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Original

Seasonality and Projected Economic Impact of Confiscation of Bovine Livers Infected with *Fasciola hepatica*

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ABSTRACT

Background: Fasciolosis is a zoonotic disease that causes economic losses through liver seizures and reduced production. Its transmission depends on environmental factors and on the intermediate host, requiring an integrated One Health approach for prevention and control. **Aim**. To evaluate the seasonality of the economic impact resulting from the seizure of bovine livers infected with *Fasciola hepatica* in Camagüey Province, Cuba, and to forecast the future trend of these losses using ARIMA time-series models to support proactive decision making. **Methods:** Records of the total number of bovine livers affected by *F. hepatica* from slaughtered cattle were analyzed over a 20-year period. Economic losses due to liver seizures were estimated. Exploratory time-series analyses were performed for the variables “animals slaughtered,” “animals affected,” and “economic losses.” ARIMA family models were fitted to forecast the behavior of the variables “animals affected” and “economic losses.” **Results:** Economic losses from liver seizures amounted to $1,722 USD. Seasonal decomposition revealed a pronounced seasonality in April–May for animals slaughtered, animals affected, and economic losses. Forecast models [ARIMA(0,1,4)(0,0,1)] showed adequate fit, with R 2=65.9\% for animals affected and R 2=66.4\% for economic losses. **Conclusions:** ARIMA modeling reinforces these findings by forecasting a substantial increase (approximately 70%) in both losses and affected cases in the near future, validating the use of predictive models as a key tool for proactive health management under a One Health framework to mitigate costs and improve animal health.
Keywords: seasonality; fasciolosis; economic losses; One Health (*Source: AGROVOC*)

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INTRODUCTION

Fasciolosis, caused by the trematode *Fasciola hepatica*, is a parasitic zoonosis with a global distribution and a substantial negative impact on both animal health and the livestock economy. (Cueva-Rodríguez *et al*., 2024; Bastidas *et al*., 2024). This situation, which is prevalent in multiple countries and notably in Cuba [Citations: Castillo-Cuenca *et al*., 2016; Fimia-Duarte *et al*., 2020], requires a One Health approach that integrates surveillance and risk communication, given the complex interactions among the environment, the intermediate host (snails), and ruminant hosts (Charlier *et al.*, 2020).

Fasciolosis, caused by the trematode *Fasciola hepatica*, is a parasitic zoonosis with a global distribution that exerts a substantial negative impact on both animal health and the livestock economy (Cueva-Rodríguez *et al.*, 2024; Bastidas *et al*., 2024). This problem, which is prevalent in multiple countries and particularly in Cuba (Castillo-Cuenca *et al*., 2016; Fimia-Duarte *et al*., 2020), demands a One Health approach that integrates surveillance and risk communication because of the complex interactions among the environment, the intermediate host (snails), and ruminant hosts (Charlier *et al*., 2020).

The dynamics of fasciolosis are intrinsically linked to environmental conditions, with highly seasonal transmission patterns that affect disease incidence at the abattoir (Dube *et al.*, 2023). To design effective control and mitigation strategies, it is essential to identify and forecast the temporal patterns of associated economic losses.

This study aims, for the first time in the Caribbean, to quantify not only the economic impact but also to predict epidemic peaks three months in advance using ARIMA models, thereby enabling producers and public-health authorities to mobilize resources before losses materialize. Accordingly, the purpose of the present study is to evaluate the seasonality of the economic impact resulting from the seizure of bovine livers due to *Fasciola hepatica* in Camagüey Province, Cuba, and to forecast the future trajectory of these losses through the application of ARIMA time-series models, thereby facilitating proactive decision-making.

MATERIALS AND METHODS

This retrospective study used records of cattle slaughtered at the César Escalante abattoir in Camagüey Province, Cuba, over a 20-year period (January 2004–December 2023). Monthly data comprised the total number of livers condemned following the official anatomo-pathological diagnosis of *Fasciola hepatica* infection performed at the abattoir.

To estimate the economic losses due to liver seizures (Total Economic Losses, TEL), the following methodology was used:

Weight and unit value: An average weight of 4 kg per condemned liver was assumed (Brito *et al*., 201?). The official organ prices per kilogram (USD/kg) were,

2004–2020: 0.90 USD/kg.

2021–2023: Official organ price: 1.07 USD/kg, adjusted following the monetary reorganization.

Loss equation: The estimation of the amount of losses was carried out using the following general equation:

$$\textbf{PET (USD)=(a×4 kg)×Unit Price (USD/kg)}$$

Where:

PET: Total economic losses (USD)

a: Total number of livers condemned (units).

4 kg: Average weight assumed per liver: 4 kg (Brito *et al*.).

Unit price: Commercial value per kg of liver by period

Exploratory analyses of the time series (animals slaughtered, affected animals, and economic losses) were performed. The seasonal component was analyzed using an additive seasonal decomposition model.

ARIMA family models (AutoRegressive Integrated Moving Average) were applied to forecast the behavior of the variables “affected animals” and “economic losses”. Parameter identification was based on the Box–Jenkins method, using the autocorrelation function (ACF) and the partial autocorrelation function (PACF).

The selected models, which showed the best fit with residuals behaving as white noise, were:

ARIMA(0,1,4)(0,0,1)

Where:

p=0,d=1,q=4: Nonseasonal components — Autoregressive, Integrated, Moving Average.

P=0,D=0,Q=1: Seasonal component: moving average of order 1 at lag 12 (monthly data).

The models were used to project the increase in affected animals and economic losses over 24 months (January 2024 to December 2025). All statistical analyses were performed using the IBM® SPSS® statistical package, version 24.

RESULTS AND DISCUSSION

During the evaluated period (2004–2023), direct economic losses due to the seizure of livers affected by *Fasciola hepatica* amounted to a total of $1,722 USD. The years with the highest absolute values were 2009, 2021, 2022, and 2023, suggesting an increasing trend in recent years (Figure 1).

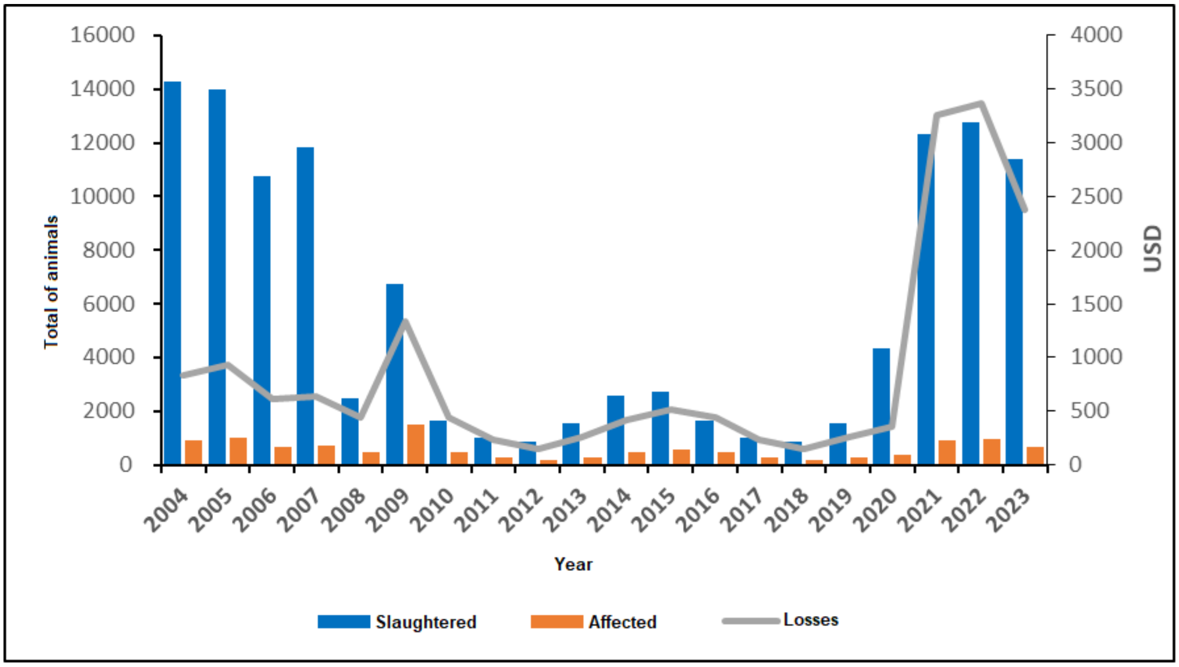

Figure 1. Economic losses from the seizure of livers affected by *Fasciola hepatica* in cattle slaughtered during the period 2004–2023

The seasonal decomposition analysis using an additive model revealed marked seasonality in the impact of *Fasciola hepatica*. April and May showed the highest seasonal index values for animals slaughtered, affected animals, and economic losses, while July and September exhibited sharp declines across all three variables (Table 1).

Table 1. Seasonal pattern of animals slaughtered, animals infected with *Fasciola hepatica*, and economic losses due to liver seizures

Month	Slaughtered animals	Affected animals	Losses
1	-136.91	-37.75	-154.94
2	-78.61	26.39	107.23
3	152.28	34.90	154.94
4	343.32	86.63	375.11
5	310.17	57.02	250.75
6	-61.68	-2.33	-1.46
7	-226.01	-85.94	-357.99
8	179.96	25.14	110.75
9	-190.65	-44.03	-200.23
10	-112.65	-27.14	-136.76
11	-142.30	-40.85	-172.79
12	-36.94	7.95	25.39

Seasonal indices (seasonal factors) Seasonal decomposition analysis
Addictive model

The selected forecasting models, ARIMA(0,1,4)(0,0,1), provided an adequate fit, yielding an R 2 of 65.9% for the affected-animals series and 66.4% for the economic-losses series, which suggests comparable temporal dynamics between the two variables.

The models forecast a concerning rise in the incidence of *Fasciola hepatica* and its associated costs for the 2024–2025 biennium (Figure 2), including increased economic losses due to the seizure of infected livers.

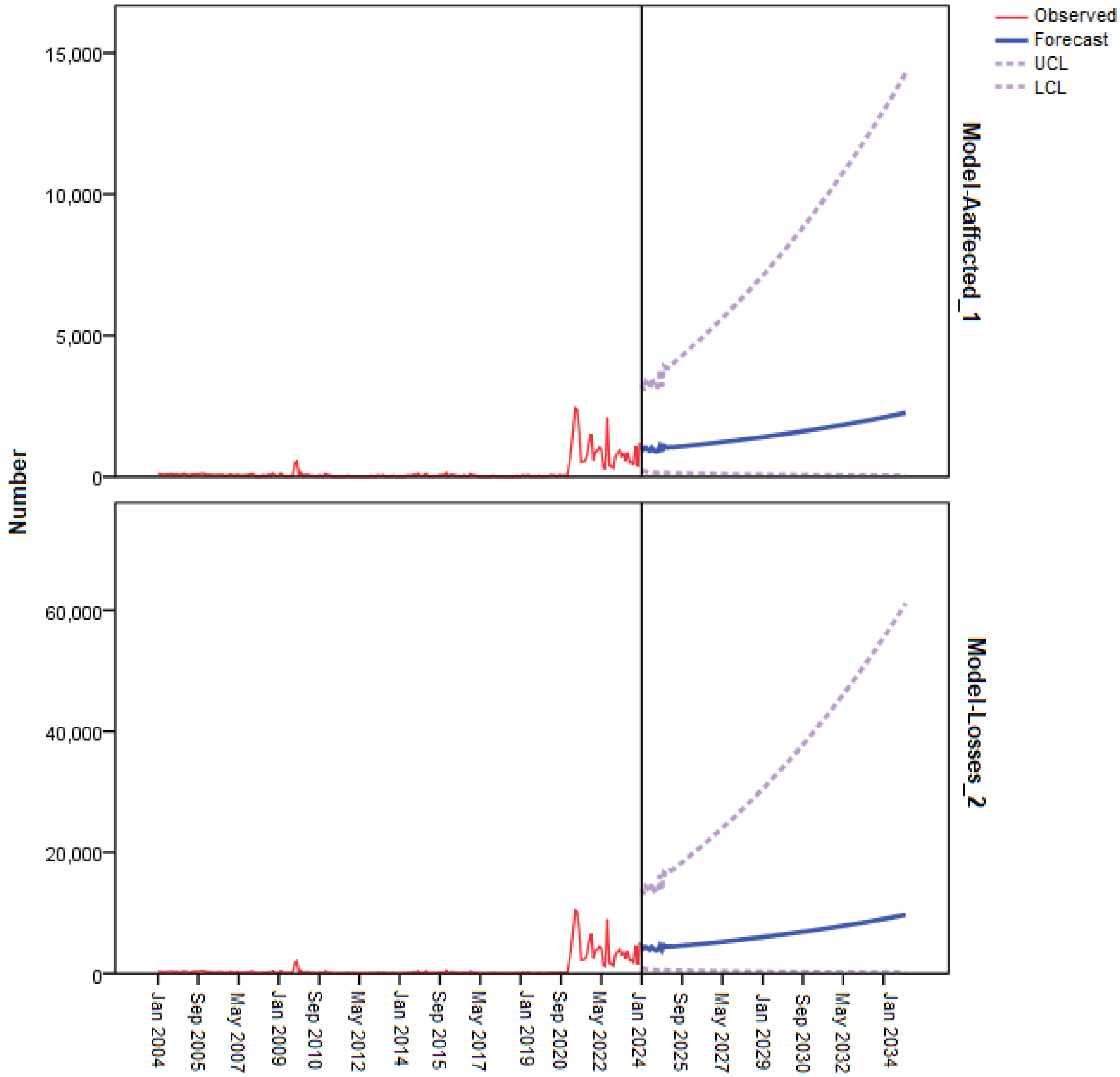

Figure 2. Forecasts of animals affected (Aaffected) by *Fasciola hepatica* [ARIMA(0,1,4)(0,0,1), R 2=65.9%] and economic losses (losses) from liver seizures [ARIMA(0,1,4)(0,0,1), R 2=66.4%]. The red line shows observed values, and the blue line shows forecasts with 95% confidence intervals. The dashed lines, labeled UCL and LCL, indicate the upper and lower confidence limits, respectively.

The analysis confirms that liver seizures constitute a tangible economic loss which, despite a modest cumulative historical total ($1,722 USD), has increased in the recent period (2021–2023). The low historical total may reflect regulated organ prices or the study's restriction to direct losses, in contrast to international studies that also account for production losses and treatment costs (Charlier *et al*., 2020; Odeniran *et al*., 2020).

The pronounced seasonality observed, with peaks in April–May, aligns with the epidemiology of fasciolosis in tropical and subtropical regions (Bennema *et al*., 2017; Hernández-Guzmán *et al*., 2021). In these climates, increases in humidity and temperature at the start of the rainy season favor the population dynamics of intermediate snail hosts and the survival of larval stages.

The application of ARIMA models with a high goodness of fit (R 2 ≈ 65%) validates the usefulness of this tool for surveillance. The projection of a 66.6% increase in affected animals and a 70% rise in economic losses by 2025 constitutes a critical warning. This forecast enables proactive resource allocation, prioritizing parasite-control measures and molluscicide interventions on farms in Camagüey before the seasonal peak in April–May (Molento *et al*., 2018; Yihunie *et al*., 2024).

Postmortem inspection at the abattoir, in addition to guiding immediate actions, is reaffirmed as a key element of epidemiological surveillance (George *et al*., 2020). Our findings highlight the need for on-farm management measures to reduce the submission of infected animals for slaughter, such as drainage of wet zones, pasture rotation, and strategic anthelmintic treatment timed to the forecasted seasonal peaks. This integrated strategy is essential under the One Health paradigm.

Incorporating climatic variables (humidity, temperature) and husbandry practices into ARIMA predictive models enhances early detection of fasciolosis outbreaks. In temperate regions, such models have predicted infection peaks with approximately 85% accuracy (Kaplan *et al*., 2023). Routine monitoring of eggs per gram (EPG) enables dynamic treatment adjustments and helps prevent underdosing (Bennema *et al*., 2017). Nevertheless, documented variability in egg shedding (Charlier *et al*., 2020) indicates that EPG should be complemented with serological assays to improve diagnostic sensitivity (Yihunie, 2024).

Integrating ARIMA model outputs into One Health strategies enables identification of critical transmission windows, permitting the scheduling of targeted treatments ahead of prevalence peaks, optimizing fasciolicide use to avoid unnecessary treatments and reduce resistance risk, and allocating health resources more efficiently by prioritizing high-risk areas and periods. Additionally, these models allow estimation of projected economic losses, facilitating cost–benefit analyses to inform decision-making at farm and regional scales (Rodríguez *et al*., 2017).

This study quantifies, for the first time in the Caribbean, the economic impact of fasciolosis and uses ARIMA models to forecast epidemic peaks with a three-month lead time, enabling producers and public-health authorities to mobilize resources before losses occur.

CONCLUSION

Quantification of losses confirmed the economic impact of fasciolosis in Camagüey and reaffirmed postmortem inspection at abattoirs as a critical component of epidemiological surveillance. Time-series analysis revealed pronounced seasonality in the impact of *Fasciola hepatica*, with the highest burden and economic losses occurring in April–May. ARIMA modeling corroborates these results, projecting an approximately 70% increase in both losses and affected cases in the near term. These findings validate the use of predictive models as a central tool for proactive health management within the One Health framework to reduce costs and improve animal health.

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AUTHOR CONTRIBUTION STATEMENT

Research conception and design: DPC, JABV, RVM, MBM; data analysis and interpretation: DPC, JABV, RVM, AAVP; manuscript writing: DPC, JABV, RVM.

CONFLICT OF INTEREST STATEMENT

The authors state there are no conflicts of interest whatsoever.