Temporal series analyses in equine infectious anemia cases in the State of Rio de Janeiro, Brazil, 2007 to 2011*

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ABSTRACT. Baptista D.Q., Bruhn F.R.P., da Rocha C.M.B.M., Torres F.C., Machado E.D., Sáfadi T. & Pereira S.M. **Temporal series analyses in equine infectious anemia cases in the State of Rio de Janeiro, Brazil, 2007 to 2011.** [Análise de series temporais dos casos de anemia infecciosa equina no estado do Rio de Janeiro, Brasil, 2007 a 2011.] *Revista Brasileira de Medicina Veterinária, 38(4):431-438, 2016*. Coordenadoria de Defesa Sanitária Animal, Secretaria de Estado de agricultura, Pecuária, Pesca e Abastecimento, Alameda São Boaventura, n° 770, Fonseca, Niterói, RJ 24120-191. E-mail: daniqb@yahoo.com

Equine Infectious Anemia (EIA) is a disease caused by a cosmopolitan infection of which the etiological agent is the *Lentivirus*, which reaches equines in general. This paper presents the results of a survey of the EIA in the State of Rio de Janeiro, Brazil, by means of a temporal series from 2007 to 2011. In addition, was estimating a model of case occurrences in subsequent years. The occurrence of EIA in the State is low (0.43%), with the highest occurrence being in 2007 (0.63%). The Livestock Defense Regionals (LDRs) that had the highest prevalence of this disease were Rio de Janeiro, Niterói, Cordeiro and Tres Rios, however, the LDRs, such as Barra Mansa, Itaocara and Campos dos Goytacazes had the lowest number of tests performed, thus presenting the lowest prevalence values. This disease is still considered endemic in the state of Rio de Janeiro. The prevision analysis indicates an approximate prediction ($p<0.01$) of the real observation of the number of EIA cases in the State of Rio de Janeiro in the year of 2011, thus constituting an important tool for planning the control and eradication of EIA.

KEYWORDS. Animal Health Defense, epidemiology, case survey, prediction.

RESUMO. Anemia Infecciosa Equina (AIE) é uma doença causada por infecção cosmopolita cujo agente etiológico é um *Lentivirus* que atinge os equídeos em geral. Esse trabalho tem como objetivos fazer um levantamento da AIE no Estado do Rio de Janeiro por meio de uma série temporal de

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2007 a 2011, alem de estimar um modelo para ocorrência dos casos em anos subsequentes, fornecendo informações aos profissionais da área, para que medidas sanitárias mais eficazes possam ser adotadas no controle e erradicação. A ocorrência da AIE no Estado é baixa (0,43%), sendo a maior (0,63%) no ano de 2007. As Regionais que apresentaram maior prevalência da doença foram Rio de Janeiro, Niterói, Cordeiro e Três Rios. As Regionais de Barra Mansa, Itaocara e Campos dos Goytacazes, obtiveram o menor número de exames realizados, assim como apresentaram os menores valores de prevalência da doença. A enfermidade é endêmica no Estado do Rio de Janeiro. A análise de previsão indica uma predição aproximada (p<0,01) da observação real no numero de casos de AIE no Rio de Janeiro no ano de 2011, constituindo assim uma importante ferramenta para o planejamento de ações de controle e erradicação da AIE no estado.

PALAVRAS-CHAVE. Defesa Sanitária Animal, epidemiologia, levantamento de casos, previsão.

INTRODUCTION

According to the World Organization for Animal Health, the equine herd in Brazil was of 7,908,215 animals in 2011, 237,311 only in the state of Rio de Janeiro (Oie 2013). In constant expansion in the agribusiness, the market for national equidae is directly linked to leisure, culture and tourism, among others. Thus, the Equine Infectious Anemia (EIA) becomes an obstacle for the growth of horse breeding.

EIA is caused by a cosmopolitan infection of which the etiological agent is a *Lentivirus,* which reaches equines in general (Guimarães et al. 2011). Its distribution is worldwide, with the exception of only the Antarctic continent. It is transmitted especially through hematophagous insects (*Tabanus* spp. and *Stomoxys calcitrans*), but the iatrogenic infection may also occur through needles, contaminated surgical instruments, blood transfusions and improperly sterilized equipment. It is most common in the hottest periods of the year, such as summer, and in humid and marshy regions. The disease may clinically range from an asymptomatic to a fatal manner (Franco & Paes 2011), also possibly occurring recurrent fever episodes, weight loss, lethargy, inappetence, depression, oedemas and anemia.

For irreversibly compromising equine performance and being transmittable and incurable, the EIA causes great damage to the animal owners, in addition to preventing the access of the animals to the international market (Almeida et al. 2006). Thus, epidemiological studies of this disease are fundamental to the success of horse breeding in whatever country or region. There are few data on the occurrence of EIA in the State of Rio de Janeiro, that each day it becomes more common in the daily life of Animal Sanitary Defense. Thus, studies which outline the profile related to the prevalence of this disease are important for aiding in directing resources and, consequently, creating a more effective control.

Temporal series analyses are a useful tool, though there is no standardization in using different techniques to construct models and interpreting them. Although case distribution and the analysis of correlograms aid in the estimation, many techniques are available for the diagnostics of the most adequate model, such as the different information criteria and statistical tests, leading the researcher to different possibilities of choosing the model most adequate for the objectives of the study (Otero et al. 2001). In the present work we aimed at describing the prevalence of EIA in different regionals which comprise the agriculture and livestock defense system of the state of Rio de Janeiro, between 2007 and 2011, by means of temporal series, in addition to estimating the occurrence for subsequent years, providing a wider view of the infirmity occurrence to professionals in this area, in order to adopt more effective sanitary measures for its control and eradication.

MATERIALS AND METHODS

Study location

A survey on the occurrence of Equine Infectious Anemia between the years of 2007 and 2011 was performed, from data of official bulletins from the Ministério da Agricultura, Pecuária e Abastecimento (MAPA), among the seven regionals which comprise the agriculture and livestock defense system organization of the State of Rio de Janeiro (Figure 1).

Seropositive diagnostics

We used the agar-gel immune-diffusion test (AGID) as a means for the EIA diagnostics, which is the method globally recommended for detecting the disease (Oie 2008). The AGID technique is described in the MAPA administrative measure n: 84, from October 19th, 1992 (Brasil 1992) and the laboratory accreditation procedures are found in the MAPA Normative Instruction n: 01 from January 16th, 2007 (Brasil 2007). The diagnostics are performed by the laboratories accredited by the MAPA which are distributed in all of the state (Oie 2008).

Statistical analyses

Descriptive statistical analyses were done on the 223,968 exams for EIA diagnostics performed in Rio de

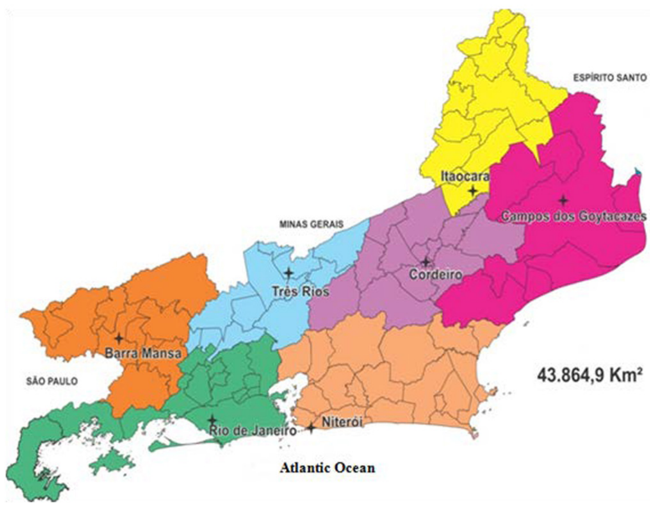

Figure 1. Map with the regional divisions of the agriculture and livestock defense of the state of Rio de Janeiro, Brazil, 2011

Janeiro between 2007 and 2011. For this same period, we constructed a temporal series model in order to evaluate disease cases in equines.

In a temporal series analysis we modeled the studies phenomenon in order to, then, describe the behavior of the series and make estimates. To adapt the models it is necessary to verify the adjustment of the data to a few assumptions needed for applying this technique. Thus, before conducting any analyses it is important to define if the series is stationary, to later establish the structure of the model which will adjust to the series' data. A series is considered stationary when its observations occur randomly around a constant mean, that is, there is no tendency or seasonality (Latorre & Cardoso 2011). For the evaluation of the seasonality, we may observe the autocorrelation function (FAC) since, when there is no seasonality, the sample autocorrelations decrease very slowly (Otero et al. 2001). In addition, we may apply the Dickey-Fuller unitary root test (Dickey & Fuller 1979), in order to determine the seasonality of the series. This test presents as null hypothesis the presence of unitary root in the temporal series of the analyzed series (Margarido & Medeiros Junior 2006).

Among the different types of temporal series models, the most simple is obtained for the seasonal series. This class of models is known as autoregressive models – AR (p order) or of moving averages – MA (q order). This is an interactive process in which we identify the p or q order through the autocorrelation or the partial autocorrelation function, from which we estimate a prediction model as well as analyze estimate residue and errors (Latorre & Cardoso 2001).

In addition to the seasonality, it is important to verify the existence of significant correlations between the observations and, consequently, the need to adjust the series model. In order to do this, instead of observing the residual autocorrelations individually, we may test if a group of autocorrelations is significantly different from zero by means of the Q statistics. For ARMA (autoregressive and moving averages) models, such as those applied in this study, Box & Jenkins (1970) suggested the use of the Box-Pierce test. In this test, elevated values for Q indicate that at least one correlation among the observations is different from zero and, therefore, a temporal series model must be adjusted to the data before performing the prediction (Ehlers 2009).

After adjusting possible series models, choosing the best model must be done based on a series of criteria. Thus, a model is considered good when it uses a smaller number of parameters in the modeling process, observed in the autocorrelation and partial autocorrelation functions of the correlogram, as well as low values for the Akaike (AIC), Hannan-Quinn and Schwartz Bayesian information criteria. To perform the predictions, it is also important to consider the model which resulted in more precise estimates, based on the evaluation of the errors associated to the series prediction for the subsequent years, such as through the value of the mean absolute percentage error (MAPE) and Theil *U* (Otero et al. 2001, Morettin & Toloi 2006, Ehlers 2009).

Thus, in the present study, we initially analyzed the seasonality of the data by observing the autocorrelation function, as well as the Dickey-Fuller test, considering a $p<0.05$ value. After verifying the seasonality of the data and adjusting possible temporal series models, the estimation of the most adequate model was based on the analysis of residue through the Box-Pierce test, on the lowest values for the Akaike (AIC), Hannan-Quinn and Schwartz Bayesian information criteria. In addition, we considered the mean absolute percentage error (MAPE), associated to the possible temporal series models adjusted for the prediction.

The noting used in this article was MA (q) and AR (p), in which q and p are the statistically significant parameters ($p<0.05$) considered in the model with a smaller number of parameters found.

With the model chosen for the series, we performed predictions for the year of 2011 based on the temporal series of January of 2007 to December of 2010. For the evaluation of the prediction performance of this model, we compared the real values to those predicted and its confidence interval of 95% (CI 95%), as well as used the Theil *U* statistics to evaluate the errors associated to the predictions in 2011.

RESULTS

In relation to the Exams for Equine Infectious Anemia between the years of 2007 and 2011 in agriculture and Livestock Defense Regionals (LDRs) in the State of Rio de Janeiro, Brazil, was observed that Barra Mansa, Itaocara and Campos dos Goytacazes regional presented the smallest number of exams performed (Table 1), as well as the smallest prevalence along the years (Table 2). In addition, we may observe that the LDRs with the highest number of exams performed were Três Rios, Niterói, Rio de

Janeiro and Cordeiro (Table 1), which present variable and even higher prevalence values then the other three LDRs (Table 2).

The prevalence of EIA in the State is low. We verified a decreasing prevalence along the years, with general prevalence of 0.43%, and the highest value being of 0.63% in 2007 (Table 2). In addition, all the Regionals presented fluctuating cases of the disease, which demonstrates regularity between 2007 and 2011, with the exception of the Itaocara LDR in 2011.

Figure 2 demonstrates the correlogram of the series of EIA cases in Rio de Janeiro with the autocorrelation functions (FAC) and the partial autocorrelation function (FACP). Despite of the apparent seasonality pattern observed in the correlogram, we verified the seasonality of the series by the Dickey-Fuller test. This indicates that the seasonality was not statistically significant, in regard to the *lags* being found inside the confidence interval at 95% (CI 95%). Though this correlogram it was possible to verify an autocorrelation different from zero in the 1, 5, 6 and 7 (FAC) and 1 and 5 (FACP) *lags*.

After estimating and evaluating the many possible models based on autocorrelation and partial autocorrelation functions, we considered the incomplete AR (5) most adequate, with constant p<0.01, since it presents the lowest values in the Akaike (AIC), Hannan-Quinn and Schwartz Bayesian information criteria (Table 3).

Figure 3 shows the residue correlogram verified after the adjustment of the incomplete AR (5) model. In this correlogram it is possible to verify the value observed inside the CI 95%, which confirms the result of the Box-Pierce test, that is, the model was well adjusted to the data.

Table 1. Exams for Equine Infectious Anemia between the years of 2007 and 2011 in agriculture and livestock defense regionals in the state of Rio de Janeiro, Brazil.

Regional	Exams Performed					
	2007	2008	2009	2010	2011	Total
Barra Mansa	3.133	2.821	3.546	3.459	3.358	16.317
Três Rios	7.177	7.996	6.536	8.846	7.960	38.515
Itaocara	1.945	1.744	3.252	2.004	2.016	10.961
Campos dos Goytacazes	4.122	3.417	3.818	4.785	4.902	21.044
Niterói	5.978	6.130	7.454	7.110	9.991	36.663
Rio de Janeiro	10.313	12.343	13.469	14.045	14.328	64.498
Cordeiro	5.640	6.251	7.566	8.005	8.508	35.970
Total	38.308	40.702	45.641	48.254	51.063	223.968

Table 2. Prevalence of Equine Infectious Anemia in the Agriculture and Livestock Defense Regionals in the state of Rio de Janeiro, between the years of 2007 and 2011.

Regional	Prevalence % (no of seropositives)					
	2007	2008	2009	2010	2011	Total
Barra Mansa	0,29(9)	0,42(12)	0,25(9)	0,2(7)	0,15(5)	0,26(42)
Três Rios	0,99(71)	0,56(45)	0,6(39)	0,58(51)	0,39(31)	0,62(237)
Itaocara	0,1(2)	0,11(2)	0,03(1)	0,05(1)	0(0)	0,06(6)
Campos dos Goytacazes	0,7(29)	0,47(16)	0,16(6)	0,12(6)	0,06(3)	0,30(60)
Niterói	0,74(44)	0,59(36)	0,29(21)	0,58(41)	0,46(46)	0,53(188)
Rio de Janeiro	0,68(70)	0,39(48)	0,69(93)	0,49(69)	0,77(111)	0,60(391)
Cordeiro	0,92(52)	0,33(21)	0,45(34)	0,87(70)	0,48(41)	0,61(218)
Total	0,63(277)	0,41(180)	0,35(203)	0,41(245)	0,33(237)	0,43(1142)

Table 3. Results of monthly parameters of equine infectious anemia (EIA) in Rio de Janeiro, Brazil, 2007 to 2011, using autoregressive (AR) temporal series models and moving averages (MA).

Parameters	Models*					
	AR (5)		MA (5)		MA (7)	
	Estimate	p	Estimate	p	Estimate	P
Phi 1	0,2492	0,03	-	-	-	-
Phi 5	-0,3234	<0,01	-	-	-	-
Theta 5	-	-	-0,3543	<0,01	-	-
Theta 6	-	-	-	-	-0,2524	0,057
Constant	19,2455	<0,01	19,1368	<0,01	18,9873	<0,01
Akaike Criteria	475,1774	477,5045	481,7684			
Hannan-Quinn Criteria	478,4542	479,9621	484,2261			
Schwartz Criteria	483,5548	483,7875	488,0515			

*models initially adjusted according to the significant *lags* (p<0,05) observed on the Autocorrelation Function (1, 5, 6 e 7) and on the Partial Autocorrelation Function (1 e 5) of the correlogram; white noise by the Box-Pierce test

After adjusting the model, it was possible to compare the original data of the series in the prediction analysis with predicted values. In table 4 we present the original and predicted values of

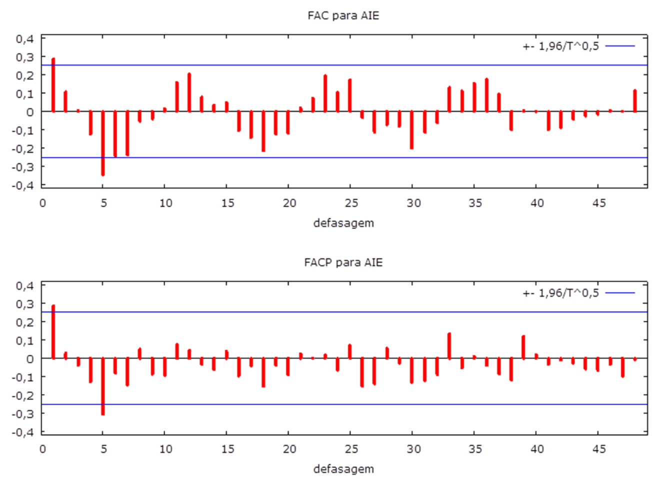

Figure 2. Correlogram with the autocorrelation functions (FAC) and the partial autocorrelation function (FACP) of the series of Equine Infectious Anemia cases in Rio de Janeiro, 2007 to 2011

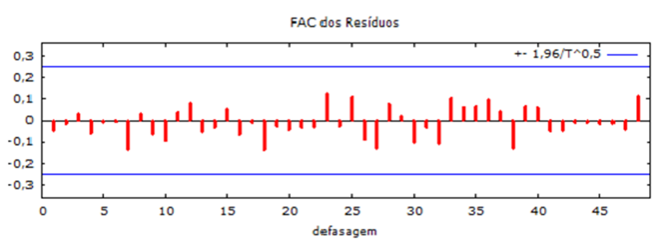

Figure 3. Residue correlogram of the incomplete autoregressive AR (5) model adjusted to the equine infectious anemia cases in the state of Rio de Janeiro, Brazil, 2007 to 2011, with a confidence interval of 95%

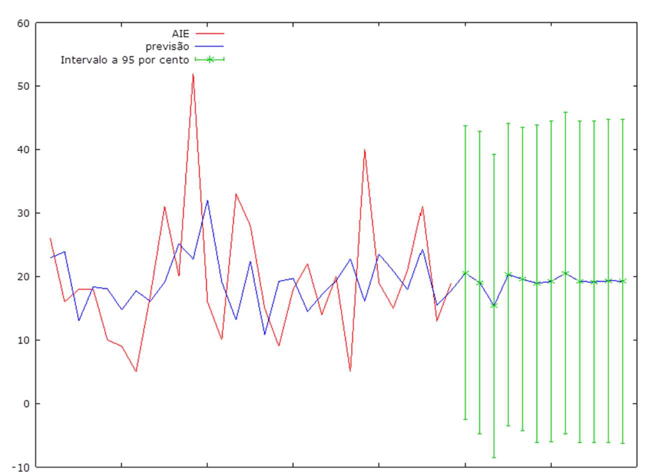

Figure 4. Distribution of the original series of monthly cases of Equine Infectious Anemia in Rio de Janeiro, Brazil, 2007 to 2011, and predicted values for 2012 with a confidence interval, after adjusting the incomplete autoregressive AR (5) model

Table 4. Comparison of the seropositive values of equine infectious anemia (EIA) virus, real and estimated by the incomplete autoregressive AR (5) model, in the state of Rio de Janeiro, Brazil.

Year of 2011	Real values in 2011	Predicted values in 2011[1]	Prediction error (%)[2]	CI (95%)
January	18	18,96	5,33	5,14-43,06
February	22	14,55	33,86	10,61-39,72
March	14	14,84	6,00	10,42-40,10
April	20	19,10	4,50	6,17-44,37
May	5	22,32	346,4	2,95-47,59
June	40	20,08	49,80	6,33-46,5
July	19	20,82	9,58	6,00-47,64
August	15	20,96	39,73	5,95-47,86
September	21	19,62	5,10	7,29-46,54
October	31	18,19	5,50	8,73-45,11
November	13	18,48	42,15	8,54-45,50
December	19	18,32	3,58	8,79-45,44

[1]Predicted values based on a temporal series of EIA cases between 2007 and 2010

[2][(real value – predicted value)/real value] *100; Mean absolute percentage error (MAPE) of the prediction model = 45,96%

the series, which allows us to have an approximate prediction of the real observation in the number of EIA cases in Rio de Janeiro in the year of 2011. In addition, we verified that the Theil *U* statistics presented a value of 0.60, which indicates that the prediction errors tend to be small, allowing us to consider good adjustments of the prediction models (Ehlers 2009) and confirms the possibility of using this technique in this type of study. In regard to the MAPE, the incomplete AR (5) model presented the smallest error (45.96%) in relation to other possible models, with adequate adjutments (white noise) by the Box-Pierce test, such as the incomplete MA (5) (66.4%).

Figure 4 shows the series of EIA cases between 2007 and 2011 in the state of Rio de Janeiro with the estimated predictions of cases in 2012.

DISCUSSION

Barra Mansa, Itaocara and Campos dos Goytacazes regionals presented the smallest number of exams performed (Table 1), as well as the smallest prevalence in relation to the other regionals along the years (Table 2). An explanation is that, in these regions, horse breeding is less present. Another aspect to consider is that there are many traction animals which do not transit between properties and, generally, are not submitted to the diagnosis test, which means many exams are not performed in these regions.

We may observe that the Regionals with the highest number of exams performed are Três Rios, Niterói, Rio de Janeiro and Cordeiro (Table 1). In these regions there are large training centers and breeding farms, in which there is a higher concern in identifying and sacrificing the seropositive animals quickly (Almeida et al. 2006), which may have contribute for these results.

Martins et al. (2005), in a study on EIA in the Municipality of Teresópolis in the State of Rio de Janeiro, and adjacent, which include the LDRs of Três Rios and Cordeiro, quote a large economic importance of the horse activities of the region, such as: competitions, auctions, expositions, horseback trekking and commercial ends, reaffirming the need of a more effective control of the disease, which would decrease large economic losses. Guimarães et al. (2011) reports a high rate of seropositive animals in months in which agriculture and livestock expositions, *vaquejadas* (sport modality widespread in the Brazilian northeast) and horseback trekking are performed, that is, when there is agglomeration of animals and, consequently, the increase of exams performed. In Mossoró, state of Rio Grande do Norte, Brazil, Lage et al. (2007) observed that the sanitary management given to equines with the growth of events such as the *vaquejada* is quite deficient, especially in regard to the prevention and control of diseases.

There are important equestrian centers situated in the Rio de Janeiro LDR, such as the Jockey Club and the Sociedade Hípica Brasileira. Many animals which compete in these locations are hosted for resting or training in farms in the Região Serrana, which encompasses the Cordeiro and Três Rios LDR, forming an important route in controlling EIA. According to Almeida et al. (2006), locations in which are present specialized horse breeding farms present lower prevalence of EIA. However, the Três Rios, Niterói, Rio de Janeiro and Cordeiro LDRs cited before, present variable and even higher prevalence values then the other three Regionals (Table 2).

The Niterói and Rio de Janeiro Regionals, although hosting high valued animals, present large areas of poverty. In this case, the proprietors of errant animals, by disinformation and inadequate management, may contribute in maintaining the virus in these locations, despite the efforts of the large farmers. Santos et al. (2001), in their studies in the state of Acre, Brazil, found higher EIA frequencies in locations in which there is little access to the laboratorial diagnostics and to veterinarian assistance.

Considering that most disease bearer equines are asymptomatic, the presence of many horse lodgings (renting stalls) in the Três Rios and Cordeiro LDRs, which do not present Veterinarians responsible for the health of the herd, may represent a higher risk, especially by making it harder to control the disease.

In this study we may observe that the prevalence of EIA in the State of Rio de Janeiro is low. Pena et al. (2006), after collecting samples from 672 equines in properties in the State of Pará, Brazil, also found low disease prevalence (1.34%). More expressive values were reported by Almeida et al. (2006), in the state of Minas Gerais, Brazil, in 6,540 service equines and a low zootechnical value, with prevalence of up to 7.4%. Guimarães et al. (2011) verified, in 2009, while collecting samples from 2,257 equines in 68 municipalities in the south of the state of Bahia, Brazil, a prevalence of 5.9%. Santos et al. (2001), from data made available by the MAPA regarding the exams performed in the state of Acre between 1986 and 1996, observed a prevalence of 7.5%. However, even with highly variable prevalence values, it is noticeable that the EIA is widespread in different regions of the country.

Almeida et al. (2006) confirmed that EIA is endemic in Minas Gerais, since disease islands were detected in all studies stratum. With the similarity of the results found by these authors, we may affirm that the infirmity is also endemic in the state of Rio de Janeiro, since all the Regionals presented fluctuating cases of the disease, which demonstrates regularity between 2007 and 2011, with the exception of the Itaocara LDR in 2011.

In the present study, we observed that the total number of exams performed in the state increased sense 2007, however, the number of disease cases decreased along the years (Table 2). This is probably related to the intensification of the animal sanitary defense measures from 2007, after an established partnership with MAPA and the state's Sanitary Defense organs, attending to the Decree n: 5,741 of 03/30/2006, which institutes the Sistema Unificado de Atenção à Sanidade Agropecuária (SUASA) (Brasil 2006).

According to Helfenstein (1996), temporal series predictions are important for aiding health services while demonstrating the expected frequency of the diseases, thus improving the plans for resource distribution. This technique may also be used as complementary to the temporal series intervention analysis method, that is, a prediction obtained from the data before the intervention may be compared to the current data obtained after the intervention (Helfenstein 1996).

In the present study, it was possible to observe values close to the originals by means of the prediction analysis, although a few present a wide confidence interval. This demonstrates that this method may be used for future predictions, thus allowing better planning and intervention in animal sanitary defense services in controlling EIA. In addition, it allows us to know the expected number of disease cases in the next years, which leads to a better monitoring and planning of intervention strategies in controlling the disease in the state.

This study presents a methodological approach not yet performed in other similar epidemiologic studies on EIA, however, as observed in a work performed by Otero et al. (2001), who evaluated death cases by malnutrition in elderly people in São Paulo and Rio de Janeiro through the SARIMA models, it presents a few limitations which must be considered while discussing the results found. We must highlight, despite the width of the geographical space, since all the State of Rio de Janeiro was included in the analysis, that it is necessary to have caution in extrapolating to the rest of the country, because of demographic, cultural, political and socioeconomic differences. In addition, it is important to highlight that the profile reported here does not inform with accuracy the prevalence rate of EIA in the state, for it refers mainly to exams performed for the intra and interstate transit and/or participation in agriculture and livestock events. However, this methodological approach is important for elucidating the dynamics of the epidemiologic situation of the infirmity in the region.

Thus, we highlight that other works evaluating this type of series intervention, such as those caused after alterations in the legislation, with effect on a higher sensitivity to detecting cases, as well as temporal series of the number of equines put down in comparison to the number of EIA cases, are useful in planning and evaluating the quality of the animal sanitary defense services in Brazil.

CONCLUSIONS

Considering the importance of horse breeding in the State of Rio de Janeiro, where there are high zootechnical value animals, the elaboration of a well-structured plan of control and eradication of the disease is indispensable. In this sense, analyses of temporal series constitute an important tool for planning actions, for they allow us to predict future events from past data. In addition, there are many aspects to be adjusted in the control and eradication of EIA, not only regarding current legislation, but also in structuring agriculture and livestock defense organs in all the country.

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