Research Article

Prevalence of Fascioliasis in Slaughtered Ruminants at Muyinga Slaughterhouse, Burundi

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Abstract | Fascioliasis is a parasitic zoonosis caused by *Fasciola hepatica* and *Fasciola gigantic*a affecting mainly domestic ruminants and occasionally humans. Due to the lack of epidemiological studies of fascioliasis in Burundi, this study was carried out to assess the prevalence of fascioliasis by liver inspection in slaughtered ruminants at Muyinga slaughterhouse. The liver of each slaughtered domestic ruminant was inspected, palpated and incised to look for flukes in the liver bile ducts. Statistical analysis was done using R software. A total of 265 domestic ruminants including 69 cattle, 190 goats, and 6 sheep were inspected to determine the presence of *Fasciola* spp. in their livers. The prevalence of *Fasciola* spp. was 13.04% (95% CI: 5.10-20.99) in cattle, 3.16% (95% CI: 0.67-5.64) in goats and 0.00% in sheep. The difference between the prevalence of *Fasciola* spp. in cattle and goats was statistically significant (OR= 4.60 (95% CI: 1.57-13.46), χ^2 = 7.345, p = 0.007). The result of this study confirmed the presence of fascioliasis in domestic ruminants in Burundi. Further studies assessing the epidemiology and socio-economic impacts of fascioliasis as well as the ecology of snails and larval fluke transmission in the definitive host should be conducted in Burundi. Effective control methods of liver flukes for intermediate and definitive hosts should be implemented to control fascioliasis in Burundi.

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Introduction

Fascioliasis is a parasitic zoonosis infecting mainly domestic ruminants and occasionally humans, caused by *Fasciola hepatica* and *Fasciola gigantica* (Mehmood *et al*., 2017; Torgerson, 2013). *F. hepatica* is mainly distributed in temperate regions including Europe, America and Oceania, while *F. gigantica* is commonly found in tropical regions of Africa and Asia, although its range may overlap with that of *F. hepatica* (Mas-Coma *et al*., 2009). The life cycle of these parasites involves an intermediate host (snail)

and a definitive host (livestock and humans). Humans and livestock get infected by ingesting encysted metacercariae with raw vegetables and contaminated pastures, respectively (WHO, 2006). Climatic conditions such as temperature, precipitation, and soil moisture influence the activity of *Fasciola* spp. and the increase in snails, which are crucial in the epidemiology of fascioliasis (Mas-Coma *et al*., 2009; Mehmood *et al*., 2017).

Fascioliasis leads to huge economic losses in the agricultural sector, due to the liver condemnation, emaciated carcasses, growth reduction, and reduced meat and milk production (Nyirenda *et al*., 2019; Torgerson, 2013). The annual economic losses ranging from 4 billion to 11 billion Australian dollars were estimated in South-East Asia cattle (Torgerson, 2013). In addition, in the public health sector, it is estimated that more than 2.6 million people worldwide are infected with *Fasciola* spp. and 180 million people are at risk of infection (Havelaar *et al*., 2015). The annual global burden of human fascioliasis was estimated at 90,000 disability-adjusted life years (DALYs) (Havelaar *et al*., 2015).

In Africa, fascioliasis due to *F. hepatica* is only distributed in the Mediterranean area, southern Zimbabwe, South Africa, Lesotho and some areas with high altitude in Kenya, Tanzania and Ethiopia, while fascioliasis due to *F. gigantica* is mainly distributed in most areas of the continent (Dermauw *et al*., 2021; Mehmood *et al*., 2017). Overall prevalence estimates in ruminants ranged from 0.19 to 73.7% in sheep, 1.2 to 91% in cattle, and 0.28 to 68.4% in goats (Mehmood *et al*., 2017). In sheep, the prevalence of fascioliasis was estimated at 20.7% in Ethiopia (Oljira *et al*., 2022), 23% in Chad (Jean-Richard *et al*., 2014), 27% in Cameroon (Takang *et al*., 2019) and 29.9% in Kenya (Kipyegen *et al*., 2022). The prevalence of fascioliasis in cattle was 0.09% in Botswana (Mochankana and Robertson, 2016), 3.8% in Sudan (Kheder and Mohamed, 2021), 6.7% in Tanzania (Mwabonimana *et al*., 2010), 18% in Cameroon (Takang *et al*., 2019), 19.9% in Rwanda (Sun *et al*., 2020), 20.24% in Ethiopia (Zewde *et al*., 2019), 27.68% in Nigeria (Magaji *et al*., 2014), 30.88% in Egypt (Elshraway and Mahmoud, 2017), 37.1% in Zimbabwe (Pfukenyi and Mukaratirwa, 2004), 46% in Kenya (Kipyegen *et al*., 2022), 64.4% in Zambia (Nyirenda *et al*., 2019), 65.7% in Uganda (Opio *et al*., 2021) and 68% in Chad (Jean-Richard *et al*., 2014). In goats, the prevalence of fascioliasis was 1.6% in Ethiopia (Oljira *et al*., 2022), 12% in Chad (Jean-Richard *et al*., 2014) and 24.1% in Kenya (Kipyegen *et al*., 2022).

Burundi is a landlocked country in East Africa. Agriculture and livestock are the pillars of the national and family economy (WFP, 2017). Domestic ruminants in Burundi are the main sources of proteins, income, and manure. The updated number of domestic ruminants is missing. In 2017, the total number of domestic ruminants in Burundi was 1,044,649 cattle; 512,882 sheep, and 3,043,059 goats (MEAE and Ministère des Finances, 2018). However, the liver condemnation due to *Fasciola* spp. infection during post-mortem inspection of carcasses and organs leads to significant economic losses for farmers and butchers (Mehmood *et al*., 2017). It was reported that in Eastern and Southern Africa, to which Burundi belongs, an overall prevalence of fascioliasis was 14.5% in cattle, 2.5% in goats, and 3.7% in sheep (Malatji *et al*., 2020). Fascioliasis has not been reported in Burundi, but extensive farming systems, water resources, and climatic conditions could contribute to the spread of that disease in Burundi (OIE, 2012; WFP, 2017). Epidemiological data on fascioliasis and liver condemnation of domestic ruminants due to *Fasciola* spp. at public slaughterhouses are lacking in Burundi. Therefore, this study was carried out to assess the prevalence of fascioliasis by liver inspection in slaughtered ruminants at Muyinga slaughterhouse in Burundi.

Materials and Methods

Study area and population

The study was conducted at the slaughterhouse of Muyinga city located in Muyinga commune of Muyinga province. Muyinga province is one of 18 Burundian provinces (Figure 1). This province borders Tanzania to the East and Rwanda to the North. It is adjacent to the provinces of Kirundo to the North, Ngozi to the West, Cankuzo to the South East and Karuzi to the South. It is made up of 7 communes such as Buhinyuza, Butihinda, Gashoho, Gasorwe, Giteranyi, Muyinga, and Mwakiro. It is characterized by a tropical climate with some differences in water and thermal regimes according to two natural regions, Bugesera and Bweru. Bweru region is characterized by an altitude varying between 1,600 and 1,800 m with a tropical climate with a long dry season (5

months), while Bugesera region is characterized by an altitude varying between 1,400 and 1,600 m with a hot tropical climate with irregular rains (Ministère de la Planification du développement et de la Reconstruction, 2006). Over the year, the temperature varies from 14°C to 28°C with an annual average temperature of 18.5°C. The average annual rainfall in the two regions is between 1,000 and 1,100 mm (Ministère de la Planification du développement et de la Reconstruction, 2006). Muyinga province covers an area of 1836.26 km^2 and the total population in 2020 was estimated at 880,706 people (ISTEEBU and UNFPA, 2013). The livestock population in 2017 was 32,745 cattle; 20,136 sheep; 261,482 goats; 29,200 pigs; 25,120 rabbits; 129,204 poultries and 165,078 guinea pigs (MEAE and Ministère des Finances, 2018). This study included all cattle, sheep, and goats brought to Muyinga slaughterhouse for slaughter.

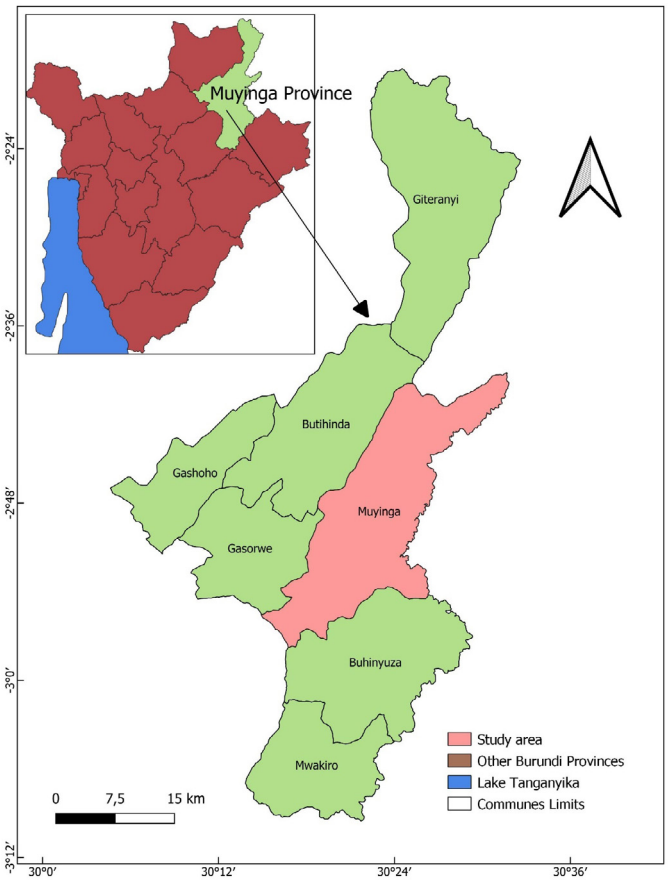

Figure 1: *Map of Burundi, Muyinga province and its 7 communes.*

Study design and sampling method

A cross-sectional study was conducted at Muyinga slaughterhouse from December 2020 to January 2021. A convenience sampling method was applied to obtain the number of cattle, sheep, and goats slaughtered at each visit to the slaughterhouse. To assess the prevalence of fascioliasis, every slaughtered domestic ruminant was diagnosed with fascioliasis by liver inspection. After slaughter, the liver of each domestic ruminant was inspected by a veterinarian in accordance with meat inspection procedures. The liver was visually inspected, palpated, and incised with a knife to look for liver flukes in the bile ducts (Figures 2 and 3). A domestic ruminant was considered positive for fascioliasis if liver flukes were found in the bile ducts (Figures 4 and 5). According to the schedule, a regular visit to the slaughterhouse was carried out twice a week (Tuesday and Friday, market days) until the end of the study. A total of 14 visits were made to the slaughterhouse during the data collection period.

Figure 2: *Dorsal side of healthy liver.*

Figure 3: *Ventral side of healthy liver.*

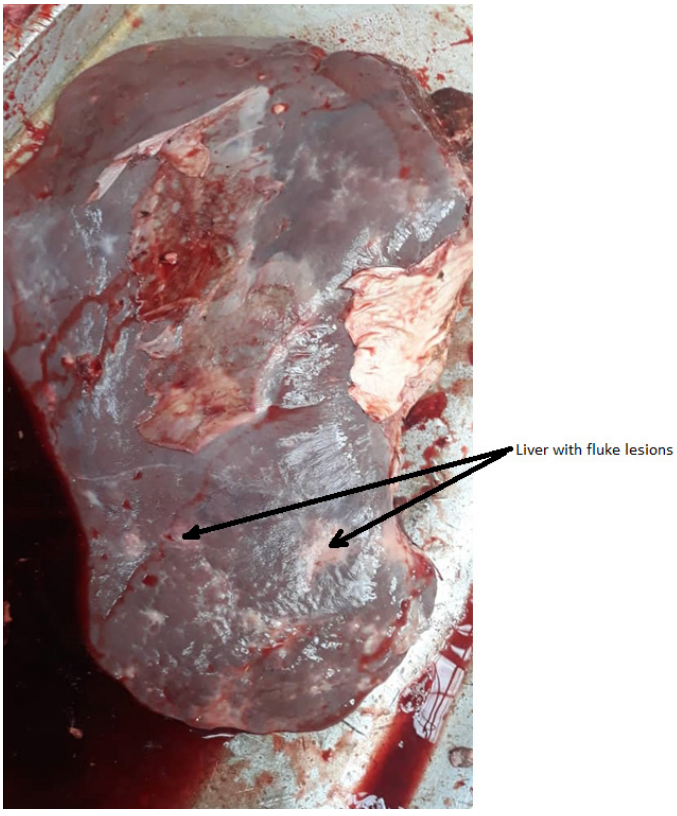

Figure 4: *Dorsal side of diseased liver with fluke lesions.*

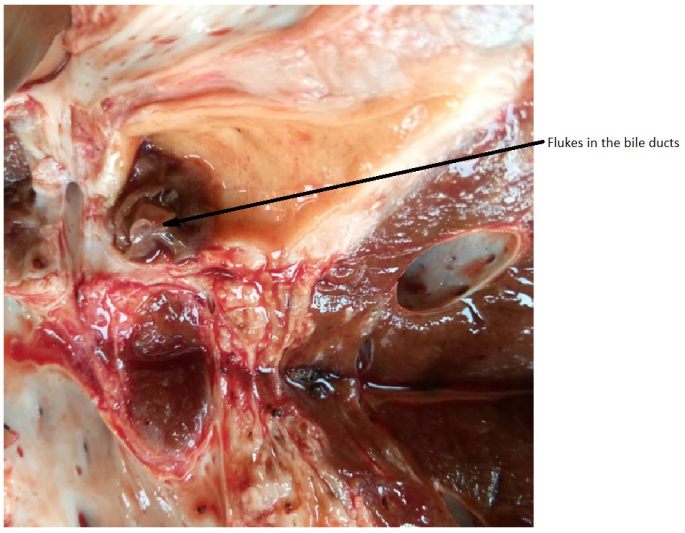

Figure 5: *Ventral side of diseased liver with flukes in the bile ducts.*

Data management and analysis

Prior to slaughter, descriptive data, including age, sex, and species of each domestic ruminant were recorded in Microsoft Excel 2007. After slaughter, positive and negative domestic ruminants for fascioliasis were also recorded. Then, data recorded in Microsoft Excel 2007 were exported in R software version 4.1 for analysis. The prevalence was calculated as a proportion of the number of infected domestic ruminants out of the total number of inspected domestic ruminants. Descriptive statistics to estimate the prevalence between age, sex and species were performed using the chi-square test. Odds ratio (OR) was used to calculate measures of associations. Results were calculated at 95% confidence intervals (CI) and the level of significance of $\alpha = 0.05$ was considered.

Results and Discussion

Description of the inspected cattle, goats, and sheep

At each visit to Muyinga slaughterhouse, an average of 5 cattle and 14 goats were sampled and inspected. A total of 265 domestic ruminants composed of 69 cattle with 16 males and 53 females, 190 goats with 59 males and 131 females, and 6 sheep with 3 males and 3 females were inspected for the presence of *Fasciola* spp. in the liver. The majority of cattle slaughtered were of the Ankole breed (88%) and other cattle (12%) were of the crossed breed. According to age, 18 cattle (26%) were under 3 years old while 51 cattle (74%) were more than three years old. In addition, all goats and sheep were local breeds. Most goats (71%) were more than two years old while 29% of goats were less than two years old. Of the total number of sheep inspected, 83% were more than two years old.

Prevalence of fascioliasis in cattle, goats, and sheep

Of the 265 domestic ruminants examined by liver inspection, 15 domestic ruminants (5.66%) were positive for *Fasciola* spp. at Muyinga slaughterhouse. The prevalence of *Fasciola* spp. by liver inspection was estimated at 13.04% in cattle, 3.16% in goats, and 0.00% in sheep (Table 1). Based on the animal species, the prevalence of *Fasciola* spp. in cattle was significantly higher ($p < 0.05$) than in goats (Table 2). However, the association between age, sex, and breed categories with the prevalence of *Fasciola* spp. in cattle, goats, and sheep was not statistically significant ($p > 0.05$) (Table 2).

Table 1: *Prevalence of Fasciola spp. in cattle, goats, and sheep at Muyinga slaughterhouse.*

Animal species	Inspected animals	Positive animals	Prevalence (%, 95% CI)
Cattle	69	9	13.04 (5.10-20.99)
Goats	190	6	3.16 (0.67-5.64)
Sheep	6	0	0.00
Total	265	15	5.66 (2.88-8.44)

CI: Confidence intervals.

This study is the first to assess the prevalence of fascioliasis in Burundi. The prevalence of fascioliasis found in cattle, goats, and sheep was lower than the prevalence reported in other African countries by liver inspection. This study found a prevalence of 13.04% in cattle, which was lower than the prevalence of 20.24% by liver inspection reported in Ethiopia (Zewde *et al.*, 2019), 27.68% in Nigeria (Magaji *et al.*, 2014), 30.88% in Egypt (Elshraway and Mahmoud, 2017), 37.1% in Zimbabwe (Pfukenyi and Mukaratirwa, 2004), 64.4% in Zambia (Nyirenda *et al.*, 2019), 65.7% in Uganda (Opio *et al.*, 2021), and 68% in Chad (Jean-Richard *et al.*, 2014). However, the prevalence found in cattle was similar to that reported in Cameroon and Eastern and Southern Africa (Malatji *et al.*, 2020; Takang *et al.*, 2019), while it was higher than 0.09% in Botswana (Mochankana and Robertson, 2016), 3.8% in Sudan (Kheder and Mohamed, 2021), and 6.7% in Tanzania (Mwabonimana *et al.*, 2010). In goats, the prevalence is in line with that found in Ethiopia (Oljira *et al.*, 2022) and lower than that in Chad (Jean-Richard *et al.*, 2014). No cases of *Fasciola* spp. in sheep were found during the liver inspection. This was due to the few sheep slaughtered at Muyinga slaughterhouse. In Burundi, sheep farming is less practised and accounts for one-sixth of the total number of goats (MEAE and Ministère des Finances, 2018). During sampling, only 6 sheep were slaughtered while 190 goats were slaughtered. In sheep, a prevalence of 23% was reported in Chad (Jean-Richard *et al.*, 2014), 27% in Cameroon (Takang *et al.*, 2019), 20.7% in Ethiopia (Oljira *et al.*, 2022), and 7.7% in Iran (Khanjari *et al.*, 2014).

Table 2: *Prevalence of Fasciola spp. based on sex, age and breed of cattle, goats, and sheep slaughtered at Muyinga slaughterhouse.*

Animals	Variables	Category	Inspected animals	Positive animals	Prevalence (%, 95% CI)	Chi-square (χ^2)	OR (95% CI)	p-value
Cattle	Sex	Male	16	2	12.50 (-3.70-28.70)	1.4968e-31	0.94 (0.17-5.04)	1.000
		Female	53	7	13.21 (4.09-22.32)			
	Age	<3years	18	2	11.11 (-3.41-25.63)	1.5515e-31	0.79 (0.15-4.18)	1.000
		>3years	51	7	13.73 (4.28-23.17)			
	Breed	Ankole	61	8	13.11 (4.64-21.59)	7.6301e-30	0.95 (0.10-8.74)	1.000
		Crossed	8	1	12.50 (-10.42-35.42)			
Goats	Sex	Male	59	4	6.78 (0.36-13.19)	2.154	4.69 (0.83-26.37)	0.142
		Female	131	2	1.53 (-0.57-3.63)			
	Age	<2years	56	3	5.36 (-0.54-11.25)	0.443	2.47 (0.48- 12.64)	0.506
		>2years	134	3	2.24 (-0.27-4.74)			
Sheep	Sex	Male	3	0	0.00	-	-	-
		Female	3	0	0.00			
	Age	<2years	1	0	0.00	-	-	-
		>2years	5	0	0.00			
Animal species	Species	Cattle	69	9	13.04 (5.10-20.99)	7.345	4.60 (1.57-13.46)	0.007*
		Goats	190	6	3.16 (0.67-5.64)			

*OR: Odds ratio, CI: Confidence intervals, *significant difference at $p < 0.05$*

The findings of this study show that the prevalence of fascioliasis in cattle was higher than in goats, which is in line with findings in Chad (Jean-Richard *et al.*, 2014). Husbandry practices and feeding patterns are likely the sources of infection in cattle and goats (Jean-Richard *et al.*, 2014; Takang *et al.*, 2019). Livestock movements in search of fodder, water points, and grazing in marshes are favourable conditions for bovine fascioliasis in Burundi. Jean-Richard *et al.* (2014) indicated that small ruminants prefer grazing and browsing on dry ground while avoiding wet areas. Nevertheless, dry pastures are not completely safe because fluke metacercariae may remain viable longer in previously flooded areas and on vegetation (Jean-Richard *et al.*, 2014). It was demonstrated that rainfall and high temperatures (>10°C) influence *Fasciola* egg hatch and snail growth (Mas-Coma *et al.*, 2009). The tropical climate with an average annual temperature of 18.5°C and annual rainfall of 1,100 mm could explain the presence of *Fasciola* spp. in Burundi (Ministère de la Planification du développement et de la Reconstruction, 2006). Furthermore, the findings of this study are not in agreement with the findings in Cameroon and Iran, where sheep were more susceptible to contracting fascioliasis than goats (Jean-Richard *et al.*, 2014; Khanjari *et al.*, 2014). They revealed that the high occurrence of fascioliasis in sheep could be explained by the fact that sheep graze on ground cover, while goats browse the leaves and branches of bushes, shrubs, and trees (Jean-Richard *et al.*, 2014; Khanjari *et al.*, 2014).

Regarding sex in cattle and goats, no significant difference was found between the prevalence of *Fasciola* spp. in males and females. Similar findings were reported by Abdi *et al.* (2015), Oljira *et al.* (2022), and Opio *et al.* (2021), where they found that sex had no impact on the occurrence of fascioliasis and that males and females are equally exposed to the infection when they move together in search of fodder and water. However, there may be a disparity in susceptibility between sexes due to intrinsic factors (genetics, physiology and immunology) and extrinsic factors (environment and management practices) (Magaji *et al.*, 2014).

Concerning age, our results demonstrated that there was no significant difference in the occurrence of fascioliasis in cattle under 3 years old and cattle over 3 years old. In addition, no difference in the occurrence of infection in goats under 2 years old and goats over 2 years old. This was not in agreement with the findings of Opio *et al.* (2021) and Zewde *et al.* (2019), who showed that the infection with *Fasciola* spp. was significantly higher in 4-years old cattle than in young cattle because they graze longer, which could increase the rate of exposure to fluke metacercariae.

Although routine meat inspection is a good veterinary practice to detect infected animals, the liver examination was performed by cutting the liver along the bile ducts, which may leave some immature parasites in the liver. It would be better to inspect the entire liver by cutting it into small pieces to see liver flukes in all bile ducts. Nevertheless, the entire liver inspection could reduce the quality and cost of meat, leading to losses for butchers. During the study, livers with light infections were trimmed, which may allow some immature liver flukes to enter the food chain. Consumption of raw or undercooked liver containing immature flukes has been shown to lead to infection in humans (Mas-Coma *et al.*, 2018). However, human fascioliasis has not been reported in Burundi. This study recommends deworming livestock twice a year, especially before and after the rainy season, as a method of controlling liver flukes. Moreover, grazing livestock with marsh fodder should be avoided, which would reduce the rate of exposure to fluke metacercariae.

This study had limitations related to the confirmation of *Fasciola* species during the liver inspection. We did not confirm that all cases were *F. gigantica*, species highly distributed in Africa because *F. hepatica* was also reported in neighbouring countries like Tanzania (Mehmood *et al.*, 2017). The sampling was carried out in the short dry season, which requires another sampling in the rainy seasons to better explain and understand the epidemiology of fascioliasis in Burundi.

Conclusions and Recommendations

This study revealed the prevalence of fascioliasis in cattle and goats. The occurrence of fascioliasis by sex, age, and breed was not statistically significant. Our study found that cattle were more susceptible to infection than goats. Further studies assessing the epidemiology and socio-economic impacts of fascioliasis as well as the ecology of snails and larval fluke transmission in the definitive hosts should be conducted in Burundi. Post-mortem inspection,

regular deworming of livestock and improved husbandry systems should be implemented to control fascioliasis in Burundi.

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Novelty Statement

This study is the first to assess the prevalence of fascioliasis in cattle, goats and sheep in Burundi. The funding of this study will contribute to the implementation of parasite control methods by stakeholders and policy makers and to the development of future research.

Author's Contribution

SM and EN conceived and designed the study, collected and analyzed the data. SM, EN, AB, AC, DN and VB wrote the paper. All authors reviewed and approved the final manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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