was calculated based on data obtained from the national agricultural databases and the World Organization for Animal Health (OIE). The number of outbreaks per year was assumed to follow a Poisson distribution. In ND-free country, an outbreak of ND had not occurred in ostriches for 25 years (1975 to 2001), therefore the mean number of outbreaks per year (?) was assumed to be at most 0.04. In the endemic country, there were 6 outbreaks in ostriches from 1997 to 2001 and thus it was assumed that an outbreak in ostriches occurred, on average, once a year ($\lambda = 1$).

The country-level prevalence during an outbreak was assumed to be low as a result of the limited spread of ND in ostriches (Huchzermeyer 2002), which was confirmed by the data available from the endemic country. The country-level prevalence during an outbreak was assumed to be the same in both countries and followed a Pert distribution. In the endemic country, only a total of 49 cases were detected during the 6 outbreaks, which resulted in a mean country-level prevalence during an outbreak of about 4.5×10^{-6}. The minimum country-level prevalence during an outbreak was 2 cases (1.1×10^{-6}), and the maximum was 22 cases (1.2×10^{-5}).

The test sensitivity of the HI test was assumed to follow a Pert distribution with a most likely value of 88%, a minimum of 83% and a maximum of 93% (Cadman y col 1997).

Sensitivity analysis. First, a rank correlation analysis was carried out on the model results to identify the endemic country showed that the risk of an ND outbreak was decreasing in time. The risk was higher from 1993 to 1996: 31 outbreaks from 1993 to 1996 (about 8 outbreaks per year) with a mean prevalence during an outbreak of 2.3 x 10^{-5} (5 times higher than in the base model). The increased risk of an outbreak and the increased prevalence were included in scenario 1 of the sensitivity analysis. In scenario 2, these parameters were increased for both countries and in scenario 3 the risk of ND-free country was changed to the absolute risk values for ND-free country (8 outbreaks per year and prevalence 2.3 x 10^{-5}). The mean diagnostic sensitivity of the ELISA was higher than the sensitivity of the HI test and ranged between 91% and 97% (Cadman y col 1997, Williams y col 1997). The improved test sensitivity in scenario 4 followed a Pert distribution with a most likely sensitivity of 93%, a minimum of 88% and a maximum of 100%.

RESULTS

The results of the rank correlation analysis in figure 1 show that the number of positive ostriches that enter Chile had the highest rank correlation with the number of outbreaks in the endemic country (0.83), followed by the number of imported ostriches from the endemic country (0.29), the number of outbreaks in the ND-free country (0.19), and the prevalence during an outbreak in the endemic country (0.17). The sensitivity of the HI test had a negative but low rank correlation, indicating that a more sensitive test would only slightly reduce the risk in the base situation (few imports, low risk). All the other variables had a rank correlation lower than 0.02. Table 1 shows the results of the base model and the sensitivity analysis.

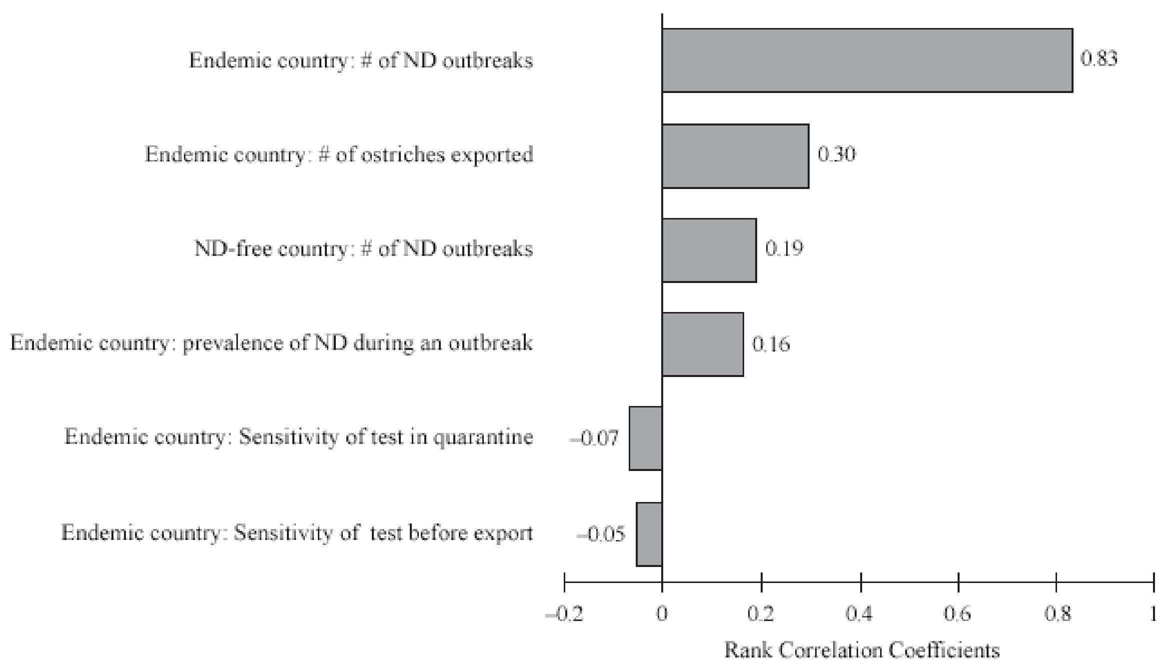

FIGURE 1. Rank correlations between the probability of introduction of ND in Chile and the most influential variables.
Correlaciones de rango entre la probabilidad de introducción de ND a Chile y las variables más influyentes.

TABLE 1. The mean and upper limit of the 90% CI of the number of ND infected ostriches that enter Chile per year and the number of years that have one ND infected ostrich to enter Chile.
Promedio y límite superior del intervalo de confianza del 90% del número de avestruces infectadas que entran Chile por año y del número de años en los cuales entra un avestruz infectado en Chile.

	ostriches/yr	CI	to enter Chile	CI
Basel Model	$2.2x10^{-5}$	$8.5x10^{-5}$	45.455	11.765
Scenario 1: Five times higher risk endemic country	$8.3x10^{-4}$	$2.3x10^{-3}$	1.205	435
Scenario 2: Five times higher risk in both countries	$8.8x10^{-4}$	$2.4x10^{-3}$	1.136	417
Scenario 3: Risk of 8 outbreaks per year in both countries	$1.9x10^{-3}$	$4.3x10^{-3}$	526	233
Scenario 4: Improved test sensitivity with an ELISA	$6.6x10^{-6}$	$2.7x10^{-5}$	151.515	37.037

The base model estimated that the mean number of ND infected ostriches that enter Chile per year amounted 2.2 x 10^{-5} with an upper 90% CI limit of 8.5 x 10^{-5} per year and 35.4% of the iterations resulted in a risk of zero. When the probability of ND outbreaks was increased eight times in one (scenario 1) or both (scenario 2) of the exporting countries, the mean number of infected ostriches that would enter Chile increased to about 1 infected ostrich in 1,000 years with an upper limit of at least 1 infected ostrich in 400 years. When both countries had an outbreak risk of 8 times per year (scenario 3), the mean number of infected ostriches that would enter Chile increased to about 1 infected ostrich in 500 years. In the base model, the more sensitive ELISA reduced the risk of introduction of ND in Chile about 3 times to 6.6 x 10^{-6}.

DISCUSSION

The risk of introduction of ND in Chile from imported ostriches was very low, mainly due to the small number of imported ostriches, the low risk of outbreaks in ostriches and the very low expected prevalence during an outbreak. In the worst case scenario, the risk of introduction of ND into Chile through importation of ostriches occurred once in 233 years. The information about outbreaks and number of cases was based on data published by the National Veterinary Services of one of the two endemic countries of which Chile imported ostriches. Information about ND in ostriches in the other endemic country was sparse and therefore one was used to represent any endemic country. This is not expected to bias the risk estimates. The literature shows that ND outbreaks in ostriches seem to follow a similar pattern anywhere in the world because the ND virus is not very virulent in ostriches and transmission occurs by direct contact (Verwoerd 2000, Huchzermeyer 2002).

The model was a simplified representation of reality. For example, the ND prevalence in the ostriches for export was assumed the same as in the total population of the exporting country. This may be an overestimation of the risk because ostriches for export are kept under more stringent biosecurity. The infected ostriches were assumed to be detected by the HI test only and not on clinical signs, which may also overestimate the risk of ND introduction in Chile. However, it is likely that ostriches with clinical disease would also be detected by the HI test. The risk of infection during transportation of the ostriches was not accounted for in the model. The risk of introducing ND may be underestimated by ignoring the probability that ostriches become infected during transport.

The model assumed that the two HI tests (before transport and in quarantine) were independent. However, this may underestimate the risk of introducing ND because the tests are probably correlated in that a false-negative ostrich in the first test may have a higher probability to test false-negative when the same test is applied the second time. It would be better to use a different test for each sample occasion. The risk could be decreased 3 times by using a more sensitive ELISA test in quarantine and although the risk for ND is not high it may be worthwhile to use the HI test in the exporting country and an ELISA in quarantine to limit the dependence between the test results.

The scenario tree model was a flexible tool, which can be adapted for other infectious avian diseases. A quantitative approach was used opposed to a qualitative approach. A quantitative approach is more informative and elaborate than a qualitative approach providing sufficient data of adequate quality are available and biology of the host, pathogen and environment are sufficiently well understood to know all risks (Vose 2000). Although, some data was sparse (i.e. on population size), the quality of the data in the study justified a quantitative approach. The advantage of the model was that it resulted in a point estimate and confidence interval around the risk estimate, leaving it to the decision makers to

The survival of the ND virus outside the bird in eggs, meat or feathers is possible for a few days (Verwoerd 2000). Nevertheless, the risk of ND introduction in Chile by importation of other ostrich derived products was not considered in the model. We expect that the risk from feathers, meat and eggs would be smaller than from live ostriches, mainly because they are less risk for poultry in Chile and the risk was therefore assumed to be negligible. The model also did not consider the risk of spread of ND to poultry. The economic losses of introduction of ND into the Chilean poultry industry would be huge as a result of the direct losses (production losses, disease control efforts, etc.) and the indirect losses due to the closure of the export market. The indirect losses would occur even when ND affected only ostriches. However, the study showed that import of ostriches is an unlikely source of infection for the poultry industry. Sources such as legally and illegally imported poultry, game fowl, pet birds and wild birds might impose a larger risk than ostriches.

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