Bovine fascioliosis in Niger state, Nigeria: effects of climatic and elevation factors on its distribution

Abstract

Aim: This study investigated the burdens and the impact of environmental risk factors on the prevalence of bovine Fascioliosis in trade cattle slaughtered in municipal abattoirs in Niger State, Nigeria.

Methodology: Retrospective abattoir surveys were conducted at five municipal abattoirs, which involve the retrieval and analysis of meat inspection data from the abattoirs carried out between January 2004 and December 2014. Records of monthly and annual returns from the abattoirs were scrutinized and used to determine prevalence of F. gigantica. A total of 19 bioclimatic variables of present climate and elevation data derived from the SRTM for Nigeria were downloaded from http://www.worldclim.org/ and were used in the prediction of bovine fascioliosis distribution using MaxEnt software version 3.3.3k. Map visualization was performed on DIVA-GIS version 7.5.6.

Results: The mean prevalence of bovine fascioliosis in Niger State, Nigeria is 1.46% over a ten years period. The average prevalence from the five municipal abattoirs; Minna, Suleja, Bida, Kotangora and New Bussa were 1.31, 1.70, 1.12, 1.05 and 1.24% respectively and was not significant difference (P>0.05). The model prediction reveals that Wushishi, Katcha, Gbako, Bosso, parts of Shiroro and Rafi LGAs lies within the high risk areas with probability of occurrence ranging from 0.8 – 1. Precipitation and mean temperature of the coldest quarter, and precipitation of wettest quarter were the environmental variables that favour high prevalence of bovine fascioliosis.

Discussion: The result of this study indicated low prevalence of 1.46% of fascioliosis in cattle in Niger State, Nigeria over the ten years period. The low prevalence might be attributed to the provision of better veterinary services and increase in consultancy services to farmers on livestock management. Conclusion: Bovine fascioliosis is endemic in Niger State Nigeria with little economic importance. The South-Eastern region of the state is at high risk of infection than other regions.

Keywords: Abattoir, Bovine, Fascioliosis, Environmental Variables, Nigeria

Background

Fascioliosis, also known as liver fluke disease, is a hepatic parasitic infection caused by three trematodes, Fasciola hepatica, Fasciola buski and Fasciola gigantica with the definitive hosts range from herbivorous mammals to humans. Fascioliosis is transmitted by fresh water snails Lymnae. Fascioliosis has the largest geographical widespread of any emerging vector-borne zoonosis, occurring in 51 countries worldwide. It causes significant economic losses to global agriculture, estimated at N3 billion USD annually, through liver condemnation and reduction of milk and meat yields. The World Health Organization estimated that 2.4 million people are infected with Fasciola species and a further 180 million are at risk of infection. Fascioliosis gains public concern not only due to its prevalence and economic significance to animal stock in all continents but also to its zoonotic aspect. Fasciola are haematophagous, their infection usually results in anaemia and can cause a high proportion of mortalities, especially in small ruminants and calves. Over the last decade there has been a substantial increase in the number of fascioliosis cases recorded. It is spurred on by both environmental changes (warmer, wetter climate) and man-made modifications such as an increase in animal movements and intensification of livestock farming. Studies in Nigeria reported that bulky nature of cattle faeces, high and sufficient moisture content of the soil gives room for larval development and survival which enabled the third larval stage to remain in the fecal droppings in the dry season until the onset of the rains, when they are released and the faeces used as a manure. The use of meat inspection to detect disease cases in slaughter facilities is particularly useful in Africa where laboratory capacity for routine disease diagnosis is limited. With paucity of empirical information on the burdens and associated predisposing internal (biological) and external (climatic and environmental) factors for Fascioliosis such data are needed to serve as convenient and inexpensive source of information for the development of fascioliosis control programs in Nigeria. This study assess the impact of environmental risk factors on the prevalence of bovine fascioliosis in trade cattle slaughtered in municipal abattoirs in Niger State, Nigeria.

Materials and methods

Study area

The study was conducted in Niger State, North-Central Nigeria located on latitude 8° 20’ N and 11° 30’ N, and longitude 3° 30’ E and 7° 20’ E. The state is the largest in terms of land mass with an area of 86,000 km². Niger State has three Agro-geographical zones, with variable climatic conditions: Zone A (Southern zone) with eight LGAs having many rivers, streams and ponds, and can cause a high proportion of mortalities, especially in small ruminants and calves. Over the last decade there has been a substantial increase in the number of fascioliosis cases recorded. It is spurred on by both environmental changes (warmer, wetter climate) and man-made modifications such as an increase in animal movements and intensification of livestock farming. Studies in Nigeria reported that bulky nature of cattle faeces, high and sufficient moisture content of the soil gives room for larval development and survival which enabled the third larval stage to remain in the fecal droppings in the dry season until the onset of the rains, when they are released and the faeces used as a manure. The use of meat inspection to detect disease cases in slaughter facilities is particularly useful in Africa where laboratory capacity for routine disease diagnosis is limited. With paucity of empirical information on the burdens and associated predisposing internal (biological) and external (climatic and environmental) factors for Fascioliosis such data are needed to serve as convenient and inexpensive source of information for the development of fascioliosis control programs in Nigeria. This study assess the impact of environmental risk factors on the prevalence of bovine fascioliosis in trade cattle slaughtered in municipal abattoirs in Niger State, Nigeria.
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Target population

Study populations were trade cattle that originated from nomadic and sedentary pastoral herds domiciled in the three agro-geographical zones.

Sampling method and bovine fascioliosis infection data

Retrospective abattoir surveys were conducted at five municipal abattoirs, located at Minna, Suleja, Bida, Kontagora and New-Bussa cities which involved the retrieval and analysis of meat inspection data from the abattoirs carried out between January 2004 and December 2014. Records of monthly and annual returns from the abattoirs were scrutinized as a result of infection with *F. gigantica*. The meat inspection was performed by certified inspectors in accordance with the standards of Livestock and Meat Industries Act of the Republic of Nigeria, under the supervision of the Chief Veterinary Officer in the Department of Veterinary Services of the Ministry of Agriculture, Niger Stat.

Environmental data

In this study, a total of 19 bioclimatic variables of present climate (1950 – 2000) for Nigeria were downloaded from http://www.worldclim.org/ (Worldclim database version 1.4) at 1 km spatial resolution and were used in the prediction of bovine fascioliosis distribution as follows: BIO1 - Annual Mean Temperature, BIO2 - Mean Diurnal Range, BIO3 - Isothermality, BIO4 - Temperature Seasonality, BIO5 - Maximum Temperature of Warmest Month, BIO6 - Minimum Temperature of the Coldest Month., BIO7 - Temperature Annual Range, BIO8 - Mean Temperature of Wettest Quarter, BIO9 - Mean Temperature of Driest Quarter, BIO10 - Mean Temperature of Warmest Quarter, BIO11 - Mean Temperature of Coldest Quarter, BIO12 - Annual Precipitation, BIO13 - Precipitation of Wettest Month, BIO14 - Precipitation of Driest Month, BIO15 - Precipitation Seasonality, BIO16 - Precipitation of Wettest Quarter, BIO17 - Precipitation of Driest Quarter, BIO18 - Precipitation of Warmest Quarter and BIO19 - Precipitation of Coldest Quarter. Elevation data derived from the Shuttle Radar Topography Mission were also downloaded from http://www.worldclim.org/. These bioclimatic variables can be summarized into 3 main variables: altitude, temperature and precipitation.

Ecological niche modeling

The potential distribution of bovine fascioliosis was modelled using MaxEnt software version 3.3.3k download from http://www.cs.princeton.edu/~schapire/maxent/. MaxEnt uses environmental data at occurrence and background locations to predict the distribution of a species across a landscape. This modeling tool was selected based on the reasons of Sarma et al. which is a presence-only modeling algorithm (i.e. absence data are not required). Its performance has been relatively better than other modelling methods and has hardly been influenced by small sample sizes and hence prediction will be relatively robust. It has been shown to be among the top performing modeling tools by Elith et al. Probability of presence of bovine fascioliosis was estimated by MaxEnt using the mean prevalence of bovine fascioliosis obtained for the five municipal abattoir in Niger State, Nigeria which served as the presence records for generation of background point used in finding the maximum entropy distribution. This modeling tool was selected based on the reasons of Sarma et al. The 19 environmental variables and the elevation data obtained were used for the ecological niche modeling. The level of significance of contribution of the altitude and 19 bioclimatic variables was used to calculate jack knife (a method of assessing the variability of data by repeating calculations on the sets of data obtained each time by removing one value from the complete set) and area under the receiver operating characteristics curve (AUC) was used to evaluate the model performance. The AUC values vary from 0.5 to 1.0; an AUC value of 0.5 showed that model predictions were not better than random, values <0.5 were worse than random, values from 0.5 to 0.7 signified poor performance, values from 0.7 to 0.9 signifies reasonable/moderate performance and values >0.9 indicated high model performance. Model validation was performed according to Sarma et al. using the ‘sub-sampling’ procedure in MaxEnt. About 75% of the parasites prevalence data were used for model calibration and the remaining 25% for model validation. Ten replicates were run and average AUC values for training and test datasets were calculated. Maximum iterations were set at 5000. Sensitivity and specificity of infections were also measured. Sensitivity, which was also named the true positive rate, can measure the ability to correctly identify areas infected. Its value equals the rate of true positives and the sum value of true positives and false negatives. Specificity, which was also named the true negative rate, can measure the ability to correctly identify areas uninfected. Its value equals the rate of true negatives and the sum value of false positives and true negatives.
**Data collection and analysis**

The prevalence of fascioliosis was calculated as the number of cattle infected with Fasciola expressed as a percentage of the total number of cattle slaughtered, and was calculated annually for each abattoir. Data were analysed using one-way analysis of variance (ANOVA) followed by turkey’s Test. Statistical analysis were performed using the Statistical Package for Social Sciences (SPSS) software (version 21.0 for windows; SPSS Inc., Chicago, IL). Statistical significance was set at p<0.05. Map visualization was performed on DIVA-GIS version 7.5.0 using grid file output of MaxEnt with the geographic area restricted to Niger State. Six classes of probabilities were given a specific colour for visual representation of model results ranging from low risk to high risk as follows: 0 – 0.1, 0.1 – 0.2, 0.4 - 0.6, 0.6 – 0.8 and 0.8 – 1.0 with varying colours.

**Results**

**Spatial distribution of bovine fascioliosis in niger state**

The mean prevalence of bovine fascioliosis in Niger State, Nigeria is 1.46% over a ten years period (Table 1). The average prevalence from the five municipal abattoirs; Minna, Suleja, Bida, Kotangora and New Bussa were 1.31, 1.70, 1.12, 1.05 and 1.24% respectively. No significant difference (P>0.05) in the prevalence of bovine fascioliosis among the five municipals. The yearly prevalence of bovine Fascioliosis were significantly different (p<0.05) with year 2010 having the highest prevalence of 7.40% while year 2013 had the least prevalence of 0.42% (Figure 2) (Table 1).

**Table 1 Annual Prevalence of Bovine Fascioliosis at Five Municipal Abattoirs in Niger State, Nigeria**

<table>
<thead>
<tr>
<th>Year</th>
<th>Minna</th>
<th>Suleja</th>
<th>Bida</th>
<th>Kontagora</th>
<th>New Bussa</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NE</td>
<td>NP (%)</td>
<td>NE</td>
<td>NP (%)</td>
<td>NE</td>
<td>NP (%)</td>
</tr>
<tr>
<td>2005</td>
<td>34658</td>
<td>785(2.26)</td>
<td>103704</td>
<td>1538 (1.48)</td>
<td>30292</td>
<td>578 (1.91)</td>
</tr>
<tr>
<td>2006</td>
<td>45940</td>
<td>701(1.53)</td>
<td>137977</td>
<td>1188 (0.86)</td>
<td>42437</td>
<td>533 (1.26)</td>
</tr>
<tr>
<td>2007</td>
<td>41852</td>
<td>819(1.96)</td>
<td>127596</td>
<td>1751 (1.37)</td>
<td>35763</td>
<td>673 (1.88)</td>
</tr>
<tr>
<td>2008</td>
<td>42921</td>
<td>836(1.95)</td>
<td>131671</td>
<td>1647 (1.25)</td>
<td>33286</td>
<td>584 (1.75)</td>
</tr>
<tr>
<td>2009</td>
<td>34184</td>
<td>779(2.28)</td>
<td>119552</td>
<td>1731 (1.45)</td>
<td>29067</td>
<td>499 (1.72)</td>
</tr>
<tr>
<td>2010</td>
<td>37208</td>
<td>597(1.60)</td>
<td>121278</td>
<td>16671 (1.35)</td>
<td>31334</td>
<td>379 (1.21)</td>
</tr>
<tr>
<td>2011</td>
<td>38228</td>
<td>652(1.71)</td>
<td>133846</td>
<td>1165 (0.87)</td>
<td>31052</td>
<td>471 (1.52)</td>
</tr>
<tr>
<td>2012</td>
<td>89782</td>
<td>601(0.67)</td>
<td>301418</td>
<td>1109 (0.37)</td>
<td>49609</td>
<td>423 (0.85)</td>
</tr>
<tr>
<td>2013</td>
<td>129999</td>
<td>670(0.52)</td>
<td>389979</td>
<td>1265 (0.32)</td>
<td>94967</td>
<td>312 (0.33)</td>
</tr>
<tr>
<td>2014</td>
<td>44174</td>
<td>640(1.45)</td>
<td>148642</td>
<td>1107 (0.74)</td>
<td>56793</td>
<td>402 (0.71)</td>
</tr>
<tr>
<td>Total</td>
<td>538946</td>
<td>7080(1.31)</td>
<td>171563</td>
<td>29172 (1.70)</td>
<td>434600</td>
<td>4854 (1.12)</td>
</tr>
</tbody>
</table>

Source: Yatswako & Alhaji. 

NE - Annual Slaughtered Cattle Trade Cattle 

NP - Annual Cases of Bovine Fascioliosis 

% - Annual Prevalence 

**Predicted risk of bovine fascioliosis infection**

The model prediction of bovine Fascioliosis reveals that Wushishi, Katcha, Gbako, Bosso and parts of Shiroro and Rafi LGAs lies within the high risk areas with probability of occurrence ranging from 0.8 – 1. Large part of Wushishi LGA fell within the high risk region. The suitability of conditions that favours the spread of this disease reduces from the five municipal abattoirs; Minna, Suleja, Bida, Kotangora and New Bussa were 1.31, 1.70, 1.12, 1.05 and 1.24% respectively. No significant difference (P>0.05) in the prevalence of bovine fascioliosis among the five municipals. The yearly prevalence of bovine Fascioliosis were significantly different (p<0.05) with year 2010 having the highest prevalence of 7.40% while year 2013 had the least prevalence of 0.42% (Figure 2).
moving northward of LGAs in Zone C. Rijau and Agwara were the least in prevalence of bovine fascioliosis with probability of 0 – 0.1. Also, parts of Borgu, Mariga and Magana LGAs fell within the low risk areas with probability of 0 – 0.1 (Figure 3) (Figure 4).

**Model performance and influencing factors**

The receiver operating characteristics (ROC) curve obtained as an average of the 10 replication runs is shown in Fig. 4. Specificity was calculated. The average and standard deviation of the area under the curve for the 10 replicate runs for this infection was 0.983±0.011. These values showed an excellent performance of the modeling software as an AUC value of greater than 0.80 showed higher sensitivity and specificity for the presence of these parasites. The relative importance of each environmental variable to the prevalence of bovine fascioliosis was assessed with the jackknife test in fig. 6a & b which gave a total training gain of 2.9 (red bar) (Figure 5) and an AUC value of 0.98 (red bar) (Figure 6). The jackknife test indicated that precipitation of the coldest quarter, mean temperature of coldest quarter and precipitation of wettest quarter were the three variables when used alone, will affect the prevalence of bovine fascioliosis the most. These three variables were more informative when used in predicting the prevalence of bovine fascioliosis.

**Discussion**

The result of this study indicated low prevalence of fascioliosis in cattle in Niger State, Nigeria over the ten years period. Magaji et al.\(^{21}\) reported the presence of this parasite in their study in Sokoto State, Nigeria. Similar abattoir studies in Zimbabwe,\(^{22}\) Kenya\(^{8,23}\) and Tanzania\(^{24,25}\) reported a higher prevalence of 37.1%, 8%, 26%, 16.5% and 8.6%, respectively. The present study is similar to the study of Mochankana and Robertson \(^{26}\) in Botswana with prevalence of 0.1%. The low prevalence observed in this study might be attributed to the provision of better veterinary services and increase in consultancy services to farmers on livestock management, which could reduce the prevalence of fascioliosis. This study suggest that bovine fascioliosis is of low clinical economic importance in Niger State, Nigeria. Other studies using bile samples from slaughtered cattle in different countries showed higher prevalence of fascioliosis; 25.46% by Khan et al.\(^{27}\) in Pakistan, 26.84% by Gul et al. \(^{28}\) in India, 27.26% and 25.2% by Kabir et al.\(^{29}\) & Affroze et al.\(^{30}\) from different provinces of Bangladesh, 25.9% by Mungube et al.\(^{31}\) in Kenya, 26.55% by Nega et al.\(^{32}\) in Ethiopia, 23.96% by Asressa et al.,\(^{33}\) in Ethiopia. The difference in prevalence could be due to the difference in agro climatic variations (rainfall, temperature), the management conditions under which the cattle were reared and the difference in grazing area. The high
humidity of the region also provided the needed condition to encyst the metacercariae. Qureshi et al. reported that metacercariae can be found on vegetation in large number during rainy season and at early dry season along river banks, lakes, and streams. The sensitivity of liver inspection at post-mortem has been reported to be 63–71% by Khaita et al. & Rapsch et al. who indicated that meat inspection for liver fluke may exhibits a sensitivity of 63.2% (55.6–70.6%), meaning that the true levels of infection may be between 1.5 and 2 times the apparent prevalence. Although useful for the confirmation of patenty infected animals, sensitivity of data from abattoir records may not be optimal, which is a major limitation. The modeling result indicated that precipitation of the coldest quarter, mean temperature of coldest quarter and precipitation of wettest quarter were the environmental variables that favours high prevalence of bovine Fascioliosis. The South-Eastern part of Niger State was observed to have a higher predicted prevalence as a result of the higher precipitation of the region and warmer temperature. Altitude do not have significant impact on the prevalence of bovine fascioliosis.

**Conclusion**

The findings of this study revealed that bovine fascioliosis is endemic in Niger State Nigeria with little economic importance. The South-Eastern region of the state are at high risk of infection than other regions as a result of the higher level of precipitation coupled with lower temperature. The temperature of the coldest quarter and precipitation of the wettest month are the major environmental variables that affect majorly the distribution of this disease.

**Recommendation**

We recommend that consultancy services be rendered by veterinary experts to cattle farmers coupled with administration of drugs. Also, the rearing of cattle in high risk areas should be regulated and restricted.

**Acknowledgments**

None.

**Conflict of interest**

Author declares that there is no conflict of interest.

**References**


