

# *In vitro* anthelmintic effect of Malvaceae family plants in sheep and goat parasites: Review

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## ABSTRACT

**Objective:** To analyze scientific database information on the *in vitro* anthelmintic effects of plant species from the Malvaceae family in sheep and goats.

**Materials and Methods:** A selection of articles was retrieved from the following databases: Biblat, Google Scholar, Reaxys, ScienceDirect, Scopus, and Springer. The inclusion criteria encompassed original studies published between 2002 and 2022 that investigated Malvaceae species, assessing their *in vitro* anthelmintic effects on parasites at any developmental stage in sheep and goats. Articles published in English, Spanish, and Portuguese were considered.

**Results:** A total of 4,020 results were identified. After abstract screening, 13 articles meeting the inclusion criteria were selected, highlighting the relevance of 10 plant species within the Malvaceae family, with particular emphasis on *Abutilon* spp. (shrubs) and *Guazuma ulmifolia* (tree). The most significant findings indicate that seven plant species exhibit effects on *Haemonchus contortus*, three on *Trichostrongylus* spp., two on *Oesophagostomum* spp., and one species each on *Moniezia expansa*, *Teladorsagia* spp., *Cooperia* spp., and *Nematodirus* spp.

**Implications:** Ovicidal activity has been reported with methanolic, aqueous, and hexanic extracts of *Abutilon theophrasti* against *H. contortus*, as well as with aqueous extracts of *Urena lobata* leaves, which demonstrated over 70% inhibition of *H. contortus* egg hatching.

**Conclusions:** Plant species within the Malvaceae family exhibit anthelmintic properties and could serve as a valuable tool in the integrated parasite control strategies for small ruminants.

**Keywords:** Plant extracts; animal helminthiasis; parasite management; secondary metabolites; alternative methods; small ruminants

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## INTRODUCTION

The production of sheep and goats is one of the most significant agricultural activities in several Latin American countries, providing economic security that other sectors often cannot offer. Additionally, it contributes to the supply of meat and milk



from these species (Hernández-Valenzuela *et al.*, 2019). However, small ruminants face multiple challenges, particularly in nutrition, reproduction, and health. Among these, gastrointestinal parasites (PGI) represent the primary health concern, significantly reducing productivity in grazing systems (Cruz-Tamayo *et al.*, 2020). The major PGI classes affecting sheep and goats flukes, cestodes, nematodes, and protozoa are responsible for substantial economic losses (Kumsa & Hagos, 2020; Rodríguez-Vivas *et al.*, 2017; Starling *et al.*, 2019; Ilangopathy *et al.*, 2019). Numerous studies highlight the high prevalence and pathogenicity of many parasite species (Arsenopoulos *et al.*, 2021; Cobon & Osullivan, 1992; López *et al.*, 2013), particularly in tropical regions where favorable climatic conditions enhance their development. This includes countries such as Mexico (Rodríguez-Vivas *et al.*, 2017) and Brazil (Starling *et al.*, 2019), where both economic and health risks associated with parasitic infections have been documented. Among these parasites, *Haemonchus contortus* is the most economically significant due to its global distribution and high pathogenicity in small ruminants (Arsenopoulos *et al.*, 2021; Cobon & Osullivan, 1992; López *et al.*, 2013; Besier *et al.*, 2016). This hematophagous nematode colonizes the abomasum, causing severe blood loss, hemorrhagic gastritis, and anemia, often leading to high mortality rates, particularly among lambs (López *et al.*, 2013; Besier *et al.*, 2016). Other nematodes of veterinary importance include *Trichostrongylus colubriformis*, *Cooperia curticei*, *Oesophagostomum columbianum*, *Trichuris* spp., and *Strongyloides papillosus*, among others (López *et al.*, 2013). PGI control is traditionally managed through anthelmintic drugs; however, their long-term effectiveness is compromised by the increasing resistance of parasites, reducing treatment efficacy (Claerebout *et al.*, 2020; Hodgkinson *et al.*, 2019; Santiago-Figueroa *et al.*, 2019). Consequently, alternative strategies for parasite control have been developed, including plant-based bioactive compounds as a sustainable approach to reducing dependence on synthetic anthelmintics (García-Hernández *et al.*, 2017; Medina *et al.*, 2014). The Malvaceae family includes economically important plant species such as cocoa, cotton, and durian, widely utilized in the textile and food industries (Wang *et al.*, 2020). Furthermore, dietary inclusion of Malvaceae species in small ruminant feed has demonstrated positive effects on animal productivity (Mayren-Mendoza *et al.*, 2018; Valdivié & Martínez, 2022). The family comprises 243 genera and 4,225 species distributed worldwide (Vadivel *et al.*, 2016). Among its secondary metabolites with therapeutic potential are thylyroside, lespedin, rutin, myricetin, quercetin, and apigenin, recognized for their antioxidant properties, as well as taraxerol, known for its anti-inflammatory effects (Fernandes de Oliveira *et al.*, 2012; Khanra *et al.*, 2015). Additionally, Calixto *et al.* (2016) identified bioactive compounds such as chlorogenic acid, rutin, and luteolin in ethanolic extracts of *Guazuma ulmifolia* leaves, which have demonstrated antiparasitic activity in previous studies on other plant species (Liu *et al.*, 2020). A selection of the most representative species is presented in Table 1.

The aim of this study is to conduct a comprehensive review of the key findings from *in vitro* studies on plant extracts from the Malvaceae family, evaluating their potential for controlling helminths in small ruminants.

**Table 1.** Main species of Malvaceae family.

Genus	Scientific name
<i>Abelmoschus</i>	<i>Abelmoschus moschatus</i> , <i>A. esculentus</i> , <i>A. Manihot</i> , <i>A. esquirolii</i> , <i>A. mindanaensis</i>
<i>Abroma</i>	<i>Abroma augustum</i> , <i>A. alata</i> , <i>A. angulata</i> , <i>A. angulosa</i> , <i>A. augusta</i> , <i>A. communis</i> , <i>A. denticulata</i> , <i>A. elongata</i> , <i>A. fastuosa</i> , <i>A. javanica</i> , <i>A. mariae</i> , <i>A. mollis</i> , <i>A. nitida</i> , <i>A. obliqua</i> , <i>A. sinuosa</i> , <i>A. tomentosa</i> , <i>A. wheleri</i>
<i>Abutilon</i>	<i>Abutilon albescens</i> , <i>A. auritum</i> , <i>A. bedfordianum</i> , <i>A. berlandieri</i> , <i>A. californicum</i> , <i>A. darwinii</i> , <i>A. eremitopetalum</i> , <i>A. fruticosum</i> , <i>A. hirtum</i> , <i>A. hulseanum</i> , <i>A. hyoleucum</i> , <i>A. incanum</i> , <i>A. indicum</i> , <i>A. pakistanicum</i> , <i>A. grandiflorum</i> , <i>A. theophrasti</i> , <i>A. insigne</i> , <i>A. leonardi</i> , <i>A. mollicomum</i> , <i>A. mollissimum</i> , <i>A. niveum</i> , <i>A. malacum</i> , <i>A. megapotamicum</i> , <i>A. menziesii</i> , <i>A. ochsenii</i> , <i>A. palmeri</i> , <i>A. pannosum</i> , <i>A. parishii</i> , <i>A. parvulum</i> , <i>A. permolle</i> , <i>A. pictum</i> , <i>A. purpurascens</i> , <i>A. reventum</i> , <i>A. sachetianum</i> , <i>A. sandwicense</i> , <i>A. thurberi</i> , <i>A. thyrsodendron</i> , <i>A. trisulcatum</i> , <i>A. venosum</i> , <i>A. virginianum</i> , <i>A. vitifolium wrightii</i>
<i>Bombax</i>	<i>Bombax albidum</i> , <i>B. anceps</i> , <i>B. blancoanum</i> , <i>B. buonopozense</i> , <i>B. ceiba</i> , <i>B. costatum</i> , <i>B. insigne</i>
<i>Duboscia</i>	<i>Duboscia acuminata</i> , <i>D. briei</i> , <i>D. macrocarpa</i> , <i>D. polyantha</i> , <i>D. viridiflora</i>
<i>Guazuma</i>	<i>Guazuma crinita</i> , <i>G. invira</i> , <i>G. iuvira</i> , <i>G. longipedicellata</i> , <i>G. ulmifolia</i>
<i>Hibiscus</i>	<i>Hibiscus sabdariffa</i> , <i>H. cannabinus</i> , <i>H. rosa-sinensis</i> , <i>H. syriacus</i> , <i>H. trionum</i>
<i>Helicteres</i>	<i>Helicteres lhotzkyana</i> , <i>H. longepedunculata</i> , <i>H. macropetala</i> , <i>H. macrothrix</i> , <i>H. microcarpa</i> , <i>H. muscosa</i> , <i>H. nipensis</i> , <i>H. ovata</i> , <i>H. pentandra</i> , <i>H. pilgeri</i> , <i>H. pintonis</i> , <i>H. plebeja</i>
<i>Herissantia</i>	<i>Herissantia crispa</i> , <i>H. dressleri</i> , <i>H. nemoralis</i> , <i>H. tiubae</i> , <i>H. trichoda</i>
<i>Lavatera</i>	<i>Lavatera bryoniifolia</i> , <i>L. cachemiriana</i> , <i>L. cashemiriana</i> , <i>L. flava</i> , <i>L. oblongifolia</i> , <i>L. trimestris</i> , <i>L. thuringiaca</i> , <i>L. olbia</i> , <i>L. punctata</i> , <i>L. triloba</i>
<i>Malva</i>	<i>Malva alcea</i> , <i>M. pánica</i> , <i>M. borealis</i> , <i>M. parviflora</i> , <i>M. aegyptia</i> , <i>M. sylvestris</i> L. <i>crispa</i> , <i>M. coromandelianum</i> , <i>M. cretica</i> , <i>M. erecta</i> his, <i>M. iljini</i> , <i>M. ilindsayi</i> , <i>M. multiflora</i> , <i>M. neglecta</i> , <i>M. arborea</i> , <i>M. nicaeensis</i> , <i>M. cathayensis</i> , <i>M. occidentalis</i>
<i>Pavonia</i>	<i>Pavonia xanthogloea</i> , <i>P. multiflora</i> , <i>P. spinifex</i> , <i>P. archavaletana</i> , <i>P. intermedia</i> , <i>P. hastata</i>
<i>Sida</i>	<i>Sida acuta</i> , <i>S. antillensis</i> , <i>S. cardiophylla</i> , <i>S. carpinifolia</i> , <i>S. ciliaris</i> , <i>S. cleisocalyx</i> , <i>S. clementii</i> , <i>S. cryphiopetala</i> , <i>S. cordifolia</i> , <i>S. rhombifolia</i> , <i>S. hermaphrodita</i> , <i>S. tuberculata</i> , <i>S. echinocarpa</i> , <i>S. fallax</i> , <i>S. hederifolia</i> , <i>S. intricata</i> , <i>S. kingii</i> , <i>S. hermaphrodita</i> , <i>S. nesogena</i> , <i>S. phaeotricha</i> , <i>S. physocalyx</i>
<i>Theobroma</i>	<i>Theobroma angustifolium</i> , <i>T. bicolor</i> , <i>T. cacao</i> , <i>T. glaucum</i> , <i>T. grandiflorum</i> , <i>T. leiocarpa</i> , <i>T. mammosum</i> , <i>T. mariae</i> , <i>T. martiana</i> , <i>T. microcarpus</i> , <i>T. obovatum</i> , <i>T. pentagona</i>
<i>Urena</i>	<i>Urena lobata</i> , <i>U. sinuata</i>

Modified from The World Flora Online, WFO (2024).

## METHODOLOGY

**Data source and search strategy.** We conducted a search for scientific articles on the use of plant species from the Malvaceae family for parasite treatment in sheep and goats. The information was retrieved from the following digital databases: Biblat, Google Scholar, Reaxys, ScienceDirect, Scopus, and Springer, considering original articles published between 2002 and 2022. The search terms used in each database were: (a) Biblat: Malvaceae, sheep, and goats; (b) Google Scholar: Malvaceae, anthelmintic, sheep, or goat; (c) Reaxys: Malvaceae, anthelmintic; (d) ScienceDirect: Malvaceae, anthelmintic; (e) Scopus: Malvaceae, anthelmintic, sheep, or goat; and (f) Springer: Malvaceae, anthelmintic, sheep, or goat. The abstracts of the retrieved articles were analyzed, and

those meeting the inclusion criteria were selected for further evaluation. Additionally, a search was conducted for the 243 genera within the Malvaceae family.

**Inclusion criteria.** Only original papers published in English, Spanish, or Portuguese, focusing on plants from the Malvaceae family and related to the *in vitro* evaluation of bioactive metabolite extracts, were included. The studies considered involved internal parasites of sheep or goats, employing various techniques to assess the effectiveness of plant-derived products at different stages of parasite development. The article selection process is illustrated in Figure 1.

The abstracts of the retrieved articles were analyzed, and those meeting the inclusion criteria were selected for evaluation. Additionally, a search was conducted for the 243 genera within the Malvaceae family. The information from the selected articles was organized into Excel sheets, identifying the author, country, year of publication, and plant species evaluated. Furthermore, the parasite involved, life cycle stages, and the technique used for the evaluation were recorded. A total of 4,022 documents were obtained: 2,800 from Google Scholar, 1,089 from Biblat, 85 from Springer, 44 from Reaxys, 3 from Scopus, and 2 from ScienceDirect. After analyzing the abstracts, eleven articles met the inclusion criteria and were selected as the basis for this study.

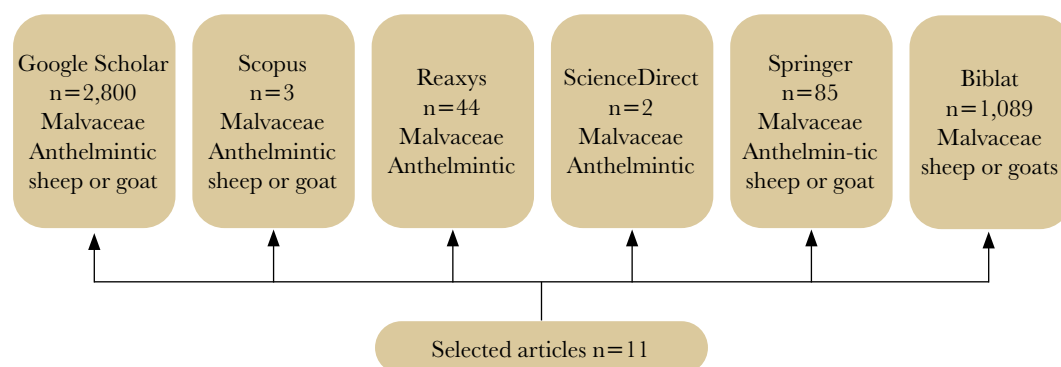
## RESULTS

Table 2 presents the reported *in vitro* evaluations of plant species from the Malvaceae family against gastrointestinal parasites of small ruminants, along with the techniques used for assessment.

Table 3. Presents the species of the Malvaceae family evaluated *in vitro* against gastroenteric nematodes of sheep and goats, the types of extracts developed, and the secondary metabolites reported.

## DISCUSSION

India and Mexico have conducted the highest number of *in vitro* experimental trials on plants from the Malvaceae family, primarily between 2018 and 2022. These studies have focused mainly on the gastrointestinal nematodes *Haemonchus* spp., *Trichostrongylus* spp., and *Oesophagostomum* spp. Within this plant family, the most extensively studied species for



**Figure 1.** Characteristics of the selected scientific articles included in this analysis.

**Table 2.** *In vitro* evaluation reports on the effectiveness of Malvaceae species in controlling gastrointestinal nematodes in small ruminants.

Country	Animal	Parasite	Technique	Reference
Slovakia	Ovine	<i>Haemonchus contortus</i>	IEH - DL	Váradyová <i>et al.</i> (2018)
France	Goat	<i>Haemonchus contortus</i> , <i>Trichostrongylus colubriformis</i>	Larval sheath inhibition	Quijada <i>et al.</i> (2015)
India	Ovine	<i>Moniezia expansa</i>	Motility inhibition - ML	Thooyavan <i>et al.</i> (2018)
India	Ovine	<i>Haemonchus contortus</i>	IEH - ML	Hassan <i>et al.</i> (2019)
Indonesia	Ovine	<i>Haemonchus contortus</i>	IEH - DL - Adult motility	Suteky & Dwatmadji (2015)
Mexico	Ovine	<i>Haemonchus</i> sp. <i>Oesophagostomum</i> sp. <i>Trichostrongylus</i> sp. <i>Cooperia</i> sp. <i>Nematodirus</i> sp.	IEH	Antonio-Irineo <i>et al.</i> (2021)
Mexico	Ovine	<i>Haemonchus contortus</i>	ML	García-Arce (2019)
Mexico	Ovine	<i>Haemonchus contortus</i>	IEH - ML	Reséndiz-González <i>et al.</i> (2022)
Pakistan	Ovine	<i>Haemonchus contortus</i>	ML	Zia-Ul-Haq <i>et al.</i> (2012)
South Africa	Ovine	<i>Haemonchus</i> sp., <i>Oesophagostomum</i> , <i>Trichostrongylus</i> <i>Teladorsagia</i>	IEH - DL - ML	Molefe <i>et al.</i> (2013)
Ukraine	Goat	<i>Strongyloides papillosus</i>	ML	Boyko & Brygadyrenko (2021)

DL: larval development test, IEH: Egg hatching inhibition test, ML: Larval mortality test.

anthelmintic purposes in small ruminants over the past two decades are *Guazuma ulmifolia* and species of the genus *Abutilon* spp. (Table 3). Antonio-Irineo *et al.* (2021) conducted a preliminary study on the *in vitro* efficacy of aqueous extracts from the leaves of four plant species at three different concentrations (0.75, 1.0, and 1.25 mL), including *Guazuma ulmifolia*, a tree widely distributed in the Americas, particularly in Brazil and Mexico. Their findings indicated that the aqueous extract of *G. ulmifolia* exhibited egg hatching inhibition (IEH) of 62.4%, 59.8%, and 22% at 1.25, 1.0, and 0.75 mL, respectively. Various secondary compounds, such as tannins, flavonoids, saponins, mucilages, alkaloids, and terpenes, have been identified in the leaves and fruits of *G. ulmifolia* (Pereira *et al.*, 2019). Moreover, condensed and hydrolyzable tannins, along with certain phenolic acids, have been isolated from other plant families with known antiparasitic potential (Cortes-Morales *et al.*, 2022; Olmedo-Juárez *et al.*, 2017). A recent study by Reséndiz-González *et al.* (2022) demonstrated that a hydroalcoholic extract of *G. ulmifolia* possesses ovicidal properties against *Haemonchus contortus*. The authors identified key bioactive compounds, including kaempferol, ethyl ferulate, ethyl coumarate, flavonol, luteolin, ferulic acid, luteolin rhamnoside, apigenin rutinoside, coumaric acid derivatives, luteolin glycoside, and quercetin glycoside, which have been shown to disrupt the biological cycle of gastrointestinal nematodes. Regarding the genus *Abutilon* (*A. indicum* and *A. theophrasti*), the primary groups

**Table 3.** *In vitro* reports of Malvaceae on gastroenteric nematodes of sheep and goats.

Species	Common name	Extracrit	Concentration			Life Cycle Phase	Isolated Compounds	Reference
			*(mg/ml)	**( $\mu$ g/mL)	***%			
<i>Abutilon indicum</i>	Indica Mallow	Methanolic	25, 50 and 100*			Adult	Alkaloids, Flavonoids, Tannins, Phenols, Terpenoids, Diterpenoids, Steroids and Cardiac Glycosides	Thooyavan G. <i>et al.</i> (2018)
<i>Abutilon theophrasti</i>	Velvet Sheet	Aqueous Hexanic Methanolic	500, 250, 125, 62.5, and 31.25*			Egg	-	Hassan <i>et al.</i> (2019)
<i>Althaea officinalis</i> L.	Marshmallow	Aqueous Methanolic		Methanolic	Aqueous	Egg, L 1 and L 3	Routine	Váradyová <i>et al.</i> (2018)
			IEH	1024, 256, 64, 16, 4, 1**	50, 25, 12.5, 6.25, 3.125*			
			DL	1365-0.66**	40-0.019			
<i>Malva sylvestris</i> L.	Common Mallow	Aqueous Methanolic		Methanolic	Aqueous	Egg, L 1 and L 3	Rutin, Gallic Acid, Quercetin, Kaempferol	Váradyová <i>et al.</i> (2018)
			IEH	1024, 256, 64, 16, 4, 1**	50, 25, 12.5, 6.25, 3.125*			
			DL	1365-0.66**	40-0.019			
<i>Grewia asiatica</i>	False	Methanolic	50, 25, 12.5, 6.25 and 3.12			L3	-	Zia-Ul-Haq <i>et al.</i> (2012)
<i>Guazuma ulmifolia</i>	Guácima	Aqueous	0.75, 1.00 and 1.25*			Egg	Phenols, Condensed Tannins and Total Tannins	Antonio-Irineo <i>et al.</i> (2021)
<i>G. ulmifolia</i>	Guácima	Hydroalcoholic	10, 5, 2.5 and 1.25			Egg & L3	Kaempferol, Ethylferulate, Ethylcoumarate, Flavonol, Luteolin, Ferulic Acid, Luteolin Rhamnoside, Apigenin Rutinoside, Coumaric Acid Derivatives, Luteolin Glycoside, and Quercetin	Reséndiz-González <i>et al.</i> (2022)
<i>Hermannia depressa</i>	-	Aqueous Acetonic	2.5, 5.0 and 7.5*			L1, L2 and L3	-	Molefe <i>et al.</i> (2013)
<i>Thuringiac lavatera</i>	Royal Mallow	Aqueous extract	3.0, 0.75 and 0.19***			L 1 and L 2	-	Boyko & Brygadyrenko (2021)
<i>Theobroma Cacao</i>	Cocoa	Acetone-water 70:30	600, 300, 150, 75 and 37.5**			L 3	Tannins	Quijada <i>et al.</i> (2015)
<i>Urena lobata</i>	Guaxima from Brazil	Aqueous	3.125, 6.25, 12.5, 25 and 50*			Egg, L 3	Alkaloids, Flavonoids, Tannins, Coumarins, Saponins, Triterpenoids,, Mangiferin, Quercetin	Suteky & Dwatmadji (2015)
<i>American Waltheria</i>	White Brush	Methanol, Hexanic Dichloromethane	50, 25, 12.5, 6.25, 3.12, 1.56 and 0.78*			L3, L4	-	Garcia-Arce (2019)

IEH Inhibition of Egg Hatching, DL Larval Development Test, L1 first stage larvae, L2 second stage larvae, L3 third stage larvae.

of secondary metabolites identified include alkaloids, flavonoids, catechins, anthocyanidins, sterols, vitamins, sugars, tannins, phenols, terpenoids, diterpenoids, steroids, and cardiac glycosides (Thooyavan *et al.*, 2018; Hassan *et al.*, 2019). The methanolic extract of *Abutilon indicum* demonstrated a concentration-dependent effect on *Moniezia expansa*, influencing both the time of paralysis and mortality of the parasite. This effect may be attributed to the presence of phenolic compounds and alkaloids in the extract (Thooyavan *et al.*, 2018). Similarly, *Abutilon theophrasti* exhibited *in vitro* antiparasitic effects depending on the concentration of methanolic, aqueous, and hexane extracts in both IEH and larval mortality (ML) assays. Among these, the methanolic extract showed the highest efficacy at 500 mg/mL, achieving 74.39% IEH and 79.79% ML (Hassan *et al.*, 2019). Additionally, *Grewia asiatica* demonstrated antiparasitic potential, with its methanolic extract achieving an LC50 of 17.21 mg/mL in ML tests against *H. contortus* (Zia-Ul-Haq *et al.*, 2012).

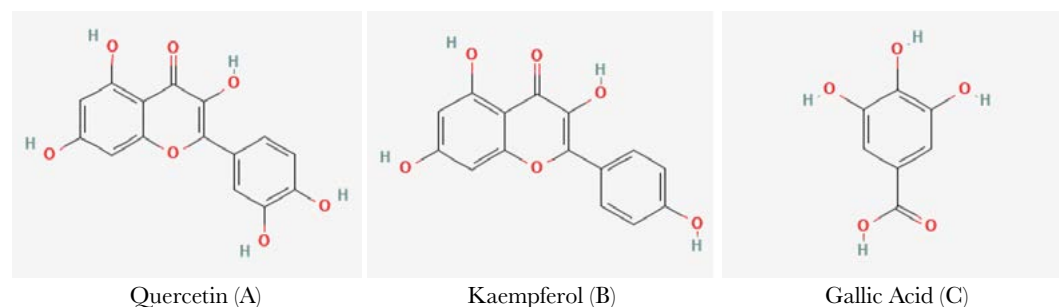
For *Hermannia depressa*, an aqueous extract at 7.5 mg/mL achieved 40.14% IEH, whereas the acetone extract resulted in only 7.4% inhibition. However, in larval development inhibition assays, the acetone extract demonstrated 100% efficacy at all tested concentrations, while the aqueous extract showed the highest inhibition at 7.5 mg/mL, reaching 66.69%. Regarding larval mortality, the aqueous extract at 7.5 mg/mL resulted in 100% mortality within 24 hours, with a clear concentration-dependent effect (Molefe *et al.*, 2013). For *Lavatera thuringiaca*, an aqueous leaf extract at a 3% concentration resulted in 97.4% ML of L1 and L2 larvae of *Strongyloides papillosus* (Boyko & Brygadyrenko, 2021). Additionally, phytochemicals such as alkaloids, cardiac glycosides, tannins, terpenoids, and saponins were identified in the leaves of *Urena lobata* (Suteky & Dwatmadji, 2015). The aqueous extract of *U. lobata* was tested for anthelmintic properties using IEH, motility, and larval development assays against *H. contortus*. The highest concentration (50 mg/mL) achieved 70.08% IEH and 57.8% ML (Suteky & Dwatmadji, 2015; Islam & Uddin, 2017). Váradyová *et al.* (2018) assessed the anthelmintic activity of 13 medicinal plants from Central Europe, including aqueous and methanolic extracts of *Althaea officinalis* roots and *Malva sylvestris* flowers, at concentrations ranging from 1 to 1,024  $\mu\text{g/mL}$  against *H. contortus*. Aqueous extracts exhibited an IEH of 88.3% in *A. officinalis* and 40.4% in *M. sylvestris*. In ML assays, the methanolic extract of *M. sylvestris* had an LC50 of 53  $\mu\text{g/mL}$ , while the aqueous extract had an LC50 of 90  $\mu\text{g/mL}$ . For *A. officinalis*, the LC50 values were 157  $\mu\text{g/mL}$  for the aqueous extract and 236  $\mu\text{g/mL}$  for the methanolic extract. In Mexico, García-Arce (2019) evaluated extracts of varying polarity from the roots and leaves of *Waltheria americana* against *H. contortus* infective larvae. The highest ML percentages at 48 hours were observed with hexanic (root), methanolic (leaf), and dichloromethane (root) extracts, achieving 42.61%, 39.1%, and 30.25%, respectively. Additionally an acetone-water extract from *Theobroma cacao* seeds was tested against *H. contortus* and *Trichostrongylus colubriformis* infective larvae. This extract was fractionated to isolate condensed tannins, specifically prodelphinidins and procyanidins (Quijada *et al.*, 2015). The study demonstrated that prodelphinidins inhibited larval sheath development at lower concentrations compared to procyanidins. Based on the findings presented, it can be concluded that the anthelmintic efficacy of extracts from Malvaceae species varies depending on the extraction method, the concentration of secondary metabolites, and the specific bioactive compounds present.

**Malvaceae Secondary metabolites.** Secondary metabolites with proven anthelmintic effects in plants from other botanical families have been identified in species of the Malvaceae family (Castillo-Mitre *et al.*, 2017; von Son-de Fernex *et al.*, 2015; García-Hernández *et al.*, 2022). *Luehea paniculata* and *Guazuma ulmifolia* were evaluated using ethanolic extracts from leaves and bark, revealing the presence of flavonoids such as quercetin (Figure 2a), rutin, and kaempferol (Figure 2b), as well as gallic acid (Figure 2c), chlorogenic acid, and caffeic acid (Calixto *et al.*, 2016). Similarly, Tanaka *et al.* (2005) isolated the metabolite epicatechin from the stems and leaves of *L. divaricata*. In *Malva sylvestris* leaves, secondary metabolites such as gallic acid, rutin, quercetin, and kaempferol were identified, while *Althaea officinalis* leaves contained rutin (Váradyová *et al.*, 2018).

Similarly, the metabolite hydroxycinnamic acid was isolated from the aqueous extract of *Malva neglecta* leaves (Sharifi-Rad *et al.*, 2020), all of which have been reported to exhibit anthelmintic activity (Liu *et al.*, 2020). Research into the potential anthelmintic effects of plant species from the Malvaceae family could contribute to the development of alternative treatments, helping to reduce the prevalence of gastrointestinal parasites and their resistance to conventional drugs in small ruminants.

It is important to note that, out of the 4,225 plant species belonging to the Malvaceae family, only 10 species have been evaluated for their *in vitro* anthelmintic effects in small ruminants. Secondary metabolites are synthesized in limited amounts within plants and are often restricted to specific genera or botanical families, including certain plant species (Ávalos & Pérez-Urria, 2009; Hernández-Alvarado *et al.*, 2018). For this reason, the Malvaceae family presents new opportunities for research into the natural control of gastrointestinal nematodes in small ruminants.

Medicinal plants serve as an alternative source of bioactive compounds for the pharmaceutical industry. Ethnobotanical and ethnopharmacological knowledge provides an essential foundation for their identification and selection (Leitão *et al.*, 2014). Malvaceae species are widely used in traditional medicine due to their antibacterial, anti-inflammatory, antiviral, hepatoprotective, analgesic, expectorant, diuretic, and antioxidant properties, as well as their role in the treatment of urinary disorders, stomach ailments, and digestive pain (Ariharan & Revathi, 2021; Hamed *et al.*, 2014; Martínez & Jiménez-Escobar, 2017). However, the vast diversity of bioactive compounds within this botanical family presents significant research opportunities, as many species remain insufficiently studied regarding



**Figure 2.** Metabolites with anthelmintic effects isolated from species of the Malvaceae family. Adapted from PUBCHEM (National Center for Biotechnology, 2023).

their phytochemical composition, making them valuable targets for further investigation (Vadivel *et al.*, 2016).

**Other Uses of Family Plants Malvaceae.** Research has been conducted on the use of Malvaceae species in animal feed and their productive impact. Mayren-Mendoza *et al.* (2018) evaluated the effect of supplementing *Guazuma ulmifolia* foliage on the productive performance of Pelibuey sheep, reporting increased dry matter intake, weight gain (0.50 kg per animal,  $p \geq 0.05$ ), and feed efficiency (0.02,  $p \geq 0.05$ ) compared to animals that did not receive this supplementation. Similarly, Mata-Espinosa *et al.* (2006) assessed the supplementation of tulip tree flour (*Hibiscus rosa-sinensis*), mulberry (*Morus alba*), and cocoitte (*Gliricidia sepium*) in pasture-fed lamb diets. Their findings showed higher daily supplement intake (167.2 vs. 149.7 vs. 97.7 g/day,  $p < 0.05$ ) and greater consumption of star grass (*Cynodon nlemfuensis*) (941.8 vs. 848.6 vs. 796.1 g/day,  $p < 0.05$ ) compared to the other evaluated forage trees. Additionally, daily weight gain (GDP) was statistically similar to that of lambs supplemented with concentrates (77.1 vs. 81.6 g/day,  $p < 0.05$ ).

Ruiz-Sesma *et al.* (2006) investigated the inclusion of *Hibiscus rosa-sinensis* hay in diets for hair sheep, analyzing diet digestibility and GDP. The highest response was observed with a diet containing 60% hay from this forage shrub per kg of dry matter. Meanwhile, Le Bodo *et al.* (2020) evaluated the addition of 30% (dry basis) fresh foliage from *G. ulmifolia* in sheep diets over a 30-day period. Their study found no significant anthelmintic or anticoccidial effects, and the impact on GDP was inconsistent, likely due to the absence of an adaptation period and the short evaluation timeframe. In conclusion, certain plants from the Malvaceae family exhibit notable anthelmintic effects and can be considered as potential alternatives for inclusion in integrated parasite control strategies. However, further *in vitro* and *in vivo* studies are necessary, along with investigations into other genera within the same botanical family that have not yet been explored. This would open up new opportunities for evaluating the biological effects of Malvaceae species in controlling gastrointestinal nematodes.

### Conflict of Interest

The authors declare no conflict of interest.

### Thanks

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## REFERENCES

- Antonio-Irinea, N., Flota-Bañuelos, C., Hernández-Marín, A., Arreola-Enríquez, J., & Fraire-Cordero, S. (2021). Preliminary study on the *in vitro* inhibition of gastrointestinal nematodes from sheep with aqueous extracts from forage plants. *Abanico Veterinario*, 11:1-15. <https://doi.org/10.21929/abavet2021.10>
- Ariharan, B., & Revathi, P. (2021). Documentation of ethnomedicinal and ethnoveterinary plants used by Paliyar tribes, Kurangani Hills, Western Ghats, Theni District, Tamil Nadu, India. *Kongunadu Research Journal*, 8(1):51-64. <https://doi.org/https://doi.org/10.26524/krj.2021.8>
- Arsenopoulos, K. V., Fthenakis, G. C., Katsarou, E. I., & Papadopoulos, E. (2021). Haemonchosis: A challenging parasitic infection of sheep and goats. *Animals*, 11(2):1-29. <https://doi.org/https://doi.org/10.3390/ani11020363>
- Ávalos, G.A., & Pérez-Urria, C.E. (2009). Secondary metabolism of plants. *Reduca (Biology)*. *Plant Physiology Series*, 2(3):119-145. <http://www.revistareduca.es/index.php/biologia/article/download/798/814>
- Besier, R. B., Kahn, L. P., Sargison, N. D., & Van Wyk, J. A. (2016). The Pathophysiology, Ecology and Epidemiology of *Haemonchus contortus* Infection in Small Ruminants. In *Advances in Parasitology*, (Vol. 93). Elsevier Ltd. <https://doi.org/10.1016/bs.apar.2016.02.022>
- Boyko O. O., & Brygadyrenko V. V. (2021). Nematicidal activity of aqueous tinctures of plants against larvae of the nematode *Strongyloides papillosus*. *Tropical Biomedicine*, 38(2):85-93. <https://doi.org/10.47665/tb.38.2.046>
- Calixto Júnior, J. T., de Morais, S. M., Gomez, C. V., Molas, C. C., Rolon, M., Boligon, A. A., At-hayde, M. L., de Morais Oliveira, C. D., Tintino, S. R., & Henrique Douglas, M. C. (2016). Phenolic composition and antiparasitic activity of plants from the Brazilian Northeast “Cerrado.” *Saudi Journal of Biological Sciences*, 23(3):434-440. <https://doi.org/10.1016/j.sjbs.2015.10.009>
- Castillo-Mitre, G. F., Olmedo-Juárez, A., Rojo-Rubio, R., González-Cortázar, M., Mendoza-de Gives, P., Hernández-Beteta, E. E., Reyes-Guerrero, D. E., López-Arellano, M. E., Vázquez-Armijo, J. F., Ramírez-Vargas, G., & Zamilpa, A. (2017). Caffeoyl and coumaroyl derivatives from *Acacia cochliacantha* exhibit ovicidal activity against *Haemonchus contortus*. *Journal of Ethnopharmacology*, 204:125-131. <https://doi.org/10.1016/j.jep.2017.04.010>
- Claerebout, E., De Wilde, N., Van Mael, E., Casaert, S., Velde, F. V., & Roeber, F. (2020). Anthelmintic resistance and common worm control practices in sheep farms in Flanders, Belgium. *Veterinary Parasitology Regional Studies and Reports*, 8:100393 <https://doi.org/10.1016/j.vprsr.2020.100393>
- Cobon, D. H., & O’Sullivan, B. M. (1992). Effect of *Haemonchus contortus* on productivity of ewes, lambs and weaners in a semi-arid environment. *The journal of Agricultural Science*, 118(2):245-248. <https://doi.org/https://doi.org/10.1017/S0021859600068854>
- Cortes-Morales, J. A., Olmedo-Juárez, A., González-Cortazar, M., Zamilpa, A., López-Arellano, M. A., Ble-González, E. A., Tapia-Maruri, D., Flores-Franco, G., & Salinas-Sánchez, D. O. (2022). *In vitro* ovicidal activity of *Brongniartia montalvoana* against Small Ruminant Gastrointestinal Nematodes. *Experimental Parasitology*, 240:108336. <https://doi.org/10.1016/j.exppara.2022.108336>
- Cruz-Tamayo, A., González-Garduño, R., Torres-Hernández, G., Becerril-Pérez, C. M., Hernández-Mendo, O., Ramírez-Bribiesca, J. E., López-Arellano, M. E., Vargas-Magaña J.J., & Ojeda-Robertos N. F. (2020). Comparison of two phenotypical methods to segregate resistant and susceptible lambs to parasitic nematodes. *Austral Journal of Veterinary Science*, 52(1):9-18. <https://doi.org/10.4067/S0719-81322020000100103>
- Fernandes de Oliveira, A. M., Sousa Pinheiro, L., Souto Pereira, C. K., Neves Matias, W., Albuquerque Gomes, R., Souza Chaves, O., Vanderlei de Souza, M. de F., Nóbrega de Almeida, R., & Simões de Assis, T. (2012). Total phenolic content and antioxidant activity of some Malvaceae family species. *Antioxidants*, 1(1):33-43. <https://doi.org/10.3390/antiox1010033>
- García Arce, C. A. (2019). *In vitro* and *in vivo* anthelmintic activity of wild plant extracts and hair roots of *Waltheria americana* Linn. Master’s Thesis. Universidad Autónoma de Morelos. 57 pp. <http://riaa.uaem.mx/handle/20.500.12055/1812>
- García-Hernández, C., Arece-García, J., Rojo-Rubio, R., Mendoza-Martínez, G.D., Albarrán-Portillo, B., Vázquez-Armijo, J. F., Avendaño-Reyes, L., Olmedo-Juárez, A., Marie-Magdeleine, C., & López-Leyva Y. (2017). Nutraceutic effect of free condensed tannins of *Lysiloma acapulcensis* (Kunth) benth on parasite infection and performance of Pelibuey sheep. *Tropical Animal Health and Production*, 49(1):55-61. <https://doi.org/10.1007/s11250-016-1157-8>
- García-Hernández, C., Rojo-Rubio, R., Mendoza-De Gives, P., González-Cortazar, M., Zamilpa, A., Mondragón-Ancelmo, J., Villa-Mancera, A., Olivares-Pérez, J., Tapia-Maruri, D., & Olmedo-Juárez, A. (2022). *In vitro* and *in vivo* anthelmintic properties of *Caesalpinia coriaria* fruits against *Haemonchus contortus*. *Experimental Parasitology*, 242:108401. <https://doi.org/10.1016/j.exppara.2022.108401>

- Hamed, R. R., Ali, O. S., Guneidy a, R. A., & Zaki, E. R. (2014). Inhibition of glutathione S-transferases by some Malvaceae flowers. *International Journal of Advanced Research*, 2(12):174-187. [https://www.journalijar.com/uploads/863\\_IJAR-4521.pdf](https://www.journalijar.com/uploads/863_IJAR-4521.pdf)
- Hassan, M., Ra, M., Joshi, T., Ahmad Yattoo, F., & Habib, H. (2019). *In vitro* anthelmintic activity of abutilon theophrasti medik. (Malvaceae) against eggs and L3 larvae of *Haemonchus contortus*. *Asian Journal of Pharmaceutical and Clinical Research*, 12(3):205-207. <http://dx.doi.org/10.22159/ajpcr.2019.v12i3.29922>
- Hernández-Alvarado, J., Zaragoza-Bastida, A., López-Rodríguez, G., Peláez-Acero, A., Olmedo-Juárez, A., & Rivero-Pérez, N. (2018). Antibacterial and gastrointestinal nematode activity of plant secondary metabolites: a focus on veterinary medicine. *Abanico Veterinario*, 8(1):14-27. <https://doi.org/http://dx.doi.org/10.21929/abavet2018.81.1>
- Hernández-Valenzuela, D., Sánchez-Vera, E., Gómez-Demetrio, W., & Martínez-García, C. G. (2019). Productive and socioeconomic characterization of a sheep production system in a natural protected area in Mexico. *Revista Mexicana de Ciencias Pecuarias*, 10(4):951-965. <https://doi.org/10.22319/rmcp.v10i4.4470>
- Hodgkinson, J. E., Kaplan, R. M., Kenyon, F., Morgan, E. R., Park, A. W., Paterson, S., Babayan, S. A., Beesley, N. J., Britton, C., Chaudhri, H., Doyle, S. R., Ezenwa, V. O., Fenton, A., Howell, S. B., Laing, R., Mable, B. K., Matthews, L., McIntyre, J., Milne, C. E., Morrison, T. A., & Devaney, E. (2019). Refugia and anthelmintic resistance: Concepts and challenges. *International Journal of Parasitology: Drugs and Drug Resistance*, 2019; 10:51-57. <https://doi.org/10.1016/j.ijpddr.2019.05.001>
- Ilangopathy, M., Palavesam, A., Amaresan, S., & Muthusamy, R. (2019). Economic impact of gastrointestinal nematodes in sheep on meat production. *International Journal of Livestock Research*, 9(10):44-48. <https://doi.org/10.5455/ijlr.20190331051814>
- Islam, M., & Uddin, M. (2017). A revision on *Ureña lobata* L. *International Journal of Medicine*, 5(1):126-131. <https://doi.org/10.14419/ijm.v5i1.7525>
- Khanra, R., Dewanjee, S., K Dua, T., Sahu, R., Gangopadhyay, M., De Feo, V., & Zia-Ul-Haq, M. (2015). *Abroma augusta* L. (Malvaceae) leaf extract attenuates diabetes induced nephropathy and cardiomyopathy via inhibition of oxidative stress and inflammatory response. *Journal of Translational Medicine*, 13(1):1-14. <https://doi.org/10.1186/s12967-014-0364-1>
- Kumsa, B., & Hagos, Y. (2020). Anthelmintic medicinal plants used for animals in Ethiopia: A Review. *The Journal of Phytopharmacology*, 9(4):274-280. <https://doi.org/10.31254/phyto.2020.9411>
- Le Bodo, E., Hornick, J.-L., Moula, N., Zuñiga, S. A., & Martínez-Alfaro, J. C. (2020). Assessment of Gastrointestinal Parasites and Productive Parameters on Sheep Fed on a Ration Supplemented with *Guazuma ulmifolia* Leaves in Southern Mexico. *Animals*, 10(9):1617. <https://doi.org/10.3390/ani10091617>
- Leitão, S. G., Fonseca-Kruel, V. S. da, Silva, I. M., & Martins, K. (2014). Medicinal plants traded in the open-air markets in the State of Rio de Janeiro, Brazil: an overview on their botanical diversity and toxicological potential. *Revista Brasileira de Farmacognosia*, 24(2):225-247. <https://doi.org/10.1016/j.bjp.2014.04.005>
- Liu, M., Panda, S. K., & Luyten, W. (2020). Plant-based natural products for the discovery and development of novel anthelmintics against nematodes. *Biomolecules*, (10)3:426. <https://doi.org/10.3390/biom10030426>
- López R. O. A., González Garduño, R., Osorio Arce, M. M., Aranda Ibáñez, E., & Díaz Rivera, P. (2013). Gastrointestinal nematodes burden and prevalent species in hair sheep for slaughter. *Revista Mexicana de Ciencias Pecuarias*, 4(2):223-224. Available in: <https://cienciaspecuarias.inifap.gob.mx/index.php/Pecuarias/article/view/2841/2385>
- Martínez, G.J., & Jiménez-Escobar, N.D. (2017). Plants of veterinary interest in the peasant culture of the Sierra de Ancasti (Catamarca, Argentina). *Boletín Latinoamericano y del Caribe de Plantas Medicinales y aromáticas*, 16(4):329-346. <https://blacpma.msditions.cl/index.php/blacpma/issue/view/23>
- Mata-Espinosa, M. A., Hernández Sánchez, D., Cobos Peralta, M. A., Ortega Cerrilla, M. E., Mendoza Martínez, G. D., & Arcos-García, J. L. (2006). Productive lamb performance and ruminal fermentation using cocoíte (*Gliricidia sepium*), morera (*Morus alba*) and Tulipán (*Hibiscus rosa-sinensis*) meal as supplement. *Revista Científica (Maracaibo)*, 16(3): 249-256. [http://ve.scielo.org/scielo.php?script=sci\\_arttext&pid=S0798-22592006000300006&lng=es&nrm=iso](http://ve.scielo.org/scielo.php?script=sci_arttext&pid=S0798-22592006000300006&lng=es&nrm=iso)
- Mayren-Mendoza, F. J., Rojas-García, A. R., Maldonado-Peralta, M. A., Ramírez-Reynoso, O., Herrera-Pérez, J., Torres-Salado, N., Sánchez-Santillán, P., Bottini-Luzardo, M. B., & Hernández-Garay, A. (2018). Productive behavior of grazing pelibuey sheep supplemented with *Guazuma ulmifolia* Lam foliage. *Agroproductividad*, 2018;11(5):29-33. <http://ri.uagro.mx/handle/uagro/1345>
- Medina, P., Guevara, F., La, O. M., Ojeda, N., & Reyes, E. (2014). Anthelmintic resistance in sheep: a review of reports from southeastern Mexico and available alternatives for the control of gastrointestinal

- nematodes. *Pastures and Forages*, 37(3):257-263. <https://payfo.ihatuey.cu/index.php?journal=pasto&page=article&op=view&path%5B%5D=1802>
- Molefe, N.I., Tsotetsi, A.M., Ashafa, A. O. T., & Thekisoe, O, M, M. (2013). *In vitro* anthelmintic activity of *Cotyledon orbiculata*, *Hermannia depressa* and *Nicotiana glauca* extracts against parasitic gastrointestinal nematodes of livestock. *Journal of Medicinal Plants Research*, 7(9):536-542. <https://doi.org/10.5897/JMPR012.1129>
- National Center for Biotechnology Information [internet]. PubChem Compound Summary for CIDS 370, 5280343 and 5280863, Gallic acid, Quercetin and Kaempferol. Maryland, USA. [Cited 2023 Aug 1]. Retrieved from <https://pubchem.ncbi.nlm.nih.gov/compound/Quercetin>
- Olmedo-Juárez, A., Rojo-Rubio, R., Zamilpa, A., Mendoza de Gives, P., Arece-García, J., López-Arellano, M. E., & von Son- de Fernex, E. (2017). *In vitro* larvicidal effect of a hydroalcoholic extract from *Acacia cochliacantha* leaf against ruminant parasitic nematodes. *Veterinary Research Communications*, 41(3):227-232. <https://doi.org/10.1007/s11259-017-9687-8>
- Pereira, G. A., Peixoto Araujo, N. M., Arruda, H. S., Farias, D. de P., Molina, G., & Pastore, G. M. (2019). Phytochemicals and biological activities of mutamba (*Guazuma ulmifolia* Lam.): A review. *Food Research International*, Isaiah 126:108713. <https://doi.org/10.1016/j.foodres.2019.108713>
- Quijada, J., Fryganas, C., Ropiak, H. M., Ramsay, A., Mueller-Harvey, I., & Hoste, H. (2015). Anthelmintic Activities against *Haemonchus contortus* or *Trichostrongylus colubriformis* from Small Ruminants Are Influenced by Structural Features of Condensed Tannins. *Journal of Agricultural and Food Chemistry*, 63(28):6346-6354. <https://doi.org/10.1021/acs.jafc.5b00831>
- Reséndiz-González, G., Higuera-Piedrahita, R. I., Lara-Bueno, A., González-Garduño, R., Cortes-Morales, J. A., González-Cortazar, M., Mendoza-de Gives, P., Romero-Romero, S. G., & Olmedo-Juárez, A. (2022). *In Vitro* Anthelmintic Activity of a Hydroalcoholic Extract from *Guazuma ulmifolia* Leaves against *Haemonchus contortus*. *Pathogens*, 11(10):1160. <https://doi.org/10.3390/pathogens11101160>
- Rodríguez-Vivas, R. I., Grisi, L., Pérez de León, A. A., Silva Villela, H., Torres-Acosta, J. F. de J., Fragoso Sánchez, H., Romero Salas, D., Rosario Cruz R., Saldierna, F., & García Carrasco, D. (2017). Potential economic impact assessment for cattle parasites in Mexico. Review. *Revista Mexicana de Ciencias Pecuarias*, 8(1):61-74. <https://doi.org/10.22319/rmcp.v8i1.4305>
- Ruiz-Sesma, D. L., Lara-Lara, P. E., Sierra-Vázquez, Á. C., Aguilar-Urquizo, E., & Magaña-Magaña & José R. Sanginés-García, M. A. (2006). Nutritional and productive evaluation of sheep fed *Hibiscus rosasinensis* hay. *Zootecnia Tropical*, 24(4):467-482. <http://www.bioline.org.br/pdf?zt06036>
- Santiago-Figueroa, I., Lara-Bueno, A., González-Garduño, R., López-Arellano, M.E., de la Rosa-Arana, J. L., & Maldonado-Simán, E. de J. (2019). Anthelmintic resistance in hair sheep farms in a sub-humid tropical climate, in the Huasteca Potosina, Mexico. *Veterinary Parasitology. Regional Studies and Reports*, 5:100292. <https://doi.org/10.1016/j.vprsr.2019.100292>
- Sharifi-Rad, J., Melgar-Lalanne, G., Hernández-Álvarez, A. J., Taheri, Y., Shaheen, S., Kregiel, D., Antolak, H., Pawlikowska, E., Brdar-Jokanović, M., Rajkovic, J., Hosseinabadi, T., Ljevernajić-Mašić, B., Baghalpour, N., Mohajeri, M., Fokou, P. V. T., & Martins, N. (2020). Malva species: Insights on its chemical composition towards pharmacological applications. *Phytotherapy Research*, 1-22. <https://doi.org/10.1002/ptr.6550>
- Starling, R. Z. C., De Almeida, F.A., Viana, M. V. G., De Castilhos, A. M., & Do Amarante, A. F. T. (2019). Losses caused by gastrointestinal nematode infections in Dorper lambs under two nutritional status. *Revista Brasileira de Parasitologia Veterinaria*, 28(4):652-660. <https://doi.org/10.1590/s1984-29612019084>
- Suteky, T., & Dwatmadji (2015). In vitro Ovicidal and Larvicidal Activity of Two Local Plants (*Ficus septicum* and *Urena lobata*) Extracts on *Haemonchus contortus*. *Proceeding ISEPROLOCAL*, 2:295-299. <http://repository.unib.ac.id/11352/1/052%20Tatiik%20S.pdf>
- Tanaka, J. C. A., Silva, C. C. da, Dias Filho, B. P., Nakamura, C. V., Carvalho, J. E. de, & Foglio, M. A. (2005). Constituintes químicos de *Luehea divaricata* MART. (TILIACEAE). *Química Nova*, 28(5):834-837. <https://doi.org/10.1590/S0100-40422005000500020>
- The world flora online. Malvaceae Juss. [internet]. USED. United Nations Convention on Biological Diversity. [Cited 2023 January 24]. Retrieved from <http://www.worldfloraonline.org/taxon/wfo-7000000360>
- Thooyavan, G., Karthikeyan, J., & Govindarajalu, B. (2018). Anthelmintic activity of *Abutilon indicum* leaf extract on sheep tapeworm *Moniezia expansa* *In vitro*. *Journal of Pharmacognosy and Phytochemistry*, 7(2):317-321. <https://www.phytojournal.com/archives?year=2018&vol=7&issue=2&ArticleId=3304>
- Vadivel, V., Sriram, S., & Brindha, P. (2016). Distribution of flavonoids among Malvaceae family members - A review. *International Journal of Green Pharmacy*, 10(1):S33-S45. <https://doi.org/https://doi.org/10.22377/ijgp.v10i1.611>

- Valdivié, M., & Martínez, Y. (2022). *Hibiscus rosa-sinensis* Forage as a Potential Feed for Animals: A Review. *Animals*, 12(3):288. <https://doi.org/https://doi.org/10.3390/ani12030288>
- Váradyová, Z., Pisarčíková, J., Babják, M., Hodges, A., Mravčáková, D., Kišidayová, S., Königová, A., Vadlejch, J., & Várady, M. (2018). Ovicidal and larvicidal activity of extracts from medicinal-plants against *Haemonchus contortus*. *Experimental Parasitology*, 195:71-77. <https://doi.org/10.1016/j.exppara.2018.10.009>
- von Son-de Fernex, E., Alonso-Díaz, M. Á., Mendoza-de Gives, P., Valles-de la Mora, B., González-Cortazar, M., Zamilpa, A., & Castillo-Gallegos, E. (2015). Elucidation of *Leucaena leucocephala* anthelmintic-like phytochemicals and the ultrastructural damage generated to eggs of *Cooperia* spp. *Veterinary Parasitology*, 214(1-2):89-95. <https://doi.org/10.1016/j.vetpar.2015.10.005>
- Wang, D., Fan, W., Guo, X., Wu, K., Zhou, S., Chen, Z., Danyang, L., Wang, K., & Zhu, Y. (2020). MaGenDB: A functional genomics hub for Malvaceae plants. *Nucleic Acids Research*, 48(D1): D-1076-D1084. <https://doi.org/10.1093/nar/gkz953>
- WFO (2024): World Flora Online. Published on the Internet; <http://www.worldfloraonline.org>. Accessed on: 27 Jul 2024.
- Zia-Ul-Haq, M., Raza Shah, M., Qayum, M., & Ercisli, S. (2012). Biological screening of selected flora of Pakistan. *Biological Research*, 45(4):375-379. <https://doi.org/10.4067/S0716-97602012000400008>

