Tropical Animal Health and Production (2020) 52:3359–3363
https://doi.org/10.1007/s11250-020-02367-7

REGULAR ARTICLES

Economic model of bovine fasciolosis in Nigeria: an update

Paul Olalekan Odeniran[1] · Kehinde Foluke Omolabi[2] · Isaiah Oluwafemi Ademola[1]

Received: 24 March 2020 / Accepted: 3 August 2020 / Published online: 21 August 2020

Abstract

Bovine fasciolosis is a zoonotic infection transmitted by infected freshwater snail—*Lymnaea* (*Radix*) *natalensis*—in tropical regions. The prevalence of bovine fasciolosis in Nigeria is overwhelming with huge financial cost. In the chronic form of the disease, hyperplastic cholangitis and calcification of bile ducts occur with severe liver damage. The aim of the study was to estimate annual economic losses of bovine fasciolosis in Nigeria. Disease prevalence was estimated at 18.3% (8.5–30.6), average annual disease incidence is maintained at 2.5%, an estimated mortality rate of 1.5%, a total liver condemnation rate of 11.1% were estimated from affected liver due to fasciolosis, annual slaughter rate of 10.5% and a total cattle population of 20 million. A total of 7.3% livestock owners consider fasciolosis as a threat, while only 4.3% have ever used molluscicide. Treatment cost of controlling fasciolosis is estimated at US$375,000, which puts the total annual loss due to fasciolosis at US$26.02 million. Both direct and indirect sources of production losses have an impact on the livestock industry in Nigeria. Bovine fasciolosis threatens food security in Nigeria; therefore, further awareness among livestock owners is needed on control strategies to improve the income base for small-scale livestock farmers.

Keywords Model · Bovine fasciolosis · Economic · Nigeria

Introduction

Fasciola gigantica (liver fluke) is the known causative agent of bovine fasciolosis in Nigeria, causing significant weight loss and liver damage. Fasciolosis is capable of infecting wide range of mammals including wildlife (Odeniran and Ademola, 2016). The economic losses associated with fasciolosis have been estimated at around US$3 billion to livestock and food industries worldwide (Elelu and Eisler, 2018). Globally, more than 300 million cattle are exposed to *Fasciola* with Switzerland reporting financial losses of €300/animal/cattle annually (Schweizer et al. 2005), which could have increased over the last 15 years. Information on the economic losses to bovine fasciolosis in Nigeria is outdated (Elelu and Eisler, 2018); hence, there is a need for reassessment considering the changing climatic conditions and management practices in this tropical environment. It has been reported that the abundance of freshwater snails and the reproductive rate of a single miracidium is capable of producing 4000 infective metacercariae through vegetative multiplication (Berhanu et al. 2018). Prevalence of bovine fasciolosis in Nigeria may be as high as 75% (Elelu et al. 2016), depending on availability of snail intermediate host, diagnostic techniques and detection expertise. Farmers' awareness has been observed to be low in this tropical region, and the disease is not recognized until after slaughter because of its chronic nature. *Fasciola gigantica* has been previously reported to have the widest geographical distribution in Nigeria among zoonotic helminths (Karshima, 2018). Economic losses may also be associated with reduced milk and skin production, decreased weight gain, increase expenses on anthelmintic drugs, impaired fertility and secondary infections (Nwanta et al. 2008). Activities around cattle production and trade is increasing among livestock owners (both small-scale and commercial), besides cattle are important supply of traction power and manure in crop production in Nigeria; therefore, it is important to update our understanding on the prevalence and economic

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s11250-020-02367-7) contains supplementary material, which is available to authorized users.

✉ Isaiah Oluwafemi Ademola
io.ademola@ui.edu.ng

[1] Department of Veterinary Parasitology and Entomology, University of Ibadan, Ibadan, Nigeria

[2] Molecular Bio-computation and Drug Design Laboratory, University of KwaZulu Natal, Durban, South Africa

losses due to bovine fasciolosis in cattle to improve the profit margin in Nigeria livestock industry.

Materials and methods

Cost estimation

The economic losses due to bovine fasciolosis were assessed using established formula (Ogunrinade and Ogunrinade, 1980), with slight modification of the treatment cost ($C_S + C_T$).

$$E_L = N_D\,(P_A \times B_W) + N_S\,(C_L) + N_C\,(D_W \times P_A) + (C_S + C_T) + M_C$$

where E_L is the estimated annual economic loss due to fasciolosis in cattle; B_W is the average body weight of Nigerian cattle in kilograms; P_A is the average market price of 1-kg beef; N_D is the number of animals that die of fasciolosis; N_C is the total number of animals with chronic infection; N_S is the total number of cattle slaughtered annually and positive for hepatic fasciolosis; D_W is the differences in weight between healthy and diseased cattle; C_L is the mean cost of the liver condemned at slaughter; $C_T + C_S$ is the treatment and control cost on fasciolosis and M_C is the miscellaneous costs.

The formula is a valid estimate of the cost of bovine fasciolosis with the following considerations: mortality in cattle directly linked to heavy infection or indirectly through predisposition to other primary infection; clinical signs of chronic infection such as cachexia, malnutrition and poor production performances; partial or complete condemnation of the liver at the point of slaughter; and other effects such as decreased fertility, milk yield or reproduction. The incidence rate of bovine fasciolosis was calculated as the proportion of reported cases in the last 1 year (2018–2019).

Total cattle population

Cattle population has increased over the years in Nigeria, although at a very slow rate. In 2014, the FAO estimated total cattle population in Nigeria to be 19.4 million (FAO, 2014), which serve as the most recent data. Therefore, this study estimated approximately 20 million cattle. We assumed a stable cattle population whose natural death or slaughter is replaced by natural birth and cattle from neighbouring regions and countries.

Annual rate of slaughtered cattle

Concise report on annual slaughtered animals in Nigeria based on records in each state has earlier been reported (Nwanta et al. 2008). From this investigation, reports were from 30 abattoirs, 132 slaughter houses and 1077 slaughter slabs with annual slaughter capacity of 14.1 million animals. Of these, the proportion of slaughtered cattle population can be assumed from total fraction of animals reported: 14.8% of 131 million animals (19.4 cattle, 40.6 sheep and 71 million goats) were reported to be classified as cattle (FAO 2014). Hence, 14.8% of total slaughtered animals (14.1 million) are assumed to be 2.1 million cattle slaughtered annually.

Rate and cost of liver condemnation

A retrospective study reported the major cause of liver condemnation in Nigeria abattoir to be fasciolosis at the rate of 88.2%, while tuberculosis, liver cirrhosis and liver abscess/other causes were reported at 5.4, 1.9 and 4.6%, respectively (Ibironke and Fasina 2010). A total of 0.72% of total cattle slaughtered with liver condemnation due to fasciolosis were reported (Ibironke and Fasina 2010). However, of this figure, only 11.9% were totally condemned, while 89.1% were partially condemned livers.

Cost associated with chronic diseases

Fasciolosis have been reported to positively correlate with weight gain/loss based on parasite load and stage of infection (Arias-Pacheco et al. 2020), although cattle with good immune status and moderate infection may be asymptomatic (Isah, 2019). Anthelminthics such as triclabendazole have been reported to improve the body conditions of chronically infected cattle (Beesley et al. 2018). According to reports of Sewell (1966), 0.198 kg of body weight per fluke is lost annually as a result of *F. gigantica* infections in cattle with average burden of 30 flukes per head. Average helminth burden of *F. gigantica* in naturally affected cattle from Nigeria abattoir is estimated at 42 with range of 5–166. Hence, $N_C\,(D_W \times P_A) = N_C\,(0.198 \times 42 \times P_A)$.

Morbidity and mortality estimates

Most cattle affected with fasciolosis often show signs of unthriftiness and morbidity chronically. The severity is directly related to management practices and nutritional status of the herd. In Nigeria, it is difficult to ascribe mortality due to fasciolosis rather than to predisposition to other infections, e.g. other helminth parasites, bacterial and viral diseases. Other indirect effects may also lead to morbidity and mortality, e.g. stresses and post-parturient infections. Hence, we obtained 1.5% mortality from data directly associated with fasciolosis.

Treatment cost

Information on treatment costs of bovine fasciolosis in Nigeria was assessed. Questionnaires were distributed among livestock owners ($n = 397$) between August 2018 and January 2020 across twenty-seven states in the country, representing 75% of the total states. The contents in the questionnaire were on treatment and control strategies against fasciolosis on cattle (Supplementary file 1). Questions include type of anthelminthic used, application frequency, route of administration, water sources, use of molluscicides, grazing methods, time of grazing and grazing locations. Data for annual cost of treatment and control were derived in US dollars. Fasciolosis is not often treated in isolation in Nigeria; hence, $n = 1/10$th model structure was derived for fasciolosis. Treatment cost $C_T = [C_D$ (cost of drug dosage per cattle)] × [P_X (prevalence of fasciolosis) × population (n) (total cattle population minus slaughtered cattle)], while control cost $C_S = [C_M$ (mean cost of molluscicide) × (frequency of treatment)] × [R_W (number of river water sources for cattle population)]÷ 10 (model structure).

Assessment of bovine fasciolosis prevalence in Nigeria

A total of four literature databases (AJOL, PubMed, Web of Science and Google Scholar) were searched electronically for published articles specifically directed towards bovine fasciolosis in Nigeria between Jan, 1980 and Jan, 2020. Full-text articles were identified using keywords such as "Nigeria", "Bovine", "*Fasciola*", "*gigantica*", "Prevalence" and "Epidemiology". Inclusion criteria were cross-sectional study directed towards the prevalence of bovine fasciolosis using faecal diagnostic tool or presence of adult worm in cattle in Nigeria. Case reports, general helminth studies, duplicated manuscripts, report on other animal group and review articles were excluded from the study. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist was used to ensure proper inclusion of all relevant information in the analysis (Moher et al. 2010).

Miscellaneous cost

This is estimated at 5% of estimated annual economic loss (Ogunrinade and Ogunrinade 1980). Fasciolosis has been associated with decreased productivity (beef production and milk yield), decreased fertility and poor carcass quality. In Nigeria, it is difficult to assess these indirect values due to underdeveloped livestock industry. Hence, this estimated value is assumed to cover all the important variables.

Results

Estimated economic losses due to bovine fasciolosis

Cost analyses

The cost of 1-kg beef is US$4.4 in current market value. The annual slaughtered cattle stand at 10.5% of total cattle population, i.e. 2.1 million cattle of total 20 million cattle population. Total losses associated with mortality (N_D ($P_A \times B_W$) depend on average carcass weight of Nigerian cattle estimated as 180 kg, while market value for such cattle is US$695. N_D is calculated as mortality (1.5%) × total cattle population (20 million) × incidence rate (2.5%).

$$\begin{aligned}\text{Mortality cost}-N_D\ (P_A \times B_W) &= 7500\ (4.4 \times 180)\\ &= 7500\ (792)\\ &= \text{US}5,940,000\end{aligned}$$

Liver condemnation estimation

A totally condemned livers have an average weight of 4 kg, while partially condemned livers were assumed at 1 kg, from $0.11N_S\ (4 \times P_L) + 0.89N_S\ (1 \times P_L)$. Annual summation of liver condemnation is estimated as 69,825 kg. One kilogram of the liver is sold for US$7 in the current market value. Considering the annual incidence rate and annual slaughter rate, the N_S can easily be estimated. Hence, total summation of both total and partial liver condemned in Nigeria due to fasciolosis can be estimated:

$$\begin{aligned}\text{Cost of liver condemnation}\ N_S \times C_L &= 5775\ (28) + 46,725\ (7)\\ &= 161,700 + 327,075\\ &= \text{US}488,775\end{aligned}$$

Losses due to chronic effects

The average disease incidence of 2.5% was used to calculate the N_C. The value considers total number of cattle chronically affected in the last 1 year. $N_C = 2.5\% \times 20$ million = 500,000.

$$\begin{aligned}\text{Loss due to chronic effects}\ N_C\ (D_W \times P_A) &= 500,000\ (8.32 \times 4.4)\\ &= 500,000\ (36.608)\\ &= \text{US}18,304,000\end{aligned}$$

Cost of control and treatment

The prevalence of bovine fasciolosis was estimated at 18.3% over the last 40 years, our calculation was based on this value. Livestock owners reported that cattle are treated with anthelminthics for worm burden. Of these treated population, a fraction of one-tenth treatment cost was associated with treatment cost of fasciolosis. Hence, $P_X = 18.3\%$, $n = 17.9$ million (total cattle population minus slaughtered cattle). $18.3\% \times 17.9$ million = 3,275,700 cattle. Quarterly anthelminthic treatment per cattle against fasciolosis was calculated at US$0.083. $C_T = 0.083 \times 3{,}275{,}700 = 271{,}833$. For control strategies, the use of molluscicides and rotation of grazing areas were often adopted. A bottle of molluscicide sold for US$3.548 is used on 100 m^2 of marshy grazing areas or river points with snail intermediate host, *Lymnaea natalensis*. An average cattle farm in this tropical region will use five bottles/annum, totalling US$17.74. A total number of 58,162 cattle households across Nigeria were identified (Bourn, 1992), which could have increased drastically. Hence, $C_S = \frac{17.74 \times 58{,}162}{10}$ = US$103,179.

Annual cost of controlling and treating disease $[C_T + C_S]$ = 271,833 + 103,179 = US$375,012.

Miscellaneous cost

The 5% of estimated annual economic loss is the miscellaneous cost.

$5/100 \times 26.02\ \mathit{million} = \mathrm{US}915,200.$

Estimated annual economic losses due to bovine fasciolosis (E_L) are US$26.02 million (equivalent to 9.37 billion naira at US$1 = 360 naira).

Heterogeneity and pooling of studies on bovine fasciolosis

A total of 22 articles were selected for meta-analysis having been screened to assess only those that focused mainly on fasciolosis. Of 162,468 cattle observed, 28,550 were positive of either *Fasciola* egg or adult-stage. Studies revealed pooled prevalence of 18.3% (8.5–30.6); $Q = 7870$; $df = 21$; $P = 0.0001$ (Supplementary file 2). Female cattle were more infected with *Fasciola* compared ($P < 0.05$) with male cattle. The incidence of bovine fasciolosis was calculated to be 2.5% from the extracted studies between the last 1 year (2018 and 2019). Decadal trend of bovine fasciolosis revealed the lowest pooled prevalence to be recorded in 2010–2019 (Fig. 1).

Questionnaire results

A total of 7.3% livestock owners were aware of bovine fasciolosis threat. Broad-spectrum anthelminthics, e.g. albendazole (31%), ivermectin (30%), levamisole (8%) or those targeting trematodes such as praziquantel (28%) were often administered to treat worm burden, while some depended on different ethnoveterinary cocktails (3%). Anthelminthics were administered twice (54.2%), quarterly (28.2%) and anytime (17.6%), depending on worm burden

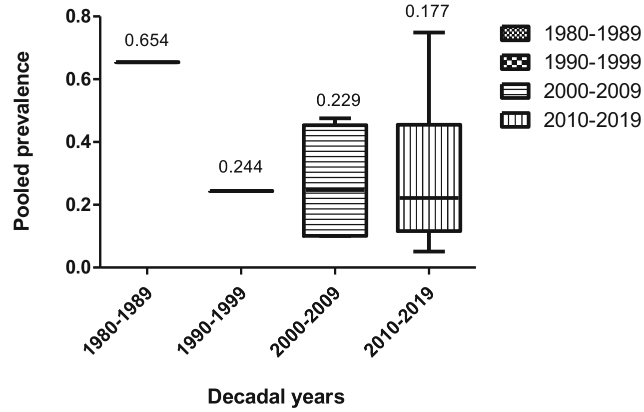

Fig. 1 Pooled prevalence of bovine fasciolosis across four decades

per season. A total of 62% make use of oral administration, as against injectables. Approximately 93% make use of river water sources and there are rotating settlements for cattle. Only few (4.3%) have ever used molluscicide on their farms or natural watering areas.

Discussion

The development and growth of livestock industry in Nigeria needs reassessment to improve constant supply of food animals for the ever-increasing population. Fasciolosis is a food-borne zoonotic parasite, mostly devastating in the chronic stage and major cause of liver damage in livestock (Karshima et al. 2016).

The estimated annual economic loss due to bovine fasciolosis was calculated to be US$26.02 million (9.37 billion naira). This estimation represents 0.03% of the livestock industry and could increase further if management and control plans are not considered. This estimation gives an indication of annual losses due to bovine fasciolosis and an urgent need for adequate control. This model revealed that 69,825 kg worth of the liver was condemned in Nigeria which was estimated at US$488,775, although this could still be lower than expected because there have been reports of restrictions from butchers and failure of compensation by the government which further slacked the enforcement of legislation on liver condemnation in Nigeria (Nwanta et al. 2008). Bovine fasciolosis economic estimation losses in other countries range from direct losses of US$210 million/year in Brazil (Molento et al., 2018), US$50 million annual loss from cattle in Peru (Espinoza et al. 2010), US$42.8 million/annum in Switzerland (Schweizer et al. 2005), US$595,560 in Mongu district of Zambia (Nyirenda et al. 2019) to US$35,082 from a single slaughterhouse of Preuvian Andes in Peru (Arias-Pacheco et al. 2020).

This study revealed that pooled prevalence of *F. gigantica* in cattle was 18.3%; however, most of the study were either detected in the laboratory or during slaughter. The pooled prevalence across the country could be due to abundant snail intermediate hosts, favourable ecological conditions and grazing management practices (Gboeloh, 2012). Decadal pooled prevalence of bovine fasciolosis showed continuous decrease due to several factors such as changes in anthelminthics usage, improved management and climate change. However, the 17.7% prevalence of the last decade is higher than the prevalence in the last 1 year with prevalence as low as 2.5%. Previous studies have reported that these factors could significantly affect the distribution of fasciolosis (Selemetas et al. 2015; Bennema et al. 2017; Molento et al. 2018). Host age and sex have also been reported to be important determinant of disease intensity and prevalence (Isah, 2019).

The economic losses were more pronounced on losses due to chronic effects and mortality cost, claiming US$18,304,000. Differences in cattle body weight (D_W) was an indicator and variations occur in response to bovine fasciolosis. The disease accounts for a significant reduction of 4.62% of carcass weight between infected and non-infected cattle, representing a reduction of US$36.6/head of revenue per infected animal. The disease severity could be directly associated with parasite burden and duration of infection. The model showed the livestock industry in Nigeria needs improvement to reduce losses associated with fasciolosis by critically considering management options and control strategies.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

References

Arias-Pacheco, C., Lucas, J.R., Rodriguez, A., Cordoba, D., Lux-Hoppe, E.G., 2020. Economic impact of the liver condemnation of cattle infected with *Fasciola hepatica* in the Peruvian Andes. Tropical Animal Health and Production, https://doi.org/10.1007/s11250-020-02211-y

Beesley N.J., Caminade C., Charlier J., Flynn R.J., Hodgkinson J.E., Martinez-Moreno A., Martinez-Valladares M., Perez J., Rinaldi L., Williams D.J.L., 2018. Fasciola and fasciolosis in ruminants in Europe: Identifying research needs. Transboundary and Emerging Diseases, 65, 1, 199–216. https://doi.org/10.1111/tbed.12682

Bennema, S.C., Molento, M.B., Scholte, R.G., Carvalho, O.S., Pritsch, I., 2017. Modelling the spatial distribution of Fasciola hepatica in bovines using decision tree, logistic regression and GIS query approaches for Brazil. Parasitology. https://doi.org/10.1017/S0031182017000786.

Berhanu, W., Bashahun, G.M. and Kebede, A., 2018. Major prevalence of liver fluke on meat market oriented of small ruminants. Scholars Journal of Agriculture and Veterinary Sciences 5, 532–540.

Bourn, D., 1992. Highlights of the Nigerian livestock resources report. Nigerian Livestock Resources, (ISBN 1898028001, Oxford, OXI 3QE, United Kingdom).

Elelu, N., Ambali, A., Coles, G.C., Eisler, M.C., 2016. Cross-sectional study of Fasciola gigantica and other trematode infections of cattle in Edu local government area, Kwara State, north-central Nigeria. Parasites and Vectors, 9, 470

Elelu, N. and Eisler, M.C., 2018. A review of bovine fasciolosis and other trematode infections in Nigeria. Journal of Helminthology, 92, 128–141.

Espinoza J., Terashima A., Herrera-Velit P., Marcos L., 2010. Fasciolosis humana y animal en el Perú: Impacto en la economía de las zonas endémicas. Revista Peruana de Medicina Experimental y Salud Pública, 27, 4, 604–612.

FAO, 2014. Food and Agriculture Organisation of the United Nations. FAOSTAT: Statistics division. Production/Live animals Nigeria (Accessed 2019). http://faostat3.fao.org/browse/Q/QA/E.

Gboeloh, L.B., 2012. Seasonal prevalence of *Fasciola gigantica* in slaughtered cattle in major abattoirs in Port Harcourt. Advances in Agriculture, Sciences and Engineering Research, 2, 336–340.

Ibironke, A.A. and Fasina, F.O., 2010. Socio-economic implications of bovine liver rejection in a major abattoir in south-western Nigeria. Revista de Ciencias Agrarias, 33, 211–216.

Isah, U.M., 2019. Studies on prevalence of fascioliasis among ruminant animals in northern Bauchi state, north-eastern Nigeria. Parasite Epidemiology and Control, 3, e00090.

Karshima, N.S., Bata, S.I. and Bobbo, A.A. 2016. Prevalence, risk factors and economic losses associated with fasciolosis in slaughtered cattle in Bauchi, North-eastern Nigeria. Alexandria Journal of Veterinary Sciences, 50, 87-93.

Karshima, S.N., 2018. Helminths of zoonotic importance in slaughtered food animals in Nigeria: a systematic review and meta-analysis. Journal of Helminthology, 93(3), 295–305.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G. and The PRIMSA Grp., 2010. Preferred reporting items for systematic reviews and meta-analyses: the PRIMSA statement. PLoS Medicine 6, e1000097.

Molento, M.B., Bennema, S., Bertot, J., Pritsch, I.C., Arenal, A., 2018. Bovine fascioliasis in Brazil: Economic impact and forecasting. Veterinary Parasitology: Regional Studies and Reports, 12, 1–3

Nwanta, J.D., Onunkwo, J.I., Ezenduka, V.E., Phil-Eze, P.O. and Egege, S.C., 2008. Abattoir operations and waste management in Nigeria: A review of challenges and prospects. Sokoto Journal of Veterinary Sciences, 7(2), 61–67.

Nyirenda, S.S., Sakala, M., Moonde, L., Kayesa, E., Fandamu, P., Banda, F. and Sinkala, Y., 2019. Prevalence of bovine fascioliasis and economic impact associated with liver condemnation in abattoirs in Mongu district of Zambia. BMC Veterinary Research, 15, 33.

Odeniran, P.O. and Ademola, I.O., 2016. Zoonotic parasites of wildlife in Africa: a review. African Journal of Wildlife Research, 46(1), 1–13.

Ogunrinade, A. and Ogunrinade, B.I., 1980. Economic importance of bovine fascioliasis in Nigeria. Tropical Animal Health and Production, 12, 155–160.

Schweizer, G., Braun, U., Deplazes, P., Torgerson, P.R., 2005. Estimating the financial losses due to bovine fasciolosis in Switzerland. Veterinary Records, 157, 188–193.

Selemetas, N., Phelan, P., O'Kiely, P., de Waal, T., 2015. The effects of farm management practices on liver fluke prevalence and the current internal parasite control measures employed on Irish dairy farms. Veterinary Parasitology, 207, 228–240.

Sewell, M.M.H., 1966. The pathogenesis of fascioliasis. Veterinary Record, 78, 98–105.