**Desarrollo de un análisis de riesgo de entrada y un modelo de difusión potencial del virus de newcastle en la República Argentina**

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## Summary

The overall objective of this thesis is to evaluate and quantify the risk and consequences of a potential entry and spread of Newcastle disease (ND) in Argentina. To do this a semi-quantitative risk analysis model and a deterministic diffusion model have been developed. Moreover, we characterized and analyzed patterns of movements among commercial poultry farms using social network analysis methodology and the graph theory.

Argentina has a highly developed poultry industry of great economic importance which represents the second largest production of live animals after cattle. Currently the country is the 7th largest producer and 5th largest exporter of poultry products. For that reason, the potential introduction and spread of infectious diseases such as ND, could cause severe socio-economic consequences. The ND is worldwide considered as one of the major diseases affecting the poultry industry due to the high mortality that can produce and to the socio-economic impacts from trade restrictions in the affected countries that can arise. Because of its importance and because it is a highly contagious disease, is included in the list of reportable diseases by the World Organization for Animal Health (OIE), being endemic in many countries of America, Middle East, Africa and Asia. Since July 1997, OIE considers Argentina as free from ND.

To evaluate and quantify the risk and consequences of the potential entry of ND, a semi-quantitative risk analysis model has been developed, according to the guidelines recommended by OIE. Up to the present no risk analysis model adapted to the characteristics of Argentina to estimate the risk of ND has been found in the literature. The analyzed pathways to assess the risk of potential entry of ND in Argentina were the most important ones and those with enough information to be evaluated. Specifically, the selected pathways for the analysis were the imports of live poultry, poultry products and fertile eggs. To perform this analysis we collected information from both national databases (such as volume of birds, hatching eggs, poultry products and imported products recorded from 2001 to 2010) and international scientific publications. The steps

followed in this study focused specifically on hazard identification and risk assessment (which included the risk estimate of release and exposure and the estimate of the total risk). The results of the semi-quantitative risk analysis indicated that the total relative risk associated with the importation of pigeons and chickens was high, being United States the country that represents the highest relative risk of release associated to pigeons and United States and Brazil regarding to chickens. Ducks, turkeys and psittacines had a medium total relative risk. The total relative risk for all products was low or negligible. Similarly, the total relative risk for ornamental birds was negligible, although the uncertainty associated to this group of birds was high. The total relative risk associated to fertile eggs was low. When analyzing live birds in total, the country that represents an increased relative risk of virus release into Argentina was United States.

To describe the spatiotemporal pattern of animal movements among poultry farms, we conducted an exploratory analysis of all movements in Argentina during 2009 and 2010 using the network analysis methodology. Taking into account the records of 2011, we also conducted a comprehensive descriptive analysis of the characteristics of the poultry farms located in Argentina. The main results from these analyzes indicated that there is no temporal variation of commercial poultry movements between farms, and that the average distance of the movements was 210 km in 2009 and 198 km in 2010. The provinces of Buenos Aires and Entre Ríos concentrate approximately 70% of the country movements in 2009 and 2010. In 2009 and 2010 the highest values of in-degree were in meat production farms and the highest values of out-degree were in hatcheries.

Moreover, we performed for the first time a deterministic SIR (susceptible-infectious-removed) diffusion model based on real a contact network among commercial farms in Argentina to quantify the potential spread of ND during the high risk period. The constructed model allowed us to evaluate the potential development of an epidemic of ND, as well as to identify areas of greatest risk and to quantify the potential consequences regarding poultry health in Argentina. The spread of the disease within the farm was also incorporated into the model allowing us to calculate the probability that an infected bird were mobilized depending on the health status of the farm and modeling more realistically the potential magnitude of the epidemic. We evaluated various scenarios to assess the sanitary consequences that a ND incursion into Argentina would have. Specifically, we performed simulations of an epidemic in which the primary outbreaks (index cases) were

different types of commercial poultry production (e.g. meat production, egg production, hatcheries and other productions), different locations and happening in different months. The model results revealed that the average size of the epidemic varies significantly according to the type of production and location of the index case, being the epidemics of greater magnitude those which started in hatcheries, followed by those originating from meat production farms. The simulation of an epidemic of ND in different months was not significant different in magnitude or duration.

Finally, we believe that the results and methodologies developed in this thesis are not only useful and applicable for the development of ND prevention and control programs in Argentina but also for supporting the review and updating of contingency plans. In addition, the proposed methodology can be potentially adapted to other diseases and animal species in Argentina and other countries with similar epidemiological data and conditions.

Keywords: Newcastle disease, risk analysis, deterministic diffusion model, social network analysis, Argentina, prevention and control of diseases.