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AUTHORS: Hurley, M. J., Riggs, C. M., Cogger, N. and Rosanowski, S. M.

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The incidence and risk factors for shipping fever in horses transported by air to Hong Kong: Results from a 2-year prospective study

M J Hurley [a, *], C M Riggs [a], N Cogger [b] and S M Rosanowski [b, 1]

[a] *Department of Veterinary Clinical Services, Hong Kong Jockey Club, Sha Tin Racecourse, Sha Tin, New Territories, Hong Kong*
[b] *EpiCentre, Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Private Bag 11-222, Palmerston North, New Zealand*

* Corresponding author. Tel.: +852 6200 8638.
E-mail address: michael.j.hurley@hkjc.org.hk (M.J. Hurley).

[1] *Current address: Veterinary Epidemiology and Public Health Group, Department of Production and Population Health, The Royal Veterinary College, University of London, North Mymms, Hatfield, Hertfordshire, UK*

Highlights

- Data were collected from 81 shipments of horses transported to Hong Kong by air.
- The incidence risk of shipping fever was 10.8 per 100 horses.
- The proportion of shipments that contained horses with shipping fever was 60%.
- Risk factors identified were country of origin and month of arrival.
- Recognition of at-risk shipments helps focus attention on preventative strategies.

Abstract

A 2 year prospective study was performed between February 2011 and January 2013 to determine the incidence and risk factors for shipping fever (SF) in horses transported by air to Hong Kong (HK). Using a questionnaire, data were collected from professional flying grooms regarding the journey to HK and horses in the shipment. Horses were monitored in quarantine for 2 weeks after arrival in HK, and clinical signs of SF recorded. Poisson and logistic regression models were used to identify risk factors for SF at the horse and shipment level.

The study analysed data from 869 horses on 81 flights arriving from Australia (*n* = 24), New Zealand (NZ; *n* = 18), the United Kingdom (UK; *n* = 33) and the United States of America (USA; *n* = 6). The incidence risk of SF was 10.8 per 100 horses and the proportion of shipments with at least one horse that developed SF was 49/81 (60%). The study identified that the rate per shipment of SF in shipments of horses originating from NZ, the USA and the UK was 2.40 (95% confidence interval [CI] 1.22 – 4.71), 2.43 (95% CI 0.66 – 8.89) and 3.08 (95% CI 1.60 – 5.93) times the rate of SF compared to Australia. Shipments arriving in HK during March and May were 5.61 (95% CI 1.55 – 20.31) and 4.51 (95% CI 1.43 – 14.26) times more likely to contain horses that developed SF compared to shipments arriving in January. The identification of these risk factors and the recognition of at-risk shipments will help focus attention on preventative strategies.

Keywords: Equine; Logistic and Poisson regression; Pleuropneumonia; Travel sickness

Introduction

Shipping fever (SF) is a common respiratory disease of horses associated with transport over long distances by road, rail, sea, or air (Racklyeft et al., 2000). Horses affected by this condition typically first develop a fever, followed by other clinical signs as the condition progresses. These clinical signs may include inappetance, lethargy, coughing, nasal discharge, dyspnoea, tachycardia, abducted elbows, reluctance to move and a stiff gait (Mair and Lane, 1989; Wilkins, 2003; Davis et al., 2014). When SF is identified and treated in the early stages of the infection, affected horses usually recover quickly (Raidal, 1995; Seltzer and Byars, 1996; Racklyeft et al., 2000). However, if the infection spreads and pleuropneumonia develops, intensive medical treatment is necessary and the prognosis for a horse returning to its former level of activity becomes poor (Racklyeft et al., 2000; Davis et al., 2014). Horses with severe SF may develop secondary complications, such as pulmonary abscessation, colitis and laminitis, which can be fatal (Raidal, 1995; Hudson et al., 1999; Sprayberry and Byars, 1999). The stress associated with long distance travel, confinement in adverse environmental conditions, an elevated head position, and pre-existing lower respiratory disease, are well-known risk factors that contribute to the development of SF in horses (Rackyleft and Love, 1990; Leadon, 1995;[1] ; Rackyleft et al., 2000; Davis et al., 2014).

The Hong Kong Jockey Club (HKJC) is responsible for the administration of Thoroughbred flat racing in Hong Kong (HK). There is no breeding industry in HK and consequently, all horses are imported by air. Shipments of horses arrive continuously

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[1] See Leadon, D., 1999. Horse Transport: History, Current Practices, the Future and Veterinary Recommendations. Rural Industries Research and Development Corporation, Kingston, ACT, Australia. https://rirdc.infoservices.com.au/downloads/99-073.pdf (accessed 12 August 2014).

throughout the year, with flights originating from Australia, New Zealand (NZ), the United Kingdom (UK), or the United States of America (USA). Due to the long flight times associated with travel from these destinations, horses imported into HK are at a risk of developing SF.

To date, research relating to the air transport of horses has investigated areas such as the recovery and acclimatisation following air transport (Marlin et al. 2001) and the effects of air transport on behaviour and heart rate (Stewart et al., 2003). Few studies have been performed to identify risk factors for SF that could be specific to air transport (Leadon et al., 1990; Thornton, 2000; Ohmura et al., 2012; Maaskant et al., 2013). The objectives of the current study were to determine the incidence risk of SF in horses imported into HK and to identify factors that may contribute to the development of this condition. Both objectives were addressed at the horse- and shipment-level, with this data having potential relevance in determining future best practice for the management of horses travelling long distances by air.

Materials and methods

Study design and data collection

A 2 year prospective study was performed between February 2011 and January 2013 on all routine shipments of horses imported into HK. Horses travelling temporarily to HK to compete in international race meetings were not included in the study. Flying grooms accompanying these shipments completed a detailed questionnaire that provided information about the journey from the quarantine unit of origin to arrival at the airport in HK. This questionnaire is available from the authors on request.

All horses were quarantined for at least 3 weeks before departure to HK and received no pre-travel treatments, such as antimicrobials or other medications. Horses were transported in dedicated jet stalls, each typically containing three horses, by one of four airlines (British Airways, Cathay Pacific, Singapore Airlines or Qantas) in either a Boeing 747-400 F or 747-8 F freighter.

During the compulsory 2 week post-arrival quarantine period, the rectal temperature of each horse was recorded twice daily, and abnormal clinical signs and treatments were documented on quarantine charts by veterinarians from the Department of Veterinary Clinical Services (DVCS) at the HKJC.

The questionnaire completed by flying grooms for this study was authorised by the HKJC and endorsed by the airfreight divisions of New Zealand Bloodstock, International Racehorse Transport and BBA Shipping & Transport Limited.

Shipping fever case definition

Horses were diagnosed with SF if they developed one or more clinical signs of lower respiratory tract infection associated with air transport to HK. Clinical signs included fever (>38.6 ºC), inappetance, depression, coughing, nasal discharge, increased respiratory rate or effort and adventitious lung sounds.

Statistical analysis

All data on individual horses and shipments were entered into a customised database (Microsoft Access 2010). Shipment-level explanatory variables included the country of origin, the number of horses in the shipment, the date of departure and arrival, the month of the shipment, the thermostat setting in the cargo hold, position of the horses in the aircraft, total time in the aircraft, total travel time between quarantine units, as well as details of any delays and stopovers that occurred during the shipment. Horse-level explanatory variables included the age, sex and whether the horse was imported for racing or for use at one of the riding schools located in HK.

The outcome variables were determined at the horse and shipment level. The horse-level outcome variable was the presence of SF in an individual horse. The shipment-level outcome variable was the number of horses with SF per consignment. Continuous explanatory variables were described using medians and interquartile ranges (IQR) for non-normally distributed variables and mean and standard deviations (SD) for normally distributed variables. Nominal explanatory variables were described using counts and percentages. A mixed effect logistic regression was used to determine those factors that were associated with whether or not a horse developed SF, including the horse-level variables of age and horse use. Country of origin was retained in the final model. Biologically plausible two-way interaction terms between variables were considered for inclusion in the multivariable model. Model diagnostics were conducted using summary measures of the goodness-of-fit of the final model (Hosmer and Lemeshow, 2000). To account for the clustering of horses, a random effect term for shipment was used.

Shipment-level explanatory variables were screened using univariable Poisson regression to determine those factors that were associated with the rate of SF in a consignment of horses and those with $P<0.20$ were included in a multivariable model, offset by the number of horses on the shipment. Continuous exposure variables were modelled as categorical variables based on terciles in the univariable analyses. A preliminary multivariable model was built using a manual backwards method of elimination in which variables were retained in the model if the likelihood ratio test statistic was significant at $P<0.05$. Continuous variables were examined for best fit, as described by Parkin et al. (2005) and as categories based on terciles. Biologically plausible two-way interaction terms between the main effect variables were considered for inclusion in the multivariable model. Significance was assessed using the likelihood ratio test statistic. Over dispersion was checked using deviance and Pearson goodness-of-fit measures. All statistical analyses were performed using Stata version 11.1 (Statacorp LP).

Results

Descriptive statistics

During the study period, data were collected from 869 horses on 81 flights arriving into HK, with a median of 10 (IQR 5 - 14) horses per shipment. Flight data were not provided for six flights that also arrived during this period. Shipments departed from one airport in NZ, two airports in Australia, and three airports in both the UK and the USA. The median number of shipments per month was 3 (IQR 2 - 4; Fig. 1) and the median number of horses to arrive in HK per month was 35 (IQR 26 - 47.8; Fig. 2). The descriptive summary of shipments and the number of horses imported is shown in Table 1. Of the horses that were imported, 840/869 (96.7%) were Thoroughbreds destined for racing in HK and the remaining 29 were a variety of horse breeds destined for riding schools. All 29 riding school horses came from the UK. The age of the horses imported ranged from 2 - 18 years of age with all horses imported for racing aged less than 6 years old. Male horses comprised 97.9% of the horses imported into HK.

The descriptive statistics for the shipment-level variables are shown in Table 2. In total, 39/81 (48%) shipments had a stopover on the way to HK lasting between 1 h 30 min and 3 h. All shipments from the USA had a stopover, 23/33 (70%) from the UK, 9/18 (50%) from NZ and 1/24 (4%) from Australia. Overall, 22/81 (27%) of shipments were delayed during the journey, with delays lasting between 1 and 7 h. Horses were positioned in the front third of the aircraft for 38/81 (47%) flights, 23/81 (28%) were positioned in the rear third of the aircraft and 20/81 (25%) in the middle third.

During the 2 week quarantine period, 94/869 (10.8%) horses, from 49/81 (60%) flights, developed clinical signs of SF (Table 3), resulting in an incidence risk of 10.8 cases per 100 horses. Of the SF cases, 36/94 (38%) were diagnosed immediately upon arrival in quarantine, and within 24 h 84/94 (89%) of all cases had been identified. Nearly all horses diagnosed with SF (90/94, 96%), had a fever of ≥38.6 ºC, and in 62/94 (66%) cases this was the only clinical sign; 18/94 (19%) had two clinical signs and 14/94 (15%) had three or more clinical signs. Apart from fever, horses diagnosed with SF were recorded as being dull, quiet or depressed (*n* = 21/94; 22%); having an increased respiratory rate (n = 15/94; 16%); adventitious lung sounds (*n* = 6/94; 6%); and inappetence (6/94; 6%). Other clinical signs included nasal discharge (*n* = 3/94; 3%), coughing (*n* = 2/94; 2%), congested mucous membranes (*n* = 2/94; 2%) and mild colic (*n* = 2/94; 2%). All 94 affected horses were treated by DVCS veterinary surgeons and all cases recovered uneventfully. On flights where horses were identified with SF, the number of cases per shipment ranged from one to six. The median number of affected horses on these shipments was 1 (IQR 1-2).

Logistic regression modelling

Taking into account clustering at the shipment-level, the presence of SF was not significantly associated with the age ($P=0.96$) or type of horse ($P=0.31$), but the country of origin was significantly associated with the outcome factor ($P<0.01$; Table 4). The goodness of fit for the model without shipment showed no evidence of a lack of fit ($P>0.05$), nor were any influential observations observed.

Poisson regression modelling

The results of the univariable Poisson regression analyses are shown in Table 5. The country of origin and the month of travel were both significant in the multivariable model. The overall significance of the model was $P<0.001$ (Table 6). One shipment from NZ containing 25 horses and no horses with SF, had a residual value <-2.5 and a highest Cook's distance. This value was evaluated and not removed from the final model.

Discussion

The objectives of this study were to determine the incidence risk of shipping fever in horses imported into HK and to identify factors contributing to the development of this condition. The second objective was achieved using logistic regression analysis at the horse level and Poisson regression analysis at the shipment level. In both regression analyses, the country of origin was a significant factor for the development of SF in the individual or in the shipment. Additionally, the month of travel was identified as a factor that was associated with increased rates of SF on flights arriving into HK.

The single most important predisposing factor for SF is transportation over long distances (Racklyeft et al., 2000). While this has been demonstrated for horses transported by road (Oikawa and Kusunose, 1995), this is the first study to quantify this risk factor for multiple shipments of horses from different countries of origin travelling by air. Country of origin was identified as a risk factor for SF, both at the individual horse level and at the shipment level. Compared to shipments from Australia, NZ shipments were more than twice as likely, and shipments from the UK more than three times as likely to contain horses that developed SF. Horses in lower risk Australian shipments travelled for less time than other countries, usually under 10 h on the aircraft and under 17 h total travel time. However, with the inclusion and influence of country of origin in the final model, transport time was not identified as a risk factor for SF. In terms of minimising risk, the effects of country of origin are difficult to substantially modify or mitigate. Further investigation is warranted regarding the cause of this effect.

In the current study the incidence risk of SF in horses was 10.8 per 100 horses. In contrast, a lower figure was reported by Leadon et al. (1990) who found that following a flight from the UK to Australia, 7/112 (6.3%) of horses developed clinical signs of SF. In the Leadon et al. study, 112 horses were transported on a chartered flight, in open wooden stalls, and the total flight time, including three stopovers, was 39 h (Leadon et al., 1990). This contrasts with the current study where the median shipment sizes and flight times were less, and the horses travelled in modern, enclosed, jet stalls on commercial flights with other cargo. It has been suggested that despite recent advances in the ease of equine air transport, the use of modern enclosed jet stalls might have resulted in an increased incidence of SF [1]. However, this could not be investigated in the current study, as we did not compare different types of stalls.

As the incidence risk of SF in individual horses and the proportion of shipments that have horses with SF is high, horses from all shipments arriving in HK are carefully monitored so that cases can be identified and treated as early as possible. All SF cases in the current study were mild and resolved without complication following treatment. Prior to the introduction at the HKJC in the 1990's of routine rectal temperature monitoring of all imported horses, it was not uncommon for horses with SF to require treatment for pleuropneumonia, as pyrexia (one of the early clinical signs of SF) had gone undetected (W. H. Chan, personal communication). The value of rectal temperature monitoring as an aid to the early detection of SF has been demonstrated by the current study, where the majority of SF cases were identified either on arrival or within 24 h of arriving in HK.

The racing season in HK starts in September and finishes the following July. Shipments arrive continuously throughout the year, with horse arrivals peaking between July and October to coincide with the start of a new racing season. Shipments arriving in HK during the spring months of March and May were found to be nearly 6 and 5 times more likely to contain horses that developed SF, compared to shipments arriving in January. In March and May, horses are travelling from either spring conditions (UK and USA) or autumn conditions (NZ and Australia). It has been suggested that hot and humid environmental conditions in the country of origin could lead to an increased susceptibility to SF after a long-distance flight (Maaskant et al., 2013). This is an area that warrants further investigation, as in the current study, climatic conditions in the country of origin were not measured.

The location of jet stalls in the cargo hold was not a significant risk factor for horses developing SF in this study. However environmental conditions, such as relative humidity (RH) and ambient temperature (AT), do vary throughout the cargo hold and might contribute to the development of SF. A previous study conducted in a Boeing 747 F, flying from the UK to Australia (Leadon et al., 1990), identified that during the in-flight period, the mean RH was 25% and the mean AT was 13 ºC in the front section of the aircraft and 41% and 16 ºC, respectively, in the rear section of the aircraft. During the stationary phase on the same flight the mean RH was 78% and the mean AT 21 ºC in the front section of the aircraft and 91% and 33 ºC, respectively, in the rear section of the aircraft. Although it is possible that the incidence of SF could be reduced by manipulating these parameters, in reality the RH is not easily controlled, and depends on many factors such as altitude, flight duration, the number of horses being carried, and the humidity during the ground phase at the departure and stopover airports (Captain E. Oon, personal communication). Although no absolute guidelines for RH are currently recommended by the International Air Transport Association (IATA)[2] when transporting horses, the general advice is to control high RH with adequate ventilation to reduce the risk of heat stress when temperatures are high, and to reduce the risk of cold stress when temperatures are low. A limitation of the current study was that RH was not measured and the thermostat setting was used as a proxy for AT. The thermostat setting for each shipment was selected by flying grooms based on their personal preference and ranged from 12 ºC to 18 ºC. These values are within the range currently recommended for the transportation of horses by the IATA of 10 - 19 ºC. One consideration regarding thermostat settings is that the actual temperature in a jet stall may differ from the AT in the cargo hold. Thornton (2000) demonstrated during four international flights, that the temperature was significantly warmer inside a fully enclosed, insect proof, jet stall than in the surrounding cargo hold. Further research is required to determine if there is an optimal combination of RH and AT when transporting horses by air over long distances for the maintainence of both health and welfare.

[2] See: http://www.iata.org/Pages/default.aspx (Accessed 17 December 2015)

Conclusions

With the increasing number of high value, elite horses being transported by air to competitions and for racing, the protection of these horses from potentially performance limiting and possibly life-threatening SF is important. As the majority of horses imported to HK are destined for the racing industry, any conditions that could have a detrimental effect on future performance are of concern. In this study, the incidence risk of SF in horses being transported into HK was high, with the country of origin and the month of travel being associated with the rate of SF in a shipment. Shipments of horses traveling from the UK had three times the rate of developing SF, compared to shipments traveling from Australia. The identification of these additional risk factors and the recognition of at-risk shipments will help focus attention on preventative strategies. While factors such as country of origin cannot be altered, extra care of horses at a higher risk or with other risk factors for SF could be managed, with particular emphasis on the early detection of the condition, to reduce the effect that SF has on the health and welfare of horses arriving into HK.

Conflict of interest statement

None of the authors of this paper has a financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of the paper

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Figure legends

Fig. 1. The number of horse shipments arriving into Hong Kong, by month, during the study period (February 2011 to January 2013)

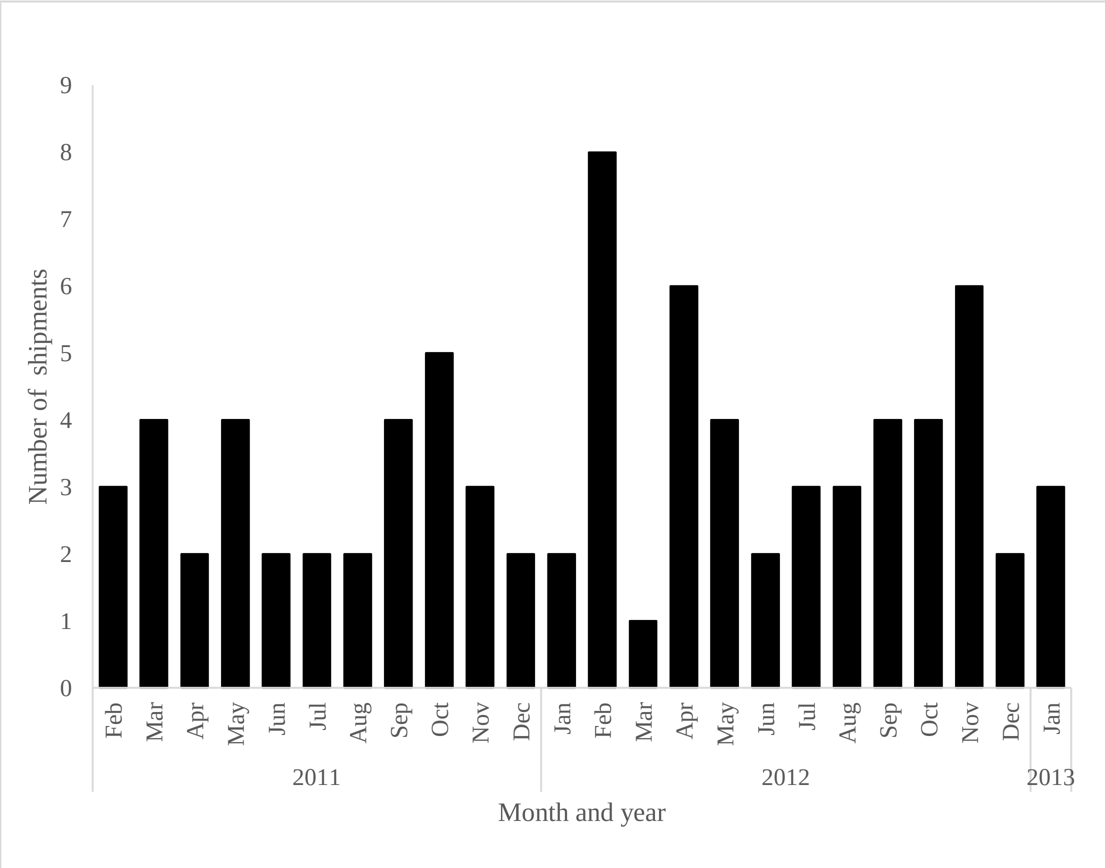

Fig. 2. The number of horses transported into Hong Kong, by month, during the study period (February 2011 to January 2013)

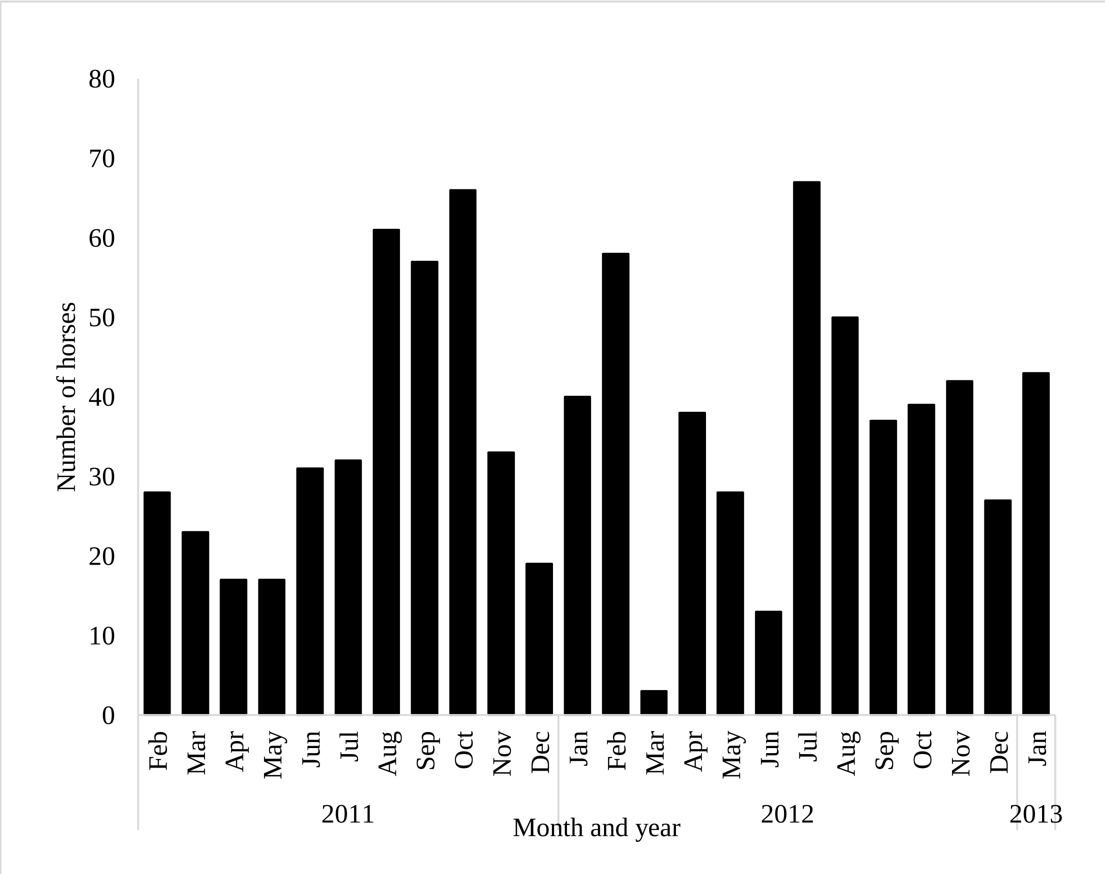

Table 1. Description of the shipments (n = 81) and horses (n = 869) imported into Hong Kong between February 2011 and January 2013, stratified by originating country

Country of Origin	Shipments	Horses per shipment					
	n (%)	*n* (%)	Minimum	25th percentile	Median	75th percentile	Maximum
Australia	24 (29.6)	260 (29.9)	3	8	11	13	20
United Kingdom	33 (40.7)	272 (31.3)	1	4	6	12	23
New Zealand	18 (22.2)	319 (36.7)	3	9	14.5	25	48
United States of America	6 (7.4)	18 (2.1)	2	2	3	4	4

Table 2. Descriptive statistics of shipments of horses (n = 81) arriving in Hong Kong between February 2011 and January 2013, stratified by originating country

Variable	Country of origin	Minimum	25th percentile	Median	75th percentile	Maximum
Total travel time between quarantine units (h) and min	Australia	13 h 50 min	14 h 25 min	15 h 5 min	16 h 40 min	31 h
	United Kingdom	16 h	18 h 55 min	21 h 50 min	23 h 15 min	27 h 50 min
	New Zealand	17 h	19 h 25min	20 h 55 min	22 h	27 h
	United States of America	22 h	32 h 30 min	33 h 20 min	36 h 55 min	42 h 30 min
Total time on board the aircraft h and min	Australia	8 h 30 min	9 h	9 h 10 min	9 h 48 min	25 h 15 min
	United Kingdom	10 h 45 min	11 h 45 min	15 h 40 min	16 h 28 min	19 h 52 min
	New Zealand	9 h 30 min	11 h 20 min	13 h 10 min	15 h 25 min	16 h 50 min
	United States of America	17 h 20 min	17 h 30 min	18 h 58 min	19 h 15 min	30 h
Thermostat setting in the cargo hold during transport (˚C)	Australia	12	14	15	15	16
	United Kingdom	12	13	14	14	17
	New Zealand	12	14	15	15	16
	United States of America	14	15	15	16	18

Table 3. Descriptive statistics of horses (n = 869) and shipments (n = 81) that developed cases of shipping fever after travelling to Hong Kong, by originating country.

Country of Origin	Shipment		Horse		
	Negative n (%)	Positive n (%)	Negative n (%)	Positive n (%)	Median (IQR)*
Australia	15 (62.5)	9 (37.5)	248 (95.4)	12 (4.6)	1 (1-3)
United Kingdom	10 (30.3)	23 (69.7)	231 (84.9)	41 (15.1)	1 (1-2)
New Zealand	4 (22.2)	14 (77.8)	281 (88.1)	38 (11.9)	2 (2-4)
United States of America	3 (50.0)	3 (50.0)	15 (83.3)	3 (16.7)	1 (1-1)

IQR, Interquartile range
*Median number of horses with shipping fever when at least one horse with positive clinical signs for shipping fever was identified on the shipment.

Table 4. Mixed effect multivariable logistic regression results for the outcome of whether an individual horse developed shipping fever after travelling to Hong Kong (P<0.01)

Variable	Level	Odds ratio	95% CI	*P*
Country of origin	Australia	REF		
	United Kingdom	4.02[a]	1.94 - 8.34	<0.001
	New Zealand	2.99	1.41 - 6.31	0.004
	United States of America	4.2	0.99 - 17.8	0.05
Age		0.99	0.69 - 1.42	0.96
Type of horse	Riding School	REF		
	Racehorse	2.55	0.42 - 15.26	0.31
Random effect for shipment		0.43	0.16 - 1.18	0.12

95% CI, 95% confidence interval
[a] Interpretation: when the clustering of horses at the shipment level is accounted for and all other variables in the model are held constant, horses from the United Kingdom are at 4.02 (95% CI 1.94 - 8.34) times the odds of developing shipping fever after travelling to Hong Kong compared to horses from Australia

Table 5. Poisson regression results for the outcome of the rate per shipment of shipping fever in horses travelling to Hong Kong

Variable	Level	Incidence rate ratio	95% CI	*P* [a]
Country of origin	Australia	REF		0.001
	United Kingdom	3.27[b]	1.72 - 6.21	<0.001
	New Zealand	2.58	1.35 - 4.94	<0.001
	United States of America	3.61	1.02 - 12.8	0.05
Location of jet stalls	Front	REF		0.01
	Middle	1.49	0.93 - 2.38	0.09
	Rear	1.15	0.67 - 1.95	0.62
Month	January	REF		0.02
	February	2.41	0.76 - 7.69	0.14
	March	4.79	1.35 - 16.97	0.02
	April	1.51	0.38 - 6.03	0.56
	May	5.07	1.62 - 15.93	0.01
	June	0.47	0.05 - 4.22	0.50
	July	2.52	0.81 - 7.80	0.11
	August	2.62	0.86 - 7.95	0.09
	September	2.65	0.85 - 8.21	0.09
	October	2.37	0.76 - 7.35	0.14
	November	1.94	0.57 - 6.62	0.29
	December	0.45	0.05 - 4.04	0.48
Total travel time	<17 h	REF		0.002
	17 to 22 h	2.18	1.14 - 4.19	0.02
	>22 h	3.13	1.58 - 6.20	<0.001
Total time in aircraft	<10 h	REF		0.05
	10 to 16 h	1.60	0.92 - 2.78	0.10
	>16 h	2.22	1.17 - 4.23	0.02
Thermostat setting		0.86	0.71 - 1.03	0.11
Stopover during transport	No	REF		0.01
	Yes	1.79	1.19 - 2.69	0.01

95% CI, 95% confidence interval

[a] *P* values that are left aligned are Likelihood ratio tests, those right aligned are Wald tests

[b] Interpretation: The rate per shipment of SF in shipments from the United Kingdom is 3.27 (95% CI 1.72 - 6.21) times that when shipments arrive from Australia

Table 6. Multivariable Poisson regression results for the outcome of the rate per shipment of shipping fever in horses travelling to Hong Kong (*P*<0.001)

Variable	Level	Incidence rate ratio	95% CI	*P*
Country	Australia	REF		
	United Kingdom	3.08[a]	1.60 - 5.93	<0.001
	New Zealand	2.40	1.22 - 4.71	0.01
	United States of America	2.43	0.66 - 8.89	0.18
Month	January	REF		
	February	2.27	0.71 - 7.28	0.17
	March	5.61	1.55 - 20.31	0.01
	April	1.65	0.40 - 6.78	0.49
	May	4.51	1.43 - 14.26	0.01
	June	0.47	0.05 - 4.23	0.50
	July	2.65	0.85 - 8.29	0.09
	August	2.75	0.90 - 8.34	0.08
	September	2.52	0.80 - 7.89	0.11
	October	2.18	0.69 - 6.88	0.19
	November	1.91	0.55 - 6.69	0.31
	December	0.65	0.07 - 5.94	0.70

95% CI, 95% confidence interval

[a] Interpretation: The rate per shipment of SF in shipments from the United Kingdom is 3.08 (95% CI 1.60 - 5.93) times that when shipments arrive from Australia