Journal of Animal and Veterinary Advances 5 (8): 651-658, 2006

Temporal Patterns of Haemorrhagic Septicaemia Mortalities Ion Cattle and Buffaloes in Peninsular Malaysia, 1993-2003

[1]Bisht, K.S., [1]N. Salim, [1]L. Hassan, [1]Z. Zunita, [2]M.I. Kamarudin and [1]A.A. Saharee
[1]Faculty of Veterinary Medicine UPM Serdang 43400 Selangor, Malaysia
[2]Department of Veterinary Services 50630 Kuala Lumpur, Malaysia

Abstract: Data on Haemorrhagic Septicaemia (HS) mortalities and climatological conditions (rainfall and temperature) were collected from 1993 to 2003 and subjected to a time series seasonal decomposition analysis. The 12-month Centered Moving Averages (CMA), Seasonal Indices (SI), Trends (T) and Cyclic patterns (C) were computed. A total of 1,489 mortalities of HS were recorded in Peninsular Malaysia with 62.9% of mortalities recorded during the last five years of the study period (1999-2003). The higher number of HS mortalities appeared to occur in the 1st and 4th quarters of the year. Seasonal index showed the greatest values during the months of 1st and 4th quarters of the year and the lowest indices were observed in 2nd and 3rd quarter of the year. The existence of 2-3-year cyclical fluctuations was observed with major peaks occurring in December 1998 to May 2000 and minor peaks observed in the year 1994-1996, 1997-1999, 2000-2001 and 2002-2003. Vaccination coverage over the study period was very low. The maximum coverage was 13.6% of the total cattle and buffalo population in year 1995. Difficulty in gaining access to the animals, inadequate facilities and the reluctance of owners to bring their animals for vaccination in the absence of disease might be the explanation for the observed epidemiological patterns of the disease. The rainfall seasonality combined with movement of carrier or susceptible animals appeared to be plausible explanations for the seasonal variations of HS. Furthermore, these findings suggested that since higher number of HS outbreaks appeared to occur during the 1st and followed by 4th quarter of the year, an appropriate control strategy may be to vaccinate animals before the 4th quarter of the year.

Key words: Temporal patterns, haemorrhagic septicaemia, time series seasonal decomposition, cattle, buffalo, climatological conditions

INTRODUCTION

Haemorrhagic septicaemia is an acute septicaemic disease in cattle and buffaloes caused by *Pasteurella multocida* B:2[1,2]. HS is a highly endemic and economically important disease of cattle and buffaloes in South Asia[3] have occurred in the form of localized outbreaks in Peninsular Malaysia for many years. The mortality rate was high, particularly in herds that were not vaccinated on a routine prophylactic basis and had poor management practices and veterinary services[4].

Time-series analysis has been useful as an analytical tool for understanding temporal patterns of infectious diseases like rabies[5,6]. Removing the short term fluctuations present in the original data allows focus on the important epidemiological patterns like seasonal fluctuations, cycles and trends. These epidemiological patterns are important considerations in controlling the disease[7].

The relationship between seasonality and HS occurrence has been studied[8,9]. However, there is little work conducted on the relationship of the seasonal and cyclic patterns of climatological conditions (rainfall and temperature) with seasonal and cyclic patterns of HS. Adverse environmental conditions such as changes in rainfall and humid weather conditions are associated with HS occurrence. Increasing vaccination of animals using alum precipitated or oil adjuvant HS vaccine before the occurrence of adverse environmental conditions may help in controlling the disease, hence, reducing the mortality rates and the number of outbreaks[3].

According to Phoung[10] and Kral *et al.*[11], the end of the dry season was considered the best time for vaccination in order to protect animals during the high-risk period of the wet season. This may only be possible when the temporal patterns such as seasonal, cyclic and trend components of disease are described. Thus, it is important to study the patterns of the HS in order to identify the actual high-risk period so that control regimes could be formulated accordingly. Thus far, no studies have been conducted to observe the temporal patterns such as seasonal, cyclic and trend components of HS.

Corresponding Author: Bisht, K.S., Faculty of Veterinary Medicine UPM Serdang 43400 Selangor, Malaysia

The present study is undertaken to identify the temporal patterns of the HS mortalities and determine the temporal distribution of the HS mortality and its association with the change of the animal population, vaccination and animal movement.

MATERIALS AND METHODS

Source of data: The original time series data on HS mortalities were collected between 1993 and 2003 from the Department of Veterinary Services (DVS) and District Veterinary Offices in Peninsular Malaysia using a standard questionnaire. The questionnaire seeks information on the size of the outbreak, number of vaccinated animals, location and time of the outbreak and other general information. The monthly climatological data collected at the Meteorological Station closest to the outbreak location, was obtained from the Meteorological Center Malaysia. The climatological data included rainfall (mm) and temperature (°C). Data on vaccination was obtained from DVS, Malaysia. The cattle and buffalo census was collected as described by FAO[12]. All data were managed, collated and analysed using the SPSS version-13 software.

Data management and analysis: A time-series seasonal decomposition method was applied on the monthly HS mortalities, monthly rainfall and temperature data as described by Makridakis and Wheelwright[13] and Lapin[14]. There were many months over the 11 years of the study period where no HS outbreak occurred. This had caused seasonal decomposition not to proceed due to the 0 moving average. Therefore, 0 in the original time series data was substituted by the subsequent yearly mean HS mortalities to eliminate the consecutive zeroes.

Decomposition matrix: A time-series decomposition matrix comprising seven components was used for the time-series analysis, namely $T_tC_tS_tI_t$= original data, T_tC_t= 12 months moving average, S_tI_t= ratio to moving average, S_t= seasonal index, I_t= ratio of moving average and seasonal index, $T_{t=}$ Trend and C_t = ratio of moving average and trend. The mathematical equation to represent time series decomposition model is as follows.

$$Y_t = \quad T_t \times C_t \times S_t \times I_t$$

where,

Y_t= observed values of time series data at time t
T_t= trend component
C_t= cyclical fluctuations factor
S_t= seasonal fluctuations factor
I_t= irregular/Random/Error fluctuations
T= time (in months)

Moving Average (MA): The MA trend line smoothed out fluctuations in the data to show patterns more clearly and eliminated the random factor. The original monthly raw data (X_n= 132) from 1993-2003 were used to compute the 12-month MA. The MA from January 1993 to the December 2003 covered the one complete set of the season. The 12-month MA was computed by adding from January 1993 (X_1) until December 1993 (X_{12}) and divided by 12. This process was continued by dropping X_1 and including X_{13}, dropping X_2 and including X_{14} and so forth until the December 2003 (X_{132}). The centered 12-month MA was further calculated by taking the average of the first two values of the 12-month MA. These values were placed opposite the seventh value (X_7) of the original data in their computations.

Seasonality and randomness: The values of the original data ($T_t \times C_t \times S_t \times I_t$) were divided by those of the centered 12-month MA ($T_t \times C_t$) to get the ratio of the actual to centered moving average, $S_t \times I_t$ which represented the seasonal and the irregular fluctuations. The ratios ($S_t \times I_t$) were arranged in a month and year matrix in order to compute the seasonal indices. The mean ratios for each month over the number of years were computed to give the unadjusted seasonal index (USI) for the month. These USI were adjusted mathematically to fluctuate around 100 by:

For each months adjusted seasonal index (ASI) =

USI for the month/Sum of monthly USIs' ×1200

The seasonal indices depicted the annual patterns of occurrence and identified the months or seasons of higher or lower occurrences.

Deseasonalised data: The deseasonalised data ($T_t \times C_t \times I_t$) were computed by dividing the original time series data ($T_t \times C_t \times S_t \times I_t$) by the corresponding value of the seasonal indices ($S_t \times I_t$) to get the patterns of occurrence without seasonality. Randomness was further eliminated by averaging several data values by 3×3-month MA. This is an study to overcome the problem of missing values at the end of data set due to the averaging, as described by Makridakis and Wheelwright (1972) to obtain the trend cycle component (T×C).

Trend (T_t) and cyclic fluctuations (C_t): The long-term trend was estimated by linear regression applied to the original data with the monthly number of HS mortalities as

Dependent Variable (DV) and the number of months (1-132) as an Independent Variable (IV). The trend values were calculated for each month (1-132) over the study period. Mathematically, they are as shown below:

$T_t = b_0 + b_1 \times X_{1i}$
Y = dependent variable
b_0= he intercept
b_1= slope or rate of change in y for any one unit change in X

The trend lines can be displayed graphically and therefore be used to compute forecast values according to the following formula:

$$\text{Forecast} = \text{trend } (T_t) \times \text{seasonal index } (S_t)$$

The cyclic component (C_t) was computed by dividing the centered 12-month MA by the corresponding trend values (T_t) and multiplying by 100 to make them fluctuate around 100. Mathematically, they are as follows:

$$C_t = (MA \div T_t) \times 100$$

The cyclic component pattern depicts longer term fluctuation cycles in the time series data.

RESULTS

Descriptive statistics: From January 1993 to December 2003, a total number of 1,489 mortalities of HS were recorded in Peninsular Malaysia. The distribution of the original time series data (number of HS mortalities) between January 1993 and December 2003 are shown in Table 1.

Moving average: The CMA provided a set of values with no seasonality, a minimum amount of randomness (error) and only cyclic and trend component ($C_t \times T_t$) of HS mortalities from 1993 to 2003. These values were relatively smooth with little error and they provided a more precise pattern of the trend and cycles in the occurrence of the HS mortalities over the 11-year period (Fig. 1).

Seasonal indices: The seasonal indices of the HS occurrence over the 11-year period of study are shown in Table 2. Indices above 100 indicated that seasonality for the occurrences of HS were higher than the usual for the relevant months. The seasonal indices were higher in January, February, March, July, November and December, i.e., the monthly HS occurrences were 67.23, 45.54, 9.66, 50.29, 0.89 and 4.19% higher than the average for each

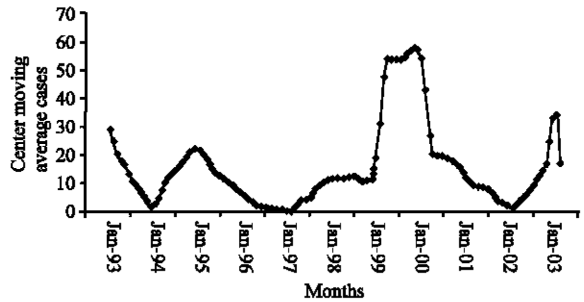

Fig. 1: Centered moving averages of haemorrhagic septicaemia mortalities between 1993 and 2003

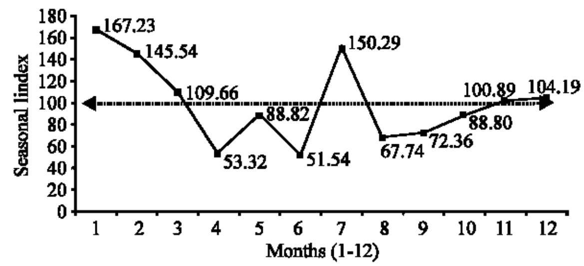

Fig. 2: Monthly adjusted seasonal indices above 100 and below 100 indicated that seasonality was higher or lower than the usual for the relevant months for haemorrhagic septicaemia mortalities between 1993 and 2003

month, respectively. The seasonal indices were lower than usual for April, May, June, August and September, i.e., 46.7, 11.2, 48.5, 32.3, 27.6 and 11.9% below than the average for each month, respectively.

The monthly adjusted seasonal indices are presented in Fig. 2. The seasonal indices over the year showed a slight upward trend from August to December and a downward from January until April. The distribution of the monthly seasonal indices, average seasonal indices and adjusted seasonal indices are shown in Table 2 over the 11-year study period (1993-2003).

Secular trend and cyclic fluctuations: There was an upward linear trend observed in the mortalities of HS over the 11-year period. The 2003 values seemed to be substantially higher than the 1993 values. The distribution of the original data set, secular trend and cyclic fluctuations are shown in Fig. 3. There was also an upward linear trend observed in the mortalities of HS in Terengganu, Perak and Kelantan from 1999-2003. The original data also showed the upward linear trend in the monthly rainfall over the 11 years of study.

Over the 11 years (1993-2003), cyclic patterns of HS occurrences were observed at 2-3 year intervals. Major peaks of HS mortalities were observed from November

Table 1: Total number of haemorrhagic septicaemia mortalities from January 1993 to December 1993 in peninsular Malaysia

Months \Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Total
January	44	0	42	12	0	8	0	233	0	11	03	50
February	51	0	0	29	0	23	0	171	0	0	02	74
March	69	8	72	0	0	0	0	3	0	0	0	152
April	2	0	0	0	0	0	0	7	20	0	0	29
May	27	0	0	0	1	0	0	28	11	0	39	106
June	53	0	0	0	0	0	0	1	3	0	0	57
July	0	0	0	0	0	44	0	0	49	0	0	93
August	0	0	0	0	0	0	0	0	0	0	0	0
September	0	0	35	0	0	0	0	3	6	0	41	85
October	0	0	0	0	0	11	0	0	0	0	157	168
November	0	0	13	0	0	0	73	0	0	0	0	86
December	0	0	9	0	0	0	74	0	6	0	0	89
Total	246	8	171	41	1	86	147	446	95	11	237	1489

Table 2: Distribution of monthly ratio, unadjusted seasonal indices (mean season indices for each month) and adjusted seasonal indices between January 1993 and December 2003

	Monthly ratio											
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1993							70.82	81.86	100.47	115.13	123.1	153.26
1994	6.46	7.69	113.24	12.38	17.82	31.8	22.31	12.66	7.86	5.7	5.2	004.78
1995	277.21	87.52	393.9	70.28	66.73	64.14	66.86	68.92	189.86	94.21	91.4	067.57
1996	96.63	251.84	35.08	42.85	47.96	52.62	59.27	84.06	125.54	139.83	155.04	173.97
1197	4.74	5.68	7.07	9.38	174.17	27.04	16.44	4.52	2.65	2.21	1.92	001.7
1998	116.9	256.45	7500	69.54	64.83	61.54	362.92	60.49	61.72	91.36	57.53	055.64
1999	104.03	114.87	110.48	107.92	86.6	62.27	38.7	25.81	22.81	23.07	136.37	137.75
2000	429.19	303.38	5.26	12.14	48.94	1.85	86.01	138.1	14.85	184.55	193.31	199.8
2001	33.53	34.96	37.31	13.06	81.37	27.43	498.45	65.67	64.29	71.02	74.91	074.28
2002	183.72	24.5	27.77	32.03	38.13	46.66	43.3	28.1	19	14.35	10.47	008.25
2003	155.22	138.18	117.928	79.251	121.09	58.47						
USI	140.76	122.51	92.30	44.88	74.76	43.38	126.51	57.02	60.91	74.14	84.93	87.70
ASI	167.23	145.54	109.66	53.32	88.82	51.54	150.29	67.74	72.36	88.08	100.89	104.19

Unadjusted Seasonal Indices (USI) = mean seasonal indices for each month, common factors= 1200 ÷Sum of 12 months USI, i.e. 1200÷1009.803 = 1.188, Adjusted seasonal indices (ASI) = USI for each months × 1.188

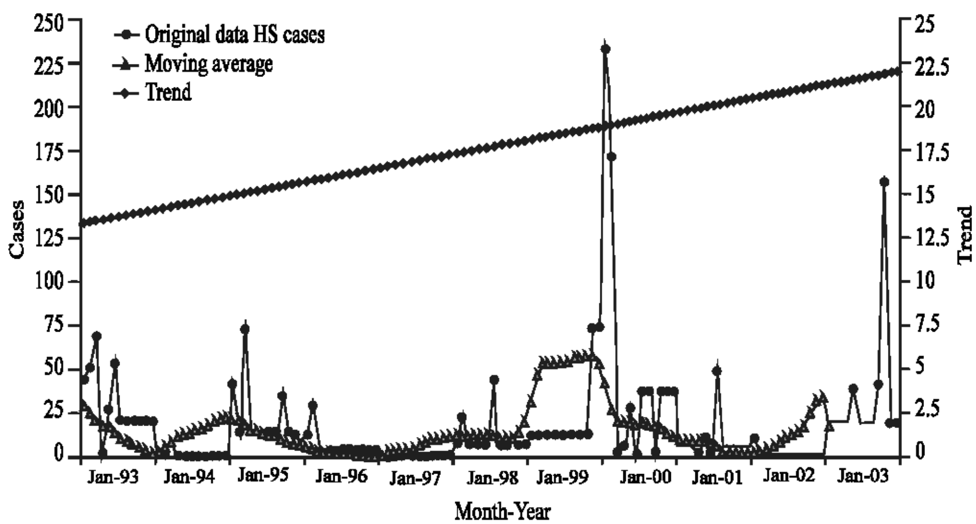

Fig. 3: The original data set, 12-month centered moving average and trend line of HS mortalities from 1993-2003 in Peninsular Malaysia

1998 to May 2000. The other peaks observed were in the years 1994-1996, 1997-1999, 2000-2001 and 2002-2003. The distribution cyclic fluctuations are shown in Fig. 4.

Temporal pattern of outbreaks: For the 11 years of study, year 2000 had the highest number of HS occurrence followed by 1993, 2003, 1995, 1999, 1998, 2001 and 1996. There was only one case each in 1994, 1997 and 2002. With respect to mean monthly occurrence of HS mortalities, January had the highest HS occurrence (32) followed by February (25), October (15), March (14) and May (10). July, September, November and December had

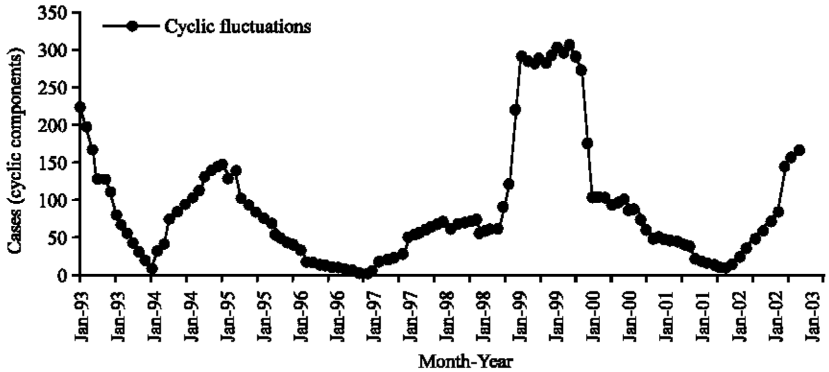

Fig. 4: The cyclic patterns showing major and minor peaks of HS mortalities in Peninsular Malaysia from 1993-2003

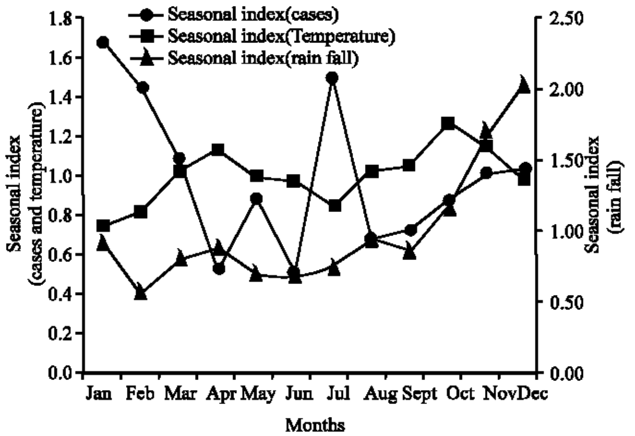

Fig. 5: Comparison of seasonal patterns between HS mortalities with seasonal patterns of rainfall and temperature from 1993 to 2003 in Peninsular Malaysia

8 mean monthly mortalities, whereas there was no HS recorded in August. With respect to quarterly occurrence of HS mortalities, the 1st quarter of the year had the highest occurrence of HS mortalities (24) followed by the 4th quarter (10). The 2nd and 3rd quarters (5 each) had the lowest occurrence.

Effects of the climatological factors on hs seasonal and cyclical fluctuations: The comparison between the seasonal indices for the HS and rainfall and seasonal indices for HS and temperature are shown in Fig. 5. There appeared to be a positive linear relationship in HS occurrences and rainfall during the late 3rd quarter and early 4th quarter of the year. However, there was a decline in temperature with the higher seasonal indices for HS mortalities. There was a decrease in the temperature from April to July with an increase in the number of mortalities. There was also a decrease in the temperature from November to February with an increase in the number of the HS mortalities. The relationship between rainfall and temperature with the total number of HS mortalities appeared more prominent during the 1st and 4th quarter of the year. However, this appeared to be not true during the 2nd and 3rd quarter of the year, where the independent t-test for HS mortalities (F=10.7; p= .033) and rainfall (F = 52.2; p = .000) was significant and the corresponding t values for temperature (F = 7.7; p =.683) was not significant. The mean HS mortalities and rainfall differed significantly between north-west and south-east monsoon but not the mean temperature. However, there was a decline in temperature with high number of mortalities.

Variations in the livestock population and vaccination coverage: During the study period, the variation in the cattle and buffalo populations was very small. The buffalo population showed a decreasing trend from 1993 until 2001. The cattle population decreased from the year 1993-1997 but showed an increasing trend from 1998-2003. The ratio between the buffalo and cattle was 1:2.1 in 1981 but drastically increased to 1:4.1 in 1993 and 1:4.7 in 2003. This indicated a decreased trend in the buffalo population compared to cattle. The mean cattle and buffalo population for the study period was 722,985 and 156,989, respectively[12].

Vaccination coverage was low. Over the past decade (1993-2003), particularly low vaccination coverage of 2.2, 7.1, 1.0, 7.9, 4.5, 2.2 and 5.8% were observed in 1997, 1998, 1999, 2000, 2001, 2002 and 2003, respectively. The highest vaccination coverage was 13.6% in 1995 over the 11-year study period.

DISCUSSION

The time-series seasonal decomposition analysis allowed evaluation of the trend, seasonal, cyclical and temporal patterns of the HS mortality occurrence in

Peninsular Malaysia from 1993-2003. The relationship between the temporal patterns of the HS mortalities and the temporal patterns of the rainfall and temperature could also be evaluated. This technique provided a basis for removing the irregularities in the data for a clearer picture of the epidemiological patterns of the HS occurrence, as described by Eduardo Alvarez Peralta *et al.*[7] for FMD and Courtin *et al.*[15] for rabies. The time-series analysis has been useful as an analytical tool for understanding the temporal patterns of the infectious diseases[6].

Seasonal fluctuation in time-series analysis refers to the short-term monthly or quarterly variations, which fluctuates around a seasonal index of 100. In this study, the monthly and quarterly seasonal indices were observed to be relatively higher during the months of 1st and 4th quarters of the year compared to the months of 2nd and 3rd quarters. The most likely explanation for these high seasonal indices of the HS might be related to the climatic changes, vaccination and animal movement activities.

The seasonal indices were higher during the wet months (October to March) as compared to the dry months (April to September). The seasonality appeared to be significantly associated with high rainfall during north-east monsoon and less associated during south-west monsoon ($p<.05$). The seasonal variation of the HS occurrence was consistent with the observation reported by Dutta *et al.*[16]. The occurrence of HS was observed to be greater during the monsoon season(2,3).

The HS mortality that occurred during the dry season appeared to be contained and less number of mortalities was observed as compared to the mortality that occurred during the 1st and 4th quarters of the year. This is in an agreement with the findings of De Alwis and Vipulasiri [17] and De Alwis[18]. Thus, there seemed to be a strong relationship between the seasonal patterns of the rainfall and the HS mortality.

The seasonal variations appeared to have a relation with vaccination because vaccination has usually been conducted during the outbreaks of the disease. The animals need to be assembled at one place in order to administer the vaccination. In such situations, animals from the neighboring farms are brought and herded together with the susceptible animals and hence, it increases the chances of HS mortality. The influence of the HS occurrence due to the movement of the field personnel and susceptible/carrier animals during the vaccination program cannot be ruled out. Therefore, we speculated that the HS dissemination and consequent mortality would be more likely to occur during the months of vaccination.

Furthermore, a higher number of the HS mortality in the 1st and 4th quarters was probably due to the movement of the animals to fulfill a higher than usual demand for meat during the festive months where the supply from the level of beef production(1) in the country is not sufficient to meet. During the past decade, the Muslim Eid Celebration fell during the 1st and 4th quarters of the year. HS mortality was also observed to occur more during April and May, the months with the highest average monthly temperature in most places in Peninsular Malaysia, while June and July were the driest months of the year[18]. The heat and dryness could precipitate stress and made the animals to be more prone to succumb to HS[21]. Heat stress is a common occurrence during the summer season and can lead to poor growth, illness and even death in animals. Summer heat stress is a major contributing factor to reproductive health[19]. However, related studies have not been conducted in the case of the HS mortality. Thus, in this study, we speculated that heat and dryness has probably played important roles in causing HS during the dry period

Cyclic trends were associated with regular and periodic fluctuations in the level of disease occurrence. The cyclic patterns may produce a regular and predictable cyclic fluctuation[20]. In this study, there was a 2- to 3-year cycle in HS deaths occurring over the 11-year study. These cycles were probably related to the time taken for the susceptible population to reach the threshold level (23), similar to the 3- to 4-year cycles in foot and mouth disease occurrence[7].

Malaysia received a higher rainfall in 2000 as the La Nina event started in June 1998 and it continued until 2000[18]. The time-series analysis of the mean annual temperatures indicated that the temperature has been increasing since the mid-70s'[18]. There was a slight increase in the temperature in 2000 after recording much lower temperature in 1999 followed by extremely high temperatures in 1998. Thus, the fluctuation in temperature together with rainfall coincided with the major peak of the HS deaths from December 1998 to May 2000.

The highest number of HS mortalities from December 1998 to May 2000 was probably due to the disturbed movements of the animals and the adjustments in the livestock industry that took place during the outbreaks of Nipah virus infection in Malaysia where more than 1 million pigs were culled. Efforts that were made on eradicating the pig disease would have resulted in negative impact on other disease situations including the HS[21].

The other minor cyclic pattern of the 2- to 3-year duration in the HS mortalities could be due to the continuous low vaccination coverage over the years. There was a tendency of the farmers to only have their animals vaccinated during HS outbreaks but not during the years after the outbreaks. Therefore, these animals (especially the newborn and the new animals which were brought to the vicinity) become more susceptible.

In this study, there was an upward linear trend in the HS mortalities over the past 11 years in Peninsular Malaysia. There was also a significant upward linear trend observed in the HS mortalities in the endemic states such as Terengganu, Perak and Kelantan from 1999 to 2003. The upward trend might be due to the greater number of the recent HS outbreaks in last 5 years (1999-2003), mainly in 2000 and 2003. The upward linear trend could also be due to the continuous low vaccination coverage during the last 5 years.

Other factors such as illegal movement of the animals, the decreased buffalo population (although very small[12] and the current extensive to semi-extensive livestock management system might also explain the upward linear trend, since HS occurrence has been associated with poor and primitive management systems[3].

CONCLUSION

It is concluded that the time-series seasonal decomposition technique successfully provided a clearer picture of the seasonal, cyclic and trend patterns of the HS occurrence in Peninsular Malaysia. The major and minor peaks of the HS occurrence were observed during the 11-year study period. The major outbreaks mainly were believed to be due to the low vaccination coverage. Furthermore, these findings suggested that HS would be expected to occur in the 1st and 4th quarters of the year and that an appropriate control regime is to vaccinate the animals early in 3rd quarter of the year. The trend pattern of the HS occurrence indicated that the HS outbreak would continue to persist if the circumstances remained the same over the coming years. Furthermore, time series seasonal decomposition technique may be useful to those who are working in the planning and controlling strategy for HS or any other animal health programs.

ACKNOWLEDGMENT

The authors would like to thank the Department of Veterinary Services, Malaysia for providing the data and information. The authors would also like to thank the Meteorological Center, Malaysia for their kind assistance in climatological data collection. The project was partly sponsored by International Foundation for Science (No. 3/3300-1) and Top-down IRPA Project (No. 01-02-04-007 BTK/ER/025).

REFERENCES

1. Bain, R.V.S., M.C.L. De Alwis, G.R. Carter and B.K. Gupta, 1982. Haemorrhagic septicaemia. FAO Animal Production and Health FAO Rome.
2. OIE Publication, 2005. Haemorrhagic septicaemia. In: Manual of Standard Diagnostic Test and Vaccines for Terrestrial Animals, Chapter 2.3.12: 1-29. Rome: Office Internationale de Epizooties
3. De Alwis, M.C.L., 1999. Haemorrhagic septicaemia. ACIAR Monograph Canberra, Australian Centre for International Agricultural Research.
4. Saharee, A.A., 1992. Epidemiology and pathogenesis of haemorrhagic septicaemia in Peninsular Malaysia, (Unpublished Ph.D. theses), Faculty of Veterinary Medicine, Universiti Putra Malaysia.
5. Childs, J.E., T. Aaron, M.E. Curns, L.A. Dey, L.F. Real, N.B. Ottar and W.K. John, 1997. Predicting the local dynamics of epizootic rabies among raccoons in the United States. Proceeding of National Academy of Sciences of United State of America, 25: 13666-13671.
6. Curk, A. and T.E. Carpenter, 1994. Efficacy of the first oral vaccination against fox rabies in Slovenia. Scientific and Technical Review. Office International des Epizooties, 13: 763-775.
7. Peralta, E.A., T.E. Carpenter and T.B. Farver, 1982. The application of time series analysis to determine the pattern of foot-and-mouth disease in cattle in Paraguay. -where the reference citation????
8. De Alwis, M.C.L., 1981. Mortality among cattle and buffaloes in Sri Lanka due to haemorrhagic septicaemia, Tropic. Anim. Health Produc., 13: 195-202.
9. Saharee, A.A. and S. Chandrasekaran, 1986. Haemorrhagic septicaemia in cattle and buffaloes in Malaysia. Livestock production and diseases. Proceeding of the 5th Conference for Institute of Tropical Veterinary Medicine, Kuala Lumpur Malaysia.
10. Phoung, P.T., 1993. Vietnam. In: Patten, B.E., Spencer, T.L., Johnson, R.B., D. Hoffmann, and L. Lehane, (Eds.), Pasteurellosis in Production Animals. Australian Centre for Intl. Agric. Res. Proceedings, 43: 240-242.
11. Kral, K., M. Maclean and S. San, 1993. Cambodia. In: Patten, B.E., Spencer, T.L., Johnson, R.B., Hoffmann, D. and Lehane, L. (Eds), Pasteurellosis in Production Animals. Australian Centre for International Agricultural Research Proceedings, Canberra, Australia, 43: 246-248.

12. Food and Agricultural Organisation (FAO), 2004. Agriculture data FAOSTAT. http.www. apps.fao.org/faostat/collection accessed on 12/04/05.
13. Makridakis, S. and S.C. Wheelwright, (5th Edn.), 1972. In: Forecasting Methods for Management, John Wiley and Sons. New York. Chichster. Brisbane. Toronto. Singapore.
14. Lapin, L.L., 1978. Statistics for Modern Business Decisions. Harcourt Brace Jovanovich, New York, NY, 778.
15. Courtin, F., T.E. Carpenter, R.D. Paskin and B.B. Chomel, 2000. Temporal patterns of domestic and wildlife rabies in central Namibia stock-ranching area, 1986-1996. Preventive Vet. Med., 43: 13-28.
16. Dutta, J.R., E.A. Mullick, R. Singh and G.C. Sharma, 1990. Epidemiological studies on occurrence of haemorrhagic septicemia. Ind. Vet. J., 67: 893-899.
17. De Alwis, M.C.L. and A.A. Vipulasiri, 1980. An epizootiological study of haemorrhagic septicaemia in buffaloes and cattle in Sri Lanka, Ceylon Vet. J., 28: 24-35.
18. Meteorological Center, Climatological Division, 2003. Meteorological Center Malaysia.
19. Thompson, J.A., D.D. Magee, M.A. Tomaszewski D.L. Wilks and R.H. Fourdraine, 1996. Management of summer infertility in Texas Holstein dairy cattle. Theriogenol., 46: 547-558.
20. Thrusfield, M., 2000. Patterns of Disease. In: Veterinary Epidemiology, 2nd Edn). Butterworth and Co. (Publisher) Ltd. and Blackwell Science Ltd. University Press, Cambridge, UK.
21. Kamarudin, M.I., 2005. Haemorrhagic septicaemia: Eradication is a possibility. In: Towardsan alternative control of haemorrhagic septicaemia. Regional Symposium on Haemorrhagic Septicaemia 2005, 1st-2nd December 2005. Putrajaya, Malaysia.