



Quantitative risk assessment of the introduction of rabies into Japan through the illegal landing of dogs from Russian fishing boats in the ports of Hokkaido, Japan



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ABSTRACT

Japan has been free from rabies since 1958 and various preventive measures are in place protecting the country from the introduction of the disease. Historical reviews indicate that the illegal landing of dogs from Russian fishing boats in the ports of Hokkaido occurred frequently especially in the early 2000s and this could potentially be a source of introduction of rabies into Japan. The method of scenario tree modelling was used and the following entry and exposure pathway was considered the most likely route of rabies entry: a rabies-infected dog arriving on a Russian fishing boat lands in a port of Hokkaido in Japan, it becomes infectious, contacts and infects a susceptible domestic animal (companion dog, stray dog or wildlife). Input parameter values were based on surveys of Russian fishermen, expert opinion and scientific data from the literature. At present (2006–2015), the probability of the introduction of rabies as a result of one Russian fishing boat arriving at a port of Hokkaido is 8.33×10^{-10} (90% Prediction Interval (PI): 7.15×10^{-11} – 5.34×10^{-9}), while this probability would have been 7.70×10^{-9} (90% PI: 6.40×10^{-10} – 4.81×10^{-8}) in the past (1998–2005). Under the current situation (average annual number of boat arrivals is 1106), rabies would enter Japan every 1,084,849 (90% PI: 169,215–20,188,348) years, while the disease would have been introduced every 18,309 (90% PI: 2929–220,048) years in the past (average annual number of boat arrivals is 7092). The risk of rabies introduction has decreased 59 fold due to both the effective control of the issue of illegal landing of dogs and the decline in the number of Russian boat arrivals. Control efforts include education of Russian fishermen, establishment of warning signs, daily patrols and regular port surveillance of potential dog landing activity. Furthermore, scenario analysis revealed that the policy of mandatory domestic dog vaccination does not contribute effectively to Japan's rabies prevention system under rabies-free situation. Although the current risk of rabies introduction is minimal, control measures against the illegal landing of dogs must be maintained. Further risk management measures, such as the removal of wildlife from the port area and regular monitoring of the rabies situation in Russia (particularly the easternmost regions), can be established to strengthen the current rabies prevention system in Hokkaido.

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1. Introduction

Japan has been free from rabies (classical rabies virus, i.e. RABV) for over 50 years where the last case of animal rabies was reported in 1957 (Takahashi-Omoe et al., 2008). Various preven-

tive measures, including mandatory registration and vaccination of domestic dogs, capture of stray dogs and strict import regimes for dogs and other mammals are in place in accordance with the Rabies Prevention Law that protects the country from the introduction and spread of rabies (Takahashi-Omoe et al., 2008). Japan has the geographical advantage of being isolated by the sea and thus the risk of introduction of rabies through land movements of rabid dogs or wildlife is practically null. However, Japan is subject to considerable movements of ships and boats which can potentially be a source of

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rabies introduction as suspected in the cases documented in Bali and Flores in Indonesia (Putra et al., 2013; Susetya et al., 2008; Townsend et al., 2013). Renowned for its fishing industry, Hokkaido is an island in northernmost Japan with large amount of boat visits every day. Furthermore, Hokkaido shares a close maritime border with Russia where animal rabies is widespread, especially in the western regions such as Belgorod Oblast, Yaroslavl Oblast, Kirov Oblast and Republic of Tartarstan (FSVPS, 2016; Makarov and Vorob'ev, 2004). Like many European countries where sylvatic rabies predominates, wild carnivores, particularly red foxes and racoon dogs, have remained the main reservoirs of the rabies virus in Russia (though pet animals, mainly dogs and cats, and farm animals are also affected by the disease) (Metlin, 2008).

Based on Japan Coast Guard (2016), there have been substantial numbers of Russian boats arriving at the 12 major ports of Hokkaido especially in the late 1990s. These boats arriving from Russia are usually small commercial fishing boats carrying sea products such as crab and sea urchin for sale; they are generally 30–35 m in length, 100–200 tons in weight and can accommodate 10–15 people. Based on the Rabies Prevention Law enforced since 1954, any dog from a ship or boat is prohibited from landing in Japan without undergoing a six-month quarantine period at the Animal Quarantine Station; alternatively, the dog would be subjected to a regime in place since November 2004 consisting of identification with microchip, two-time rabies vaccination, antibody level titration and a 180-day waiting period in the country of origin (Kamakawa et al., 2009; Takahashi-Omoe et al., 2008). However, many Russian fishermen who bring their dogs while sailing often ignored these rules and allowed the dog out to roam freely in the port area (MHLW, 2002; Ogawa, 2000). According to past surveys at Port of Wakkanai in 1997 and 1999, 60% of Russian fishing boats had dogs on board ($n = 108$); 34% of the fishermen of these boats admitted that they would take their dogs out of the boat ($n = 65$) with 99% of them knowing that the landing of dogs in the port area is illegal without a permit ($n = 108$) (Ogawa, 2000). Since the early 2000s, massive control efforts against this problem have been in place including education of Russian fishermen using information pamphlets, establishment of warning signs, daily patrols and regular port surveillance (MHLW, 2002; MAFF, 2010). In particular, port surveillance is conducted regularly in each month involving whole-day monitoring of the presence of dogs on Russian fishing boats and should any illegal landing of dogs be noticed, warning would be given to the fisherman.

In terms of domestic preventive measures, pet owners are obliged to register and vaccinate their dogs every year under the Rabies Prevention Law. The reported national vaccination rate averages 74% during 2005–2014 (MHLW, 2015a). The actual vaccination coverage is however estimated to be less than 40% due to owners who do not register and vaccinate their dogs (Takahashi-Omoe et al., 2008). Hidano et al. (2012) revealed that companion dogs taken less frequently for walks are significantly less likely to be vaccinated by their owners based on survey information from the whole Japan. In addition, capture of stray dogs and dogs without a tag certifying registration and vaccination are also strictly enforced in Japan. The reported number of detained dogs has been decreasing every year over the past 20 years i.e. from 244,061 in 1994 to 35,599 in 2014 (MHLW, 2015a). The situation of stray dogs in Hokkaido is also under control where the annual number of detained dogs has decreased from 2470 in 2009 to 1,233 in 2014 (MHLW, 2015b). On the other hand, the Sakhalin fox (*Vulpes vulpes schrencki*; a subspecies of red fox) is a wild animal abundant in Hokkaido and the presence of such wildlife may serve as a reservoir of rabies should the disease be introduced into Japan.

This study aims to quantitatively assess the risk of the introduction of rabies into Japan through the illegal landing of dogs from Russian fishing boats in the ports of Hokkaido. Through such

risk analysis, the present study evaluates the current rabies prevention system against the illegal landing of dogs and thereby gives evidence-based recommendations regarding which control measures should be maintained, intensified or discontinued. Since Japan is one of the few rabies-free countries/regions which still implements the policy of mandatory domestic dog vaccination, the value of such strategy is also critically reviewed.

2. Material and methods

2.1. Assessment framework and parameter estimation

The current risk assessment was performed based on the World Organisation for Animal Health (OIE) framework of risk analysis (OIE, 2015a). The following entry and exposure pathway was considered the most likely route of rabies entry: a rabies-infected dog arriving on a Russian fishing boat lands in a port of Hokkaido in Japan, it becomes infectious, contacts and infects a susceptible domestic animal (companion dog, stray dog or wild animal). A stochastic Monte Carlo model was developed, based on the generic rabies risk assessment framework developed by Ward and Hernández-Jover (2015) with specific modifications to accommodate the local conditions in Japan. The parameter values input into the model were based on the following sources:

1. Survey conducted at the Port of Wakkanai and data from regular port surveillance conducted at the Port of Hanasaki
2. Elicitation of expert opinion
3. Scientific data from literature reviews of previous rabies quantitative risk assessments.

Current survey of Russian fishermen were conducted by the authors at the Port of Wakkanai for one week during 8–15 July 2015. The paper questionnaire was first written in English and then translated into Russian; it included a series of closed questions to obtain information on whether a dog is present on the fishing boat and whether the fisherman would land the dog in the port area. Eighteen captains of Russian fishing boats were interviewed during the survey period. To collect expert opinion, five staff members from three local shipping agencies with extensive field experience in providing logistics services for Russian fishing boats were also interviewed. Each shipping agency was asked independently via paper questionnaire to infer the probability of contact between a landed Russian dog and domestic animals. Finally, field observation at the port was also undertaken to validate the findings from survey and expert opinion, for example whether a dog would actually land in the port area when the fisherman provided a “no” answer in the questionnaire, and when a low contact probability is inferred, whether this expert opinion is appropriate judging from actual field situation.

Another investigation trip was taken at Port of Hanasaki in Nemuro during 9–11 November 2015. Data collected from regular port surveillance during 2002–2015 (until October) was provided by the Nemuro city government and this serves as the survey information on Port of Hanasaki. Elicitation of expert opinion (five experts from three shipping agencies) and field observation were conducted in the same manner as in Wakkanai. The Port of Wakkanai and Port of Hanasaki were selected as investigation sites because these two ports had the largest number of Russian fishing boat arrivals during 1998–2015, a total of 23,996 and 15,180, respectively. The locations of the 12 major ports Hokkaido are shown in Fig. 1.

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