PESQUISA VETERINÁRIA BRASILEIRA
Brazilian Journal of Veterinary Research
ISSN 0100-736X (Print)
ISSN 1678-5150 (Online)

Pesq. Vet. Bras. 45:e07588, 2025
DOI: 10.1590/1678-5150-PVB-7588

Original Article
Livestock Diseases

Abamectin poisoning in adult beef cattle and calves in northern and midwestern Brazil[1]

Leandro S. Rocha[2], Bethania S. Santos[3], Maryele Rodrigues[4], João P.S. Cavasani[2], Flávio H.B. Caldeira[5], Fernando H. Furlan[2] and Edson M. Colodel[2]*

ABSTRACT.- Rocha L.S., Santos B.S., Rodrigues M., Cavasani J.P.S., Caldeira F.H.B., Furlan F.H. & Colodel E.M. 2025. **Abamectin poisoning in adult beef cattle and calves in northern and midwestern Brazil.** *Pesquisa Veterinária Brasileira 45:e07588, 2025.* Faculdade de Medicina Veterinária, Universidade Federal de Mato Grosso, Av. Fernando Corrêa da Costa 2673, Bairro Boa Esperança, Cuiabá, MT 78068-900, Brazil. E-mail: edson.colodel@ufmt.br

Abamectin is an anthelminthic widely used in agriculture, human, and veterinary medicine. The predomination in cases of abamectin toxicosis are neurological changes such as ataxia, lethargy, coma, tremors, convulsions, mydriasis, and blindness. This article describes the clinical, morphological, and toxicological results of cattle accidentally poisoned by abamectin on properties in the states of Rondônia and Mato Grosso, Brazil. Clinical and epidemiological data on the affected herd were collected from the owners, employees, and veterinarians of the properties. A clinical examination was conducted, and a necropsy was performed on the affected animals, with organ samples collected for histological and toxicological analysis. The main clinical signs observed were ataxia, apathy, and death. No significant gross or histologic changes were present. The concentration of abamectin in the brains and livers was > 25.00 µg/kg. The predisposing factors for the occurrence of these outbreaks were visual estimation of cattle weight, standardization of medication doses for batches of cattle, and medication bottle error during application resulting in poisoning and death of cattle. The findings emphasize the need to improve animal management and team training prior to drug application in properties.

INDEX TERMS: Antiparasitic, avermectins, bovine, poisoning, livestock.

RESUMO.- [Intoxicação por abamectina em bezerros e bovinos de corte adultos no Norte e Centro-Oeste do Brasil]. Abamectina é um medicamento amplamente utilizado na agricultura, medicina humana e veterinária. Na intoxicação por abamectina predominam alterações neurológicas como ataxia, letargia, coma, tremores, convulsões, midríase e cegueira. Este trabalho descreve os achados clínicos, morfológicos e análises toxicológicas em bovinos de corte acidentalmente intoxicados por abamectina nos Estados de Rondônia e de Mato Grosso, Brasil. Histórico, dados epidemiológicos e informações clínicas foram colhidos com proprietários, colaboradores e médicos veterinários nas propriedades. Foi realizado exame clínico nos bovinos e posteriormente, necropsia com colheita de amostras dos órgãos para análise histológica e toxicológica. Os principais sinais encontrados foram ataxia, apatia e morte. Não foram notadas alterações morfológicas significativas. A concentração de abamectina nos encéfalos e fígados foi > 25,00 µg/kg. Fatores predisponentes para a ocorrência desses surtos foram a estimativa visual de peso dos bovinos, padronização de doses do medicamento para os lotes e erro de frasco do medicamento durante a aplicação. Os achados enfatizam a necessidade de melhorias no manejo animal e treinamento da equipe antes do período de aplicação de medicamentos nas propriedades.

TERMOS DE INDEXAÇÃO: Antiparasitário, avermectinas, bovinos, intoxicação, pecuária.

[1] Received on December 13, 2024.
Accepted for publication on January 13, 2025.

[2] Faculdade de Medicina Veterinária (FAVET), Universidade Federal de Mato Grosso (UFMT), Av. Fernando Corrêa da Costa 2367, Boa Esperança, Cuiabá, MT 78060-900, Brazil. *Corresponding author: edson.colodel@ufmt.br

[3] Fiscal Estadual Agropecuário, Agência de Defesa Sanitária Agrosilvopastoril do Estado de Rondônia (IDARON), Rua Oscarina Marques 411, Urupa, Ji-Paraná, RO 76900-152, Brazil.

[4] Médica Veterinária, Coordenadora de Sanidade, BEA·MFG Agropecuária Ltda, Mato Grosso, MT Brazil

[5] Instituto Federal de Educação, Ciência e Tecnologia de Rondônia (IFRO), BR-435 Km 63, Zona Rural, Colorado do Oeste, RO 76993-000, Brazil.

INTRODUCTION

Avermectins are substances belonging to the macrocyclic lactone group that are widely used in agriculture and medicine due to their anthelmintic properties (Salman et al. 2022). Other pharmacological effects have been investigated, including anticancer, antidiabetic, antiviral, and antifungal properties, as well as the treatment of various metabolic disorders (El-Saber Batiha et al. 2020). Examples of avermectins are ivermectin, abamectin, moxidectin, doramectin, eprinomectin, and selamectin (Jayakumar 2009).

The dosage of avermectins generally used in cattle is 0.2 mg/kg for injectable formulations and 0.5 mg/kg for pour-on formulations (Prichard et al. 2012). Abamectin poisoning at therapeutic doses is reported mainly in young animals and Collie dogs (Salman et al. 2022).

In poisoning, neurological alterations such as ataxia, lethargy, tremors, convulsions, mydriasis, and blindness predominate. Avermectins generally have a long half-life, and therefore overdoses result in a prolonged clinical course (Merola & Eubig 2018).

The diagnosis of avermectin poisoning can be based on the history of exposure, clinical signs, and analysis of residues in tissues or body fluids. Gastrointestinal contents, liver, fat, and feces are samples that are usually analyzed to detect drug residues, while brain tissue is used to confirm poisoning (Gwaltney-Brant et al. 2018).

On farms, the choice of antiparasitic is made by livestock farmers and occasionally by veterinarians (Klafke et al. 2024). As there is no specific treatment (Gwaltney-Brant et al. 2018), it is essential to characterize outbreaks of abamectin poisoning.

This study describes the clinical, epidemiological, pathological, and toxicological findings of three outbreaks of accidental abamectin poisoning in beef cattle.

MATERIALS AND METHODS

Ethical approval. This study follows the precepts of Act No. 11,794, dated October 8, 2008, and was submitted and approved as certified in Process No. 23108.031812/2023-07 issued by the Ethics Committee on Animal Use of the "Universidade Federal de Mato Grosso" (CEUA-UFMT-5838902).

The poisoning outbreaks were monitored by technicians from the "Laboratório de Patologia Veterinária" (Veterinary Pathology Laboratory – LPV) of the UFMT. They occurred in three rural properties located in the municipality of Nova Mamoré (Prop-1) (10° 24′ 47″ South, 65° 19′ 38″ West), state of Rondônia, North Brazil, and Tangará da Serra (Prop-2) (14° 37′ 40′ South, 57° 30′ 25″ West) and Poxoréu (Prop-3) (15° 50′ 27″ South, 54° 23′ 39″ West), both in the state of Mato Grosso, Midwest Brazil. The cattle's history, epidemiological, and clinical data were collected from owners, employees, and veterinarians during visits to the three properties during outbreaks. This study included evaluations of five cattle (Bov1, Bov2, Bov3, Bov4 and Bov5) from Prop-1, three cattle (Bov6, Bov7 and Bov8) from Prop-2 and a calf (Bov9) from Prop-3.

The clinical examination was performed on eight cattle (Bov1, Bov3, Bov4, Bov5, Bov6, Bov7, Bov8, and Bov9) according to Constable et al. (2021). Six cattle (Bov1, Bov2, Bov6, Bov7, Bov8, and Bov9) were necropsied, and organ fragments from these animals were fixed in 10% formalin, routinely processed for histology, and stained with hematoxylin-eosin (HE) at LPV-UFMT for microscopic analysis.

Samples of liver (Bov1 and Bov2) and central nervous system (Bov6, Bov7, and Bov8) were collected, stored in a freezer at -20 °C and sent to determine the concentration of abamectin (samples liver and central nervous system), and ivermectin (samples central nervous system) in the tissues using liquid chromatography with triple-quadruple mass spectrometry (LC-MS/MS) at the Microbioticos® Laboratory in Campinas, São Paulo, Brazil.

RESULTS

Prop-1 was intended to raise Nelore and crossbred steers and bulls. The animals were acquired from various farms within the region. Their average weight and age were estimated at 240 kg (ranging between 190 and 290 kg) and 20 months. On October 22 and 23, 2021, health management was carried out in 1,500 cattle that recently arrived on the property, using subcutaneously 6 ml/bovine of an antiparasitic composed of ivermectin 2.25%/abamectin 1.25% (indication of 1 ml for every 50 kg of live weight) and a vaccine against clostridial diseases. Two hours after the application of these medications, 50 cattle presented sialorrhea, drowsiness, tympanism, difficulty locomotion, and apathy (Table 1). Eleven cattle died from October 22, 2021, to November 1, 2021. Close to death, all cattle showed severe apathy and remained in sternal or lateral recumbency. The morbidity coefficient was 3.3%, and the mortality was 0.7%.

Bov1, a crossbred steer, was dehydrated, with pale mucous membranes, tenesmus (Fig.1), and hematochezia. It was

Table1. Abamectin poisoning in beef cattle: Information on the properties and clinical outcome of poisoned cattle

Property	Morbidity/mortality coefficient	Onset of clinical signs in animals	Bovine identification	Age	Sex	Main clinical signs	Clinical outcome
Prop-1 Nova Momoré/RO	3.3%/0.7%	2 h	Bov1	20 months	M	Tenesmus, apathy, hematochezia	Death*
			Bov2	20 months	M	Apathy and tympanism	Death
			Bov3	20 months	M	Apathy and aggression	Death
			Bov4	20 months	M	Apathy and difficulty moving	Survived
			Bov5	20 months	M	Sialorrhea and dehydration	Survived
Prop-2 Tangará da Serra/ MT	10%/4.4%	48 h	Bov6	24 months	M	Ataxia and muscle tremors	Death
			Bov7	24 months	M	Ataxia and muscle tremors	Death
			Bov8	24 months	M	Ataxia and muscle tremors	Death
Prop-3 Poxoréu/MT	100%/85.7%	24 to 48 h	Bov9	4 days	M	Severe apathy, ataxia, head down	Death

* Animal subjected to euthanasia; h = hours, M = male, RO = Rondônia, MT = Mato Grosso.

euthanized and then subjected to necropsy. Bov2, a Nelore steer, had difficulty moving, apathy, and tympanism, died after two days of evolution, and was subjected to necropsy. Bov3, a Nelore steer, was leaning on the fences of the paddock or in sternal recumbency (Fig.2) and when stimulated, became aggressive; however, it died 10 days after sanitary management. Bov4, a crossbred steer, had difficulty moving and Bov5, a crossbred steer, had severe apathy, sialorrhea (Fig.3), and dehydration; both survived.

Prop-2 raised Nelore and crossbred cattle. There was a batch of 180 Nelore cattle already on the farm, with an average weight and age of 250 kg and 24 months. On December 13, 2022, was administered subcutaneously 8 ml/bovine of an antiparasitic composed of ivermectin 2.25%/abamectin 1.25% (indication of 1 ml for every 50 kg of live weight) in the batch of 180 cattle. Of these, 18 animals showed ataxia, apathy, motor incoordination, muscle tremors (mainly in the lips), and sialorrhea. Eight cattle died within two days after drug administration, and three of them were necropsied

Fig.1-3. Clinical presentation of abamectin poisoning in beef cattle in Nova Mamoré/RO, Brazil. (**1**) Cattle (Bov1) presenting tenesmus. (**2**) Cattle (Bov3) in sternal recumbency presenting apathy. (**3**) The bovine (Bov5) was apathetic and had sialorrhea.

(Bov6, Bov7, and Bov8). The morbidity coefficient was 10%, and the mortality was 4.4%.

Prop-3 raised and marketed Nelore beef calves. They were born weighing an average weight of 28 kg. On 22 June 2022, 1 ml of the antiparasitic compound abamectin 1% (contraindicated for calves) was administered subcutaneously to 21 newborn calves. The calves became ill, and 18 of them died three days after the drug was administered. A calf was necropsied (Bov9). Clinical signs began between 24 and 48 hours after the drug was administered and included severe apathy, ataxia, and head-down. The morbidity coefficient was 100%, and the mortality coefficient was 85.7%.

No significant gross or microscopic lesions were found in the cattle necropsied during the outbreaks. Concentrations greater than 25 µg/kg of abamectin were found in samples of central nervous system and liver. Ivermectin was not detected in the brain samples.

DISCUSSION

The diagnosis of abamectin poisoning on farms was based on the history, epidemiology, clinical signs, absence of pathological changes, and the identification of avermectins in the brains and livers of cattle.

Livestock farming activity can be significantly reduced due to the effects of parasites that affect cattle, as they affect the well-being and productivity of cattle. In Brazil, direct and indirect losses are associated with gastrointestinal nematodes, tick spoliation, mainly *Rhipicephalus microplus*, and dipterans such as horn flies (*Haematobia irritans*), human botfly (*Dermatobia hominis*), New World screwworm (*Cochliomyia hominivorax*), and stable fly (*Stomoxys calcitrans*) (Grisi et al. 2014).

The indiscriminate use of chemical pesticides in veterinary medicine facilitates the development of resistance by parasite populations to the active ingredients of these products (Melo et al. 2021). Also, it causes illness and death in cattle related to the toxic effects of the drugs, as described in our study.

One of the determining factors for the occurrence of outbreaks was the visual estimate of the weight of the cattle. In Prop-1, it is believed that abamectin poisoning is related to the standardized dose of 6 ml/bovine, subcutaneously, without taking into account the individual assessment of weight, breed, or age, resulting in overdoses in some cattle in the herd. The estimated average weight of the batch was 240 kg, with a variation of 50 kg. Therefore, some cattle received an overdose of approximately 1 to 2 ml of the antiparasitic.

In Prop-2, 8 ml of dewormer was administered to the cattle, but it was later estimated, based on the average weight, that the dose should not exceed 5 ml/bovine. Although some animals may be more susceptible to poisoning, any species can be poisoned if the dose of the drug administered is sufficient to cross the blood-brain barrier (Andrade 2017).

The medication used in Prop-1 and Prop-2 was composed of ivermectin 2.25%/abamectin 1.25%. In addition to the consistent clinical signs and compatibility with reports by Seixas et al. (2006), abamectin was found in brain samples and the liver, which is known to be the most toxic of the avermectins (Prichard et al. 2012).

In Prop-3, the collaborators reported knowing the toxic effects of abamectin on calves. They reported that they routinely used ivermectin on newborns, but in this case, the poisoning was attributed to confusion with the medication packaging. The presentation has similar containers and greenish labels. The product was switched; instead of ivermectin, each calf received a dose of 1 ml of abamectin 1%. Abamectin (0.4 mg/kg) is toxic to calves, and although there are no detectable lesions at necropsy, clinical and epidemiological evaluations are essential to conclude the field diagnosis when laboratory assistance is limited (Guizelini et al. 2020).

Avermectins have broad-spectrum efficacy against various ecto-endoparasites and have been shown to enhance animal welfare and productivity. They are an advantageous choice for routine parasite control programs when used at recommended doses. However, indiscriminate use of these drugs can cause serious harm to animal production (Lifschitz et al. 2024).

It is common to apply injectable antiparasitics to newborn calves with the main objective of preventing umbilical myiasis and also controlling ticks. It is important to train farm employees before administering medication to the animals. To prevent umbilical myiasis, a good alternative is to replace injectable avermectins with topical products (Aquino et al. 2022). The use of a topical alcohol-iodine solution (6 to 10% concentration) at birth is effective in healing the navel. The dressing must be applied more than once, and it is essential to observe if there is myiasis or other inflammation before the subsequent application of an appropriate drug (Ribeiro & Furlong 2021).

Avermectins have a wide pharmacological safety margin for ruminants (Andrade 2017); however, the therapeutic use of ivermectin in cows can result in hormonal changes such as a decrease in serum follicular stimulating hormone, luteinizing hormone, and estradiol for up to three months (Sadek & Shaheen 2015) and the iatrogenic therapeutic dose of abamectin can cause deaths in calves (Seixas et al. 2006) or when suckling calves have mothers treated with abamectin-based pour-on (Borges et al. 2021). The therapeutic safety of avermectins in adult cattle is intricately linked to the level of expression and activity of the gene for the multidrug-resistant protein 1(MDR1 or ABCB1), an ABC transporter gene that encodes for P-gp in the blood-brain barrier (Gwaltney-Brant et al. 2018, Machado & Riet-Correa 2022). The toxic effect and detection of avermectins in the central nervous system are observed when there are high concentrations of avermectins in the blood that saturate the possibility of clearance by the P-gp efflux pump (Borges et al. 2021, Machado & Riet-Correa 2022). These effects are more severe in newborn calves because the blood-brain barrier is wholly formed, and the expression of the ABC transporters genes and proteins are effective in other organs, but the MDR1 and P-gp expression in the vessels of CNS is very low at birth and increases significantly over the next two weeks (Merola & Eubig 2018, Verscheijden et al. 2020)

It is necessary to use medications responsibly in animal production, associated with improvements in cattle management that include the choice of more appropriate protocols for the prevention of umbilical myiases. Training and guidance for farm technicians are recommended before avermectin administration periods to minimize poisoning by these drugs.

CONCLUSION

Abamectin poisonings on different farms were associated with overdoses or errors in the selection of medication vials. The cattle showed ataxia, sialorrhea, apathy, and death. The

diagnosis should be based on the history of use, the relationship between body weight and dose administered, clinical signs, and the absence of significant morphological lesions. It should be complemented by the detection of abamectin in tissue samples from the animal.

Acknowledgments.- The authors would like to thank the "Coordenação de Aperfeiçoamento de Pessoal de Nível Superior" (CAPES) and "Fundação de Amparo à Pesquisa do Estado de Mato Grosso" (FAPEMAT) for granting a grant to carry out the study.

Conflict of interest statement.- The authors declare that there is no conflict of interest.

Credit author statement.- Leandro S. Rocha – Postgraduate Researcher, responsible for scientific writing, review, and investigations on abamectin poisoning in adult cattle in the state of Rondônia. Bethania S. Santos – State Veterinary Inspector at IDARON-RO, responsible for clinical evaluation, necropsy, and sample collection in cases reported in Rondônia. Maryele Rodrigues – Veterinarian, responsible for clinical evaluation and necropsy of adult cattle in cases occurring in the State of Mato Grosso. João P.S. Cavasani – Veterinarian, responsible for clinical investigation and necropsy in cases of abamectin poisoning in calves reported in this study. Flávio H.B. Caldeira – Veterinariy Pathologist, responsible for histomorphological analysis of abamectin poisoning cases in the State of Rondônia. Fernando H. Furlan – Professor and Veterinary Pathologist, responsible for histological analysis of abamectin poisoning cases in calves occurring in the State of Mato Grosso. Edson M. Colodel – Professor and Veterinary Pathologist, responsible for morphological analysis and complementary evaluations of the effects of abamectin use in cattle reported in this study.

Data availability statement.- The authors confirm that the data supporting the findings of this study are deposited in the archives of the LPV, Veterinary Hospital, UFMT, Cuiabá/MT, Brazil, and will be made available upon request to the corresponding author (Colodel E.M.).

REFERENCES

Andrade SF. Manual de Terapêutica Veterinária: consulta rápida. Rio de Janeiro: Roca; 2017.

Aquino LM, Ferreira LL, Zapa DMB, Heller LM, Trindade ASN, Morais IML, Salvador VF, Leal LLLL, Couto LFM, Mendonça RP, Costa IS, Soares VE, Monteiro CMO, Lopes WDZ. Number of rainy days in a week influencing screwworm navel myiasis in beef calves and efficacies of injectable and topical antiparasitics. Res Vet Sci 2022; https://doi.org/10.1016/j.rvsc.2022.10.004, PMid:36252323

Borges DGL, Borges FA, Vieira MC, Pupin RC, Araújo MA, Guizelini CC, Lemos RAA. Poisoning of calves reared with cows treated with abamectin. Toxicon 2021; https://doi.org/10.1016/j.toxicon.2021.10.005, PMid:34662630

Constable P, Hinchcliff K, Done S, Grünberg W. Clínica Veterinária: um tratado de doenças de bovinos, ovinos, suínos e caprinos. 11ª ed. Rio de Janeiro: Guanabara Koogan; 2021.

El-Saber Batiha G, Alqahtani A, Ilesanmi OB, Saati AA, El-Mleeh A, Hetta HF, Beshbishy AM. Avermectin derivatives, pharmacokinetics, therapeutic and toxic dosages, mechanism of action, and their biological effects. Pharmaceuticals, Basel 2020; https://doi.org/10.3390/ph13080196, PMid:32824399

Grisi L, Leite RC, Martins JRS, Barros AT, Andreotti R, Cançado PHD, León AA, Pereira JB, Villela HS. Reassessment of the potential economic impact of cattle parasites in Brazil. Rev Bras Parasitol Vet 2014; https://doi.org/10.1590/s1984-29612014042, PMid:25054492

Guizelini CC, Pupin RC, Möck TBM, Morais DR, Arredondo JAC, Robalinho LL, Gimelli A, Lemos RAA. Approaches for a field diagnosis of abamectin poisoning in calves. Pesq Vet Bras 2020; https://doi.org/10.1590/1678-5150-PVB-6498

Gwaltney-Brant SM, DeClementi C, Gupta RC. Macrocyclic lactone endectocides, p.539-550. In: Gupta RC. Veterinary Toxicology. 3rd ed. St Louis: Elsevier; 2018.

Jayakumar J. Bio-efficacy of Streptomyces avermitilis culture filtrates against root knot nematode, *Meloidogyne incognita* and reniform nematodes, *Rotylenchulus reniformis*. Karnataka J Agric Sci 2009;22:567-571.

Klafke GM, Golo PS, Monteiro CMO, Costa-Júnior LM, Reck J. Brazil's battle against *Rhipicephalus* (*Boophilus*) *microplus* ticks: current strategies and future directions. Rev Bras Parasitol Vet 2024; https://doi.org/10.1590/S1984-29612024026, PMid:38922203

Lifschitz A, Nava S, Miró V, Canton C, Alvarez L, Lanusse C. Macrocyclic lactones and ectoparasites control in livestock: efficacy, drug resistance and therapeutic challenges. Int J Parasitol Drugs Drug Resist 2024; https://doi.org/10.1016/j.ijpddr.2024.100559, PMid:39128184

Machado M, Riet-Correa F. Intoxicações por avermectinas e milbemicinas, p.30-33. In: Riet-Correa F, Schild AL, Lemos R, Borges JR, Mendonça FS, Machado M. Doenças de Ruminantes e Equídeos. Vol.2. 4ª ed. São Paulo: Medvet; 2022.

Melo LRB, Sousa LC, Oliveira CSM, Alvares FBV, Ferreira LC, Bezerra RA, Athayde ACR, Feitosa TF, Vilela VLR. Resistance of bovine gastrointestinal nematodes to four classes of anthelmintics in the semiarid region of Paraíba state, Brazil. Rev Bras Parasitol Vet 2021; https://doi.org/10.1590/S1984-29612021077, PMid:34550213

Merola VM, Eubig PA. Toxicology of avermectins and milbemycins (macrocylic lactones) and the role of P-glycoprotein in dogs and cats. Vet Clin North Am Small Anim Pract 2018; https://doi.org/10.1016/j.cvsm.2018.07.002, PMid: 30139545

Prichard R, Ménez C, Lespine A. Moxidectin and the avermectins: Consanguinity but not identity. Int J Parasitol Drugs Drug Resist 2012; https://doi.org/10.1016/j.ijpddr.2012.04.001, PMid:24533275

Ribeiro ACCL, Furlong J. Cura de Umbigo. Empresa Brasileira de Pesquisa Agropecuária, Agronegócio do Leite; 2021. Accessed on July 15, 2024. https://www.embrapa.br/agencia-de-informacao-tecnologica/criacoes/gado_de_leite/producao/sistemas-de-producao/manejo-sanitario/cura-de-umbigo

Sadek KM, Shaheen HM. The biochemical effects of ivermectin on reproductive hormones and mineral homeostasis in Baladi cows post parturition. Vet Arh 2015;85(1):95-103.

Salman M, Abbas RZ, Mehmood K, Hussain R, Shah S, Faheem M, Zaheer T, Abbas A, Morales B, Aneva I, Martínez JL. Assessment of avermectins-induced toxicity in animals. Pharmaceuticals 2022; https://doi.org/10.3390/ph15030332, PMid:35337129

Seixas JN, Peixoto PV, Armién AG, Jabour FF, Brito MF. Aspectos clínicos e patogenéticos da intoxicação por abamectina em bezerros. Pesq Vet Bras 2006; https://doi.org/10.1590/S0100-736X2006000300006

Verscheijden LFM, van Hattem AC, Pertijs JCLM, de Jongh CA, Verdijk RM, Smeets B, Koenderink JB, Russel FGM, de Wildt SN. Developmental patterns in human blood-brain barrier and blood-cerebrospinal fluid barrier ABC drug transporter expression. Histochem Cell Biol 2020; https://doi.org/10.1007/s00418-020-01884-8, PMid: 32448916