Review

Utilization of the *Viscum* Species for Diet and Medicinal Purposes in Ruminants: A Review

Onke Hawu 1,2,*, Khuliso Emmanuel Ravhuhali 1,2, Mutshidzi Given Musekwa 1,2, Nkosomzi Sipango 1,2, Humbelani Silas Mudau 1,2, Kwena Hilda Mokoboki 1,2 and Bethwell Moyo 3

1 Department of Animal Science, School of Agricultural Sciences, Faculty of Natural and Agricultural Sciences, North-West University, Mmabatho 2735, South Africa
2 Food Security and Safety Niche Area, Faculty of Natural and Agricultural Sciences, North-West University, Mmabatho 2735, South Africa
3 Department of Animal Production, Fort Cox Agriculture and Forestry Training Institute, Middledrift 5685, South Africa
* Correspondence: onkehawu97@gmail.com

Simple Summary: True mistletoe (of the *Viscum* species) is a semi-parasitic, perennial browse species that is found attached to its host—a shrub or a tree. It has important pharmaceutical and chemical properties that allow it to be used for a variety of purposes, including livestock production. Mistletoes are cheap and are a readily available source of minerals and protein for livestock, especially during the dry season. They grow primarily on the outer branches of the tree crown; however, they also frequently grow directly on the tree trunk in order to consume its nutrients and water, thereby affecting their host’s quality and development. Many countries are expected to discover and explore the potential of *Viscum* spp. and their management tools, which we investigate through this review.

Abstract: A cost-effective, alternative protein and mineral source such as the *Viscum* species can be key to livestock production. *Viscum* spp. are used as feed in many semi-arid and arid regions globally, particularly during feed shortages. The species’ feeding value, and their pharmaceutical attributes, have been recognized worldwide, albeit with variation in nutritive value from one host to another. The antinutritional factors found in *Viscum* spp. may benefit livestock when consumed in moderation due to their immunomodulatory, proapoptotic, and antimicrobial properties. The *Vachellia* species are known to be the common hosts for *Viscum* spp. Further, even though *Viscum* spp. inhibit host tree development by reducing carbon absorption and the host tree’s carbohydrates, the efforts to regulate their infestation should not result in the plant’s total eradication due to the benefits to livestock (as well as in fodder and medicine). This review will help to improve understanding of *Viscum* species control measures, while also increasing the productivity of ruminants.

Keywords: nutritive value; semi-arid; protein; host; parasitic

1. Introduction

Finding inexpensive alternative protein sources such as the *Viscum* species is necessary since livestock productivity has continued to be severely constrained by the cost of livestock feed. True mistletoe (of the genus *Viscum*) is a semi-parasitic, perennial browse species that attaches to its host, shrubs or various tree species [1,2]. It is mainly dispersed by frugivorous birds from one host to another [1]. It has fodder value, as well as anthelmintic and therapeutic properties with evergreen leaves [2,3]. The genus *Viscum* contains many species that are primarily found in America, Africa, Asia, and Europe [4]. The *Viscum* spp. found in southern Africa include *V. verrucosum*, *V. rotundifolium*, *V. anceps*, *V. songimveloensis*, and *V. combricola* [5–7]. They are fodder resources for ruminants, especially during dry periods when good quality forage is scarce [8]. Öztürk et al. [3] highlighted that the *Viscum*
species extract nutrients and water from their host; hence, they are a rich fodder resource for ruminants.

True mistletoes are ingested and preferred by livestock without any reported digestive orders [9]. Even though their ecological importance for birds, medicinal properties, and fodder value for livestock are known, they are still regularly removed from orchards and rangelands/forests due to their detrimental effect on the host plant [10]. This research aims to help improve understanding of Viscum species control measures, while also increasing the productivity of ruminants. This means that developing mitigation strategies to minimize its spread should take into account a more balanced understanding that incorporates knowledge of its nutritive value as a source of protein, as well as its negative impact on rangelands. In this paper, we reviewed the primary uses of Viscum spp. in the livestock industry as well as in other human endeavors.

2. Description of the Viscum Species

True mistletoe (Viscum spp.) is an evergreen hemiparasitic plant that inhabits trees. Yellowish flowers, small yellowish green leaves, and waxy, white berries characterize this parasitic plant (Figure 1). Some of the species have leaves while some do not have leaves (Table 1). For example, V. album, when on the branch of a host tree, will grow as much as 60–90 cm long with a drooping yellowish evergreen shrub. It has densely packed forking branches that are 5 cm long, leathery, oval- to lance-shaped leaves that are placed in pairs on branches. The bisexual, or unisexual, blooms are arranged in tight spikes and have consistent symmetry [11]. However, some Viscum spp. have smooth, round, green stems that are covered in sessile, yellowish blooms in tiny clusters (Figure 2). The flowers of the Viscaceae family are narrow, tubular, dioecious, with (or without) a corolla, and thus pollinated by insects and the wind [12].

![Figure 1. Viscum rotundifolium in Limpopo Province, photo taken by KE Ravhuhali.](image)

Table 1. Viscum species and their distribution.

| Viscum spp. with leaves | Distribution | References |
|------------------------|-------------|-----------|
| V. articulatum         | Asia, Australia | [13]      |
| V. album               | Asia, Europe and Nepal | [14]      |
| V. cruciatum           | Asia, Africa and Europe | [15–17]  |
| V. rotundifolium       | Africa      | [5]       |

| Viscum spp. without leaves | Distribution | References |
|---------------------------|-------------|-----------|
| V. angulatum              | Asia        | [18]      |
| V. combrticola            | Africa      | [19]      |
| V. anceps                 | Africa      | [20]      |
| V. songimveloensis        | Africa      | [7]       |
| V. verrucosum Harv.       | Africa      | [21]      |
Animals 2022, 12, x 3 of 10

whether livestock have a comparable preference for mistletoes on plant hosts. Water from the host plant for their survival [22]. Although their leaves may photosynthesize, they do so at a slower rate than their hosts [23]. Ahmad et al. [24] highlighted that they contain a functionally low amount of chlorophyll, and their low capability for photosynthesis explains their capability to adapt to dry conditions. They can survive in semi-arid regions, deserts, temperate woodlands, and semi-tropic wetlands [25]. It has been suggested that true mistletoes selectively parasitize host species that are high in nitrogen since nitrogen is frequently a limiting resource for plants [26]. Moreover, in South Africa, the genus Vachellia are the most important hosts of Viscum spp. Clark et al. [27] highlighted that there are just four Viscum species in South Africa that are unique or specific to a single host, which is a relatively low number.

4. Negative Impact and Control of the Viscum Species

It has been extensively researched for years how common Viscum spp. affect woody species, particularly in rangelands and in plantations. Mistletoe inhibits host tree development by reducing carbon absorption and host tree carbohydrates, all of which have an impact on the quality and quantity of woody species produced and the soil’s nutrient cycle [28]. Within its current range, mistletoe abundance has been growing, and the intensification of climatic stress in the form of protracted droughts has increased the rate of tree mortality in mistletoe-infected woody species, thus altering the dynamics of the community [29]. Moreover, true mistletoe spp. induce nutrient and water stress, which, in turn, changes the phyto-hormone profile, as well the defense mechanism of the host plant and causes affected trees to be more susceptible to insect attacks [30]. To overcome such problems, mistletoe spp. infestations should be controlled or managed in the rangelands.

Viscum spp. can be controlled using mechanical, chemical, or biological means. The single most successful approach to eradicate mistletoe in rangelands or forests is mechanical removal of mistletoe by clipping infected branches; however, this requires a large amount of labor and finances [28]. The use of chemicals as a control measure has been documented. Further, injecting a chemical into the trunk of a plant with mistletoe has been proposed [31]. However, this method does not address the root of the infestation and entails the possibility that the dosage will either fail to eradicate the mistletoe or harm the host plant. Livestock browse preferably on mistletoes when available; this, therefore, suggests that livestock can be used as biological agents to control the spread of mistletoe spp. However, it is unknown whether livestock have a comparable preference for mistletoes on plant hosts.

Figure 2. Viscum verrucosum Harv. in North West Province, photos taken by O Hawu.

3. Adaptation of the Species

Viscum spp. grow on the branches of various tree species. They extract nutrients and water from the host plant for their survival [22]. Although their leaves may photosynthesize, they do so at a slower rate than their hosts [23]. Ahmad et al. [24] highlighted that they contain a functionally low amount of chlorophyll, and their low capability for photosynthesis explains their capability to adapt to dry conditions. They can survive in semi-arid regions, deserts, temperate woodlands, and semi-tropic wetlands [25]. It has been suggested that true mistletoes selectively parasitize host species that are high in nitrogen since nitrogen is frequently a limiting resource for plants [26]. Moreover, in South Africa, the genus Vachellia are the most important hosts of Viscum spp. Clark et al. [27] highlighted that there are just four Viscum species in South Africa that are unique or specific to a single host, which is a relatively low number.
5. Crude Protein and Fiber Fraction of *Viscum* Species

The high prices of livestock’s more conventional feeds make *Viscum* spp. a nutritionally suitable feed for ruminants during particularly dry periods. Grasses during this period normally deteriorate and lose their nutritive value. The nutritive value of *Viscum* spp. usually varies from one host to another due to link-specific nutrient transfer characteristics [32]. Previous studies have reported that *Viscum* spp. have a crude protein (CP) content of more than 80 g/kg DM, which is considered to be enough for rumen microbes in growing ruminants (cattle, sheep, and goats) [2,33]. This further highlights the importance of *Viscum* spp. during the dry season, as they address protein deficiencies when the CP content of grasses is between 20 and 60 g/kg DM. Hawu et al. [34] highlighted that low CP content usually decreases feed intake, and adversely affects ruminant growth and productivity.

The fiber content of forage is one of the most vital parameters to consider as this will affect both feed intake and digestibility for ruminants. *Viscum* spp. contain relatively low fiber concentrations, as shown in Table 2; this is due to their low photosynthesis capacity. *Viscum* spp. may not produce some more complex carbon materials such as fiber, which are, however, produced by other woody browse species [35]. Consequently, *Viscum* spp. do not have high acid detergent fiber, neutral detergent fiber, or acid detergent lignin content, thus making them highly digestible. Therefore, the low fiber content in *Viscum* spp. does not constrain the use of *Viscum* spp. as a fodder for ruminants that are adept at utilizing forages that are high in fiber.

| Table 2. Chemical composition (g/kg DM) of *Viscum* species. |
|----------------|------------|-----------|----------|----------|-----------|----------|--------|
| Species        | DM (g/kg) | CP        | EE       | NDF      | ADF       | ADL      | References |
|----------------|-----------|-----------|----------|----------|-----------|----------|--------|
| *V. album*     | 960       | 150       | 80       | 339      | 202       | 94       | [33,36] |
| *V. verrucosum*| 912       | 121       | 276      | 244      | 75        | 97       | [2,32] |
| *V. rontudifolium* | 163       | 241       | 121      | 121      | 97        | 97       | [37,38] |

DM: dry matter, CP: crude protein, EE: ether extract, NDF: neutral detergent fiber, ADF: acid detergent fiber, and ADL: acid detergent lignin.

6. Potential of *Viscum* Species as a Source of Minerals for Ruminants

Minerals play an important role in the metabolic functions of livestock. These functions assist with supporting growth, development, immune function, and the reproductive performance of livestock [39,40]. *Viscum* spp. are known as a source of minerals such as phosphorous (P), iron (Fe), calcium (Ca), magnesium (Mg), zinc (Zn), copper (Cu), and other minerals that are required for ruminants’ wellbeing (Table 3). Umucalılar et al. [41] reported average Ca (13 g/kg), P (3 g/kg DM), Fe (110 g/kg DM), Cu (10 g/kg DM), and Zn (41 g/kg DM) in *V. album* from different plant hosts.

Numerous physiological processes depend on calcium. Calcium (Ca) plays an important role in blood clotting, membrane permeability, nerve conduction, muscle contraction, enzyme activity, and hormone secretion [42,43]. The concentration level of Ca in *Viscum* spp. is higher than the 5.8 g/kg required by growing calves [44]. However, there may be a need to reduce the Ca concentration level in ruminant diets that contain *Viscum* spp. in order to avoid toxicity. Phosphorus is an essential component of adenosine triphosphate (ATP) and nucleic acid, it is also important for the formation of teeth and bones [45]. The concentration level of P in *Viscum* spp. is equivalent to the 2 g/kg that is required by lactating cows [44]. Iron is required for the synthesis of hemoglobin and myoglobin, as well as several other enzymes that aid in the formation of ATP via the electron transport chain [46]. Hill and Shannon [47] highlighted that Zn plays a variety of roles in immunity and disease resistance. Moreover, Zn is essential for growth and cell division, where it is required for protein and DNA synthesis, insulin activity, ovary and testis metabolism, and liver function [48–50]. Copper performs a physiological role in cellular respiration, bone development, heart health (functions), the formation of connective tissue, the myelination of the spinal cord, and in keratinization and pigmentation processes [51,52]. The concentration level of Cu in *V. verrucosum* is equivalent to the 0.01–0.02 g/kg required by growing
lambs [53]. These mineral values, as mentioned above, suggest that *Viscum* spp. can be fed to ruminants without mineral supplementation since these values are higher than the minimum mineral requirement [54,55].

Table 3. Mineral content (g/kg DM) of *Viscum* ssp.

| Species          | Ca | K  | P     | Mg | Na | Zn | Cu | S    | Fe | Mn | References       |
|------------------|----|----|-------|----|----|----|----|------|----|----|-----------------|
| V. album         | 13 | 25 | 3     | 32.57 | 2 | 1.1 | 14.4 | 29.2 | 99 | [41,56,57]     |
| V. verrucosum    | 76 | 97 | 2     | 7   | 1.2 | 0.02 | 0.03 | 0.44 | 0.05 | [2]            |

7. Antinutritional Factors Associated with *Viscum* ssp.

Plants use phytochemicals as a defense mechanism against diseases and other external threats [58]. There is increasing interest in studying the bioactivity and the antinutritional factors (ANFs) (phytochemicals) of *Viscum* spp. To clarify, antinutritional factors are plant components that have the potential to negatively impact livestock productivity. Several authors have reported the presence of ANFs in *Viscum* spp., as shown in Table 4. García-García et al. [57] reported that *Viscum* spp. contain ANFs such as tannins, saponins, alkaloids, and flavonoids; further, *Viscum* spp. depend on the host they grow on. In contrast, it has been discovered that some ANFs might benefit livestock when consumed in moderation. Wang et al. [59] stressed that flavonoids have various bioactive effects, such as cardio protective, anti-inflammatory, and antiviral. Saponin has a number of biological effects on livestock, such as hemolysis of erythrocytes, a decrease in blot (in ruminants), a reduction in the activity of smooth muscles, an inhibition of enzymes, a reduction in nutrient absorption, and an alteration in cell wall permeability, and thus produces some poisonous effects when ingested [60,61]. High tannin concentrations in ruminants are known to reduce palatability, feed intake, and degradability [34], while low tannin concentrations are known to have health benefits such as antiviral and antibacterial effects [62]. In relation to greenhouse gases, tannins are regarded as an important alternative in mitigating carbon dioxide (CO₂), as well as methane (CH₄) [63]. The same authors found that the addition of tannins into Nellore bulls’ urine had an effect on the reduction in CH₄.

Table 4. Antinutritional factors content (g/kg DM) in *Viscum* species.

| Species            | Tannins | Saponins | Phenolic | Oxalate | Phytates | Flavonoids | References |
|--------------------|---------|----------|----------|---------|----------|------------|------------|
| V. album           | 99      | 33       | 28.3     | 158     | 227      | 2.4        | [65]       |
| V. rontudifolium   | 7.3     | 33       | 28.3     | 158     | 227      | 2.4        | [66]       |

8. Health Benefits of *Viscum* Species in Livestock

In many parts of the world, *Viscum* spp. have been consumed for a long period of time as an herbal tea and as a supplement to health care [8]. Furthermore, *Viscum* spp. have been used to improve livestock health, or simply as forage, when feedstuffs are limited due to drought [10,67]. Previous studies have highlighted that *Viscum* spp. have immunomodulatory, proapoptotic, and antimicrobial properties [8,68]. According to Ishiwu et al. [67], in Nigeria, rural farmers give the leaves of *Viscum* spp. to goats that have newly given birth, even though they do not, in reality, know of their health benefits. Moreover, Ohikhena et al. [61] highlighted that *Viscum* spp. are used to treat vision weakness and for promoting muscular relaxation prior to delivery. Drury [69] also highlighted the use of decoctions from *Viscum* spp. berries in cows to promote the expulsion of the afterbirth and to stop bleeding. In Nigeria, *Viscum* spp. are used to treat bacterial infections, skin conditions, diarrhea, diabetes, and prostate cancer in livestock [70]. It was reported that salmonellae in sheep rumen fluid were inhibited by diets containing *V.*
Further, Madibela and Jansen [72] highlighted that tanniferous species such as *Viscum* spp. can reduce the fecal egg count in ruminants. Apart from ruminants, Korean mistletoe enhanced lymphocytes and reduced *Salmonella* spp. of ceca in broiler hens [73]. Furthermore, *Viscum* spp. are used to treat infertility, epilepsy, rheumatism, and menopausal syndrome in humans [74].

9. The Use of *Viscum* Species in Ruminant Diets

The *Viscum* species are used as feed in many semi-arid and arid regions around the world, particularly during the dry season. *Viscum* spp. are rich sources of proteins and minerals, even though they contain antinutritional factors. Several studies have found that true mistletoes, when combined with other feed sources, can help reduce ruminant forage crop requirements in dryland areas. According to Jibril et al. [33], *V. album* can substitute sorghum stover by up to 50% in rams’ diets, without negatively affecting the growth performance. Similarly, Abubakar et al. [9] came to the conclusion that Red Sokoto Bucks can consume mistletoe leaf meal for up to 22.5% of their diet without any negative effects on the animals’ ability to produce. In an in vitro study, Ndagurwa and Dube [32] found that *V. verrucosum* had higher in vitro dry matter degradability, in vitro gas production, and in vitro metabolizable energy than *Acacia karroo*, thus making *Viscum* spp. a potential alternative browse for goats in semi-arid regions. Ramatsi et al. [2] also found that the in vitro dry matter degradability of *V. verrucosum* ranged from 510–517 g/kg at 72 h.

Apart from livestock ruminants, studies also show the positive effects of *Viscum* spp. in nonruminant livestock. It was reported that *V. album* improved the growth, meat, and carcasses of rabbits (*Oryctolagus cuniculus*), and can be added into rabbits’ diet at amounts of up to 15% [70]. Further, Ologhobo et al. [75] concluded that *V. album* had no effect on the growth performance, biochemical profile, and carcass characteristics of broilers.

10. Conclusions

*Viscum* spp. have the potential to serve as a substitute source of feed for ruminant animals due to their nutritional makeup, medicinal properties, and livestock acceptance. The utilization strategy will be of paramount importance and will be determined through establishing the correct mistletoe inclusion level in relation to low quality roughages. Even though the species does have detrimental impacts, it is advised that mistletoe control management in rangelands be conducted with caution. Moreover, the efforts taken to regulate it should not result in the plant’s total eradication due to the benefits it provides in terms of fodder, medicine, and in other areas. Future research may be required to assess the livestock preference of each species when present in different hosts. Again, there is a need to assess the palatability index of different *Viscum* species.

Author Contributions: Authors O.H., K.E.R., M.G.M., N.S., H.S.M., K.H.M. and B.M. All participated equally to the review article draft. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Teodoro, G.S.; van den Berg, E.; Arruda, R. Metapopulation dynamics of the mistletoe and its host in savanna areas with different fire occurrence. *PLoS ONE* **2013,** *8,* 68386. [CrossRef]

2. Ramantsi, R.; Mnisi, C.M.; Ravhuhali, K.E. Chemical composition and in vitro dry matter degradability of mistletoe (*Viscum verrucosum* (Harv.)) on *Vachellia nilotica* (L.) in North West Province of South Africa. *Trop. Agric.* **2019,** *96,* 53–60.
Anim. Sci. Technol. 1979; Volume 10, pp. 43–56.

A new species of mistletoe from South Africa. S. Afr. J. Bot. 2018, 115, 194–198. [CrossRef]

Monograph on quality standards of Viscum angulatum B. Heyne. Bot. Res. Letters 2020, 1–13. [CrossRef]

Morphology, geographic distribution, and host preferences of mistletoe species endemic to southern Africa. J. Arid Environ. 2011, 75, 898–902. [CrossRef]

Evaluation of potential and effective rumen digestion of mistletoe species and woody species browsed by goats in a semi-arid savanna, southwest Zimbabwe. Anim. Feed Sci. Technol. 2013, 186, 106–111. [CrossRef]

Proximate and mineral components of Tapirira guianensis. Anim. Feed Sci. Technol. 2011, 165, 106–111. [CrossRef]

White-berry mistletoe (Viscum album L.): A hemiparasitic plant: Occurrence and ethnobotanical use in Kashmir. J. Pharmocog. Phytochem. 2018, 7, 1813–1833.

Nutritional relationships between hemi-parasitic mistletoe and some of its deciduous hosts in different habitats. Biologia 2010, 65, 859–867. [CrossRef]

Phytochemistry, Pharmacology, and Toxicity of an Epiphytic Medicinal Shrub Viscum articulatum Burm. f.: A review on its phytochemistry, pharmacology and traditional uses. J. Pharm. Pharmacol. 2018, 70, 159–177. [CrossRef]

3. Öztürk, Y.E.; Gülümser, E.; MUT, H.; Başaran, U.; Doğrusöz, M.C. A preliminary study on change of mistletoe (Viscum album L.) silage quality according to collection time and host tree species. Turk. J. Agric. Forest. 2022, 46, 104–112. [CrossRef]

4. Klessen, E.; Timar, A.V.; Memete, A.R.; Miere, F.; Vicas, S.I. On Overview of Bioactive Compounds, Biological And Pharmacological Effects Of Mistletoe (Viscum Album L.). Pharmacophore 2022, 13, 10–26. [CrossRef]

5. Okubamichael, D.Y.; Griffiths, M.E.; Ward, D. Host specificity, nutrient and water dynamics of the mistletoe Viscum rotundifolium and its potential host species in the Kalahari of South Africa. J. Arid Environ. 2011, 75, 898–902. [CrossRef]

6. Ndaguwva, H.G.T.; Dube, J.S. Evaluation of potential and effective rumen digestion of mistletoe species and woody species browsed by goats in a semi-arid savanna, southwest Zimbabwe. Anim. Feed Sci. Technol. 2013, 186, 106–111. [CrossRef]

7. Oosthuizen, D.; Balkwill, K. Viscum songoiwelensis, a new species of mistletoe from South Africa. S. Afr. J. Bot. 2018, 115, 194–198. [CrossRef]

8. Majeed, M.; Rehman, R.U. Phytochemistry, Pharmacology, and Toxicity of an Epiphytic Medicinal Shrub Viscum album L. (White Berry Mistletoe). In Medicinal and Aromatic Plants; Aftab, T., Hakeem, K.R., Eds.; Springer Nature: Cham, Switzerland, 2021; pp. 287–301. [CrossRef]

9. Abubakar, A.D.; Abubakar, M.; Yerima, J. Response of Red Sokoto Bucks Fed Graded Levels of Mistletoe Leaf Meal. Anim. Feed Sci. Technol. 2021, 24, 74–80. [CrossRef]

10. Kim, C.W.; An, C.H.; Lee, H.S.; Yi, J.S.; Cheong, E.J.; Lim, S.H.; Kim, H.Y. Proximate and mineral components of V. meyeri var. coloratum grown on eight different host tree species. J. Forest. Res. 2019, 30, 1245–1253. [CrossRef]

11. Maul, K.; Krug, M.; Nickrent, D.L.; Müller, K.F.; Quandt, D.; Wicke, S. Morphology, geographic distribution, and host preferences are poor predictors of phylogenetic relatedness in the mistletoe genus Viscum L. Mol. Phylogenet. Evol. 2019, 131, 106–115. [CrossRef]

12. Muche, M.; Muasya, A.M.; Tsegay, B.A. Biology and resource acquisition of mistletoes, and the defense responses of host plants. Ecol. Process. 2022, 11, 24. [CrossRef]

13. Patel, B.P.; Singh, P.K. Viscum articulatum Burm. f.: A review on its phytochemistry, pharmacology and traditional uses. J. Pharm. Pharmacol. 2018, 70, 159–177. [CrossRef]

14. Adeneye, A.A. Subchronic and chronic toxicities of African medicinal plants. In Toxicological Survey of African Medicinal Plants; Kuete, V., Ed.; Elsevier: Amsterdam, The Netherlands, 2014; pp. 99–133. [CrossRef]

15. Aparicio Martínez, A.; Gallego Cidoncha, M.J.; Vázquez, C. Reproductive biology of Viscum cruciatum (viscaceae) in southern Spain. Int. J. Plant Sci. 1995, 165, 42–49. [CrossRef]

16. Smith, D.; Barkman, T.J.; de Pamphilis, C.W. Hemiparasitism. In Hemiparasitism. In, 2nd ed.; Scheiner, M.S., Ed.; Elsevier Inc.: Amsterdam, The Netherlands, 2001; pp. 70–78. [CrossRef]

17. Besri, M. Viscum cruciatum: A threat to the olive production in the Moroccan Rif Mountains. IOBC WPRS Bull. 2005, 28, 169.

18. Sunil Kumar, K.N.; Puneth, V.S.; Tamizh, M.M.; Rubeena, M. Monograph on quality standards of Viscum angulatum B. Heyne ex DC. Indian J. Nat. Prod. Resour. 2021, 11, 320–332. [CrossRef]

19. Wiens, D.; Tölken, H.R. Viscaceae. In Flora of Southern Africa; Leistner, O.A., Ed.; Botanical Research Institute: Pretoria, South Africa, 1979; Volume 10; pp. 43–56.

20. Sosnovsky, Y.; Krasylenko, Y.; Nachychko, V. Viscum meyeri (Viscaceae)—A new name for Viscum anceps, an old-established mistletoe species endemic to southern Africa. Phytotaxa 2021, 523, 284–290. [CrossRef]

21. Wiens, D.; Barlow, B.A. Translocation heterozygosity in southern African species of Viscum. Bothalia 1980, 13, 161–169. [CrossRef]

22. Anselmo-Moreira, F.; Teixeira-Costa, L.; Ceccantini, G.; Furlan, C.M. Mistletoe effects on the host tree Tapiirira guianensis: Insights from primary and secondary metabolites. Chemoecology 2019, 29, 11–24. [CrossRef]

23. Al-Rowaily, S.L.; Al-Nomari, G.S.; Assaeed, A.M.; Facelli, J.M.; Dar, B.M.; El-Bana, M.I.; Abd-ElGawad, A.M. Infection by Placosepalus curviflorus mistletoe affects the nutritional elements of Acacia species and soil nutrient recycling in an arid rangeland. Plant Ecol. 2020, 221, 1017–1028. [CrossRef]

24. Ahmad, S.; Mir, N.; Sultan, S. White-berry mistletoe (Viscum album L.): A hemiparasitic plant: Occurrence and ethnonbotanical use in Kashmir. J. Pharmacog. Phytochem. 2018, 7, 1813–1833.

25. Türe, C.; Böcük, H.; Aşan, Z. Nutritional relationships between hemi-parasitic mistletoe and some of its deciduous hosts in different habitats. Biologia 2010, 65, 859–867. [CrossRef]

26. Okubamichael, D.Y.; Griffiths, M.E.; Ward, D. Host specificity in parasitic plants—Perspectives from mistletoes. AoB Plants 2016, 8, plw069. [CrossRef] [PubMed]

27. Clark, N.F.; McComb, J.A.; Taylor-Robinson, A.W. Host species of mistletoes (Loranthaceae and Viscaceae) in Australia. Aust. J. Bot. 2020, 68, 1–13. [CrossRef]

28. Szmidla, H.; Tkaczyk, M.; Plewa, R.; Tarwacki, G.; Sierota, Z. Impact of common mistletoe (Viscum album L.) on Scots pine forests—A call for action. Forests 2019, 10, 847. [CrossRef]

29. Griebel, A.; Watson, D.; Pendall, E. Mistletoe, friend and foe: Synthesizing ecosystem implications of mistletoe infection. Environ. Res. Letters 2017, 12, 115012. [CrossRef]

30. Griebel, A.; Metzen, D.; Pendall, E.; Nolan, R.H.; Clarke, H.; Renchon, A.A.; Boer, M.M. Recovery from Severe Mistletoe Infection After Heat- and Drought-Induced Mistletoe Death. Ecosystmes 2022, 25, 1–16. [CrossRef]

31. Bhat, K.A.; Akhtar, S.; Dar, N.A.; Bhat, M.I.; Bhat, F.A.; Rizwan, R.; Horielev, O.; Krasylenko, Y. Mistletoe Eradicator-A Novel Tool for Simultaneous Mechanical and Chemical Control of Mistletoe. J. Vis. Exp. 2022, 181, e63455. [CrossRef]
32. Ndagurwa, H.G.T.; Dube, J.S. Nutritive value and digestibility of mistletoes and woody species browsed by goats in a semi-arid savanna, southwest Zimbabwe. *Livest. Sci.* 2013, 151, 163–170. [CrossRef]

33. Jibril, J.A.; Gazali, Y.M.; Dantani, M.; Alamin, H.; Zannah, B.B. Performance of Balami Rams Fed Graded Levels of Mistletoe Leaves (*Viscum album*) and Sorghum Stover in Semi-Arid Zone of Borno State, Nigeria. *Niger. J. Anim. Sci. Technol.* 2020, 3, 25–31.

34. Hawu, O.; Ravhuhali, K.E.; Mokoboki, H.K.; Lepoba, C.K.; Sipango, N. Proximate analysis, in vitro dry matter degradability and palatability index of legume residues and maize straws for ruminants. *Legume Res.* 2022, 45, 601–607. [CrossRef]

35. Watson, L.H.; Owen-Smith, N. Phenological influences on the utilization of woody plants by eland in semi-arid shrubland. *Afr. J. Ecol.* 2002, 40, 65–75. [CrossRef]

36. Atalay, A.I. Determination of nutritive value and anti-methanogenic potential of mistletoe leaves (*Viscum album*) grown on different host. *Int. J. Agric. Forest. Life Sci.* 2020, 4, 120–123.

37. Madibela, O.R.; Boitumelo, W.S.; Lebou, M. Chemical composition and in vitro dry matter digestibility of four parasitic plants (*Tapinanthus lugardii, Erianthenum ngamicum, Viscum rotundifolium and Viscum verrucosum*) in Botswana. *Anim. Feed Sci Technol.* 2000, 84, 97–106. [CrossRef]

38. Madibela, O.R.; Mabutho, S.; Sebolai, B. Dry matter and crude protein degradability of four parasitic plants (Mistletoes) associated with browse trees in Botswana. *Trop. Anim. Health Prod.* 2003, 35, 365–372. [CrossRef] [PubMed]

39. Tripathi, D.; Mani, V.; Pal, R.P. Vanadium in biosphere and its role in biological processes. *J. Food Sci.* 2020, 84, 129–137. [CrossRef]

40. Diniz, W.J.; Reynolds, L.P.; Borowicz, PP.; Ward, A.K.; Sedive, K.K.; McCarthy, K.L.; Kassetas, C.J.; Baumgarten, F.; Kirsch, J.D.; Dorsam, S.T.; et al. Maternal vitamin and mineral supplementation and rate of maternal weight gain affects placental expression of energy metabolism and transport-related genes. *Genes* 2021, 12, 385. [CrossRef] [PubMed]

41. Umucalilar, H.D.; Guşen, N.; Coşkun, B.E.H.I.; Hayirli, A.; Dural, H.U.S.E.Y.I.N. Nutrient composition of mistletoe (*Viscum album*) and its nutritive value for ruminant animals. *Agroforest. Syst.* 2007, 71, 77–87. [CrossRef]

42. Hernández-Castellano, L.E.; Hernández, L.L.; Bruckmaier, R.M. Endocrine pathways to regulate calcium homeostasis around parturition and the prevention of hypocalcaemia in periparturient dairy cows. *Animal* 2020, 14, 330–338. [CrossRef]

43. Galęska, E.; Wrzecin ska, M.; Kowalczyk, A.; Araujo, J.P. Reproductive Consequences of Electrolyte Disturbances in Domestic Animals. *Bioll Trace Elem. Res.* 2018, 186, 52–67. [CrossRef]

44. Hill, G.M.; Shannon, M.C. Copper and zinc nutritional issues for agricultural animal production. *Bioll. Trace Elem. Res.* 2019, 188, 148–159. [CrossRef]

45. Bakhshizadeh, S.; Aghjahgheshlagh, F.M.; Taghizadeh, A.; Seifdavati, J.; Navidshad, B. Effect of zinc sources on milk yield, milk composition and plasma concentration of metabolites in dairy cows. *S. Afr. J. Anim. Sci.* 2019, 49, 884–891. [CrossRef]

46. Angeles-Hernandez, J.C.; Miranda, M.; Muñoz-Benitez, A.L.; Vieyra-Alberto, R.; Morales-Aguilar, N.; Paz, E.A.; Gonzalez-Navarro, M. Zinc supplementation improves growth performance in small ruminants: A systematic review and meta-regression analysis. *Anim. Prod. Sci.* 2021, 61, 621–629. [CrossRef]

47. Fadl, A.M.; Abdelnaby, E.A.; El-Sherbiny, H.R. Supplemental dietary zinc sulphate and folic acid combination improves testicular volume and haemodynamics, testosterone levels and semen quality in rams under heat stress conditions. *Reprod. Domest. Anim.* 2022, 57, 567–576. [CrossRef] [PubMed]

48. Cortinhas, C.S.; Freitas, J.D.; Naves, J.D.R.; Porcionato, M.A.D.F.; Silva, L.F.P.; Renno, F.P.; Santos, M.V.D. Organic and inorganic sources of zinc, copper and selenium in diets for dairy cows: Intake, blood metabolic profile, milk yield and composition. *Rev. Bras. de Zootec.* 2012, 41, 1471–1483. [CrossRef]

49. Wysocka, D.; Snarska, A.; Sobiech, P. Copper—an essential micronutrient for calves and adult cattle. *J. Elemental.* 2019, 24, 101–110. [CrossRef]

50. MacPherson, A. Trace-mineral status of forages. In *Forage Evaluation in Ruminant Nutrition*; Givens, D.I., Owen, E., Axford, R.F.E., Amed, H.M., Eds.; CAB International: Wallingford, UK, 2000; pp. 345–370.

51. National Research Council. *Nutrient Requirements of Beef Cattle*; National Academy Press: Washington, DC, USA, 1996.

52. Cortinhas, C.S.; Freitas, J.D.; Naves, J.D.R.; Porcionato, M.A.D.F.; Silva, L.F.P.; Renno, F.P.; Santos, M.V.D. Organic and inorganic sources of zinc, copper and selenium in diets for dairy cows: Intake, blood metabolic profile, milk yield and composition. *Rev. Bras. de Zootec.* 2012, 41, 1471–1483. [CrossRef]

53. Pugh, D.G. Feeding Practices in Sheep. In *MSD and the MSD Veterinary Manual*; Merck & Co., Inc.: Rahway, NJ, USA, 2020.

54. MacPherson, A. Trace-mineral status of forages. In *Forage Evaluation in Ruminant Nutrition*; Givens, D.I., Owen, E., Axford, R.F.E., Amed, H.M., Eds.; CAB International: Wallingford, UK, 2000; pp. 345–370.

55. National Research Council. *Nutrient Requirements of Dairy Cattle*, 7th ed.; National Academy Press: Washington, DC, USA, 2001.

56. Mutlu, S.; Osma, M.; Acar, B.; Kurtoglu, H.I.; Attici, O. Mistletoe (*Viscum album*) reduces the growth of the Scots pine by accumulating essential nutrient elements in its structure as a trap. *Trees* 2016, 30, 815–824. [CrossRef]

57. Garcia-Garcia, J.D.; Anguiano-Cabello, J.C.; Arredondo-Valdés, R.; Candido del Toro, C.A.; Martínez-Hernández, J.L.; Segura-Cenceros, E.P.; Govea-Salas, M.; González-Chávez, M.L.; Ramos-González, R.; Esparza-González, S.C.; et al. Phytochemical characterization of Phoradendron bollanum and *Viscum album* subs. *austriacum* as Mexican mistletoe plants with antimicrobial activity. *Plants* 2021, 10, 1299. [CrossRef]

58. Djmouai, D.; Saidi, M.; Rahmani, Z.; Djmouai, A. Qualitative phytochemical analysis and estimation of antioxidant activities, phenolics, flavonoids and tannins. *J. Fundam. Appl. Sci.* 2016, 8, 1–4.
59. Wang, T.Y.; Li, Q.; Bi, K.S. Bioactive flavonoids in medicinal plants: Structure, activity and biological fate. *Asian J. Pharm.l Sci.* 2018, 13, 12–23. [CrossRef]
60. Egbuna, C.; Ifemeje, J.C. Biological functions and anti-nutritional effects of phytochemicals in living system. *IOSR J. Pharm. Biol. Sci.* 2015, 10, 10–19.
61. Ohikherena, F.U.; Wintola, O.A.; Afolayan, A.J. Proximate composition and mineral analysis of *Phragmanthera capitata* (Sprengel) Balle, a mistletoe growing on rubber tree. *Res. J. Bot.* 2017, 12, 23–31. [CrossRef]
62. Huang, Q.; Liu, X.; Zhao, G.; Hu, T.; Wang, Y. Potential and challenges of tannins as an alternative to in-feed antibiotics for farm animal production. *Anim. Nutr.* 2018, 4, 137–150. [CrossRef] [PubMed]
63. Siniscalchi, D.; Cardoso, A.D.S.; Corrêa, D.C.D.C.; Ferreira, M.R.; Andrade, M.E.B.; da Cruz, L.H.G.; Ruggieri, A.C.; Reis, R.A. Effects of condensed tannins on greenhouse gas emissions and nitrogen dynamics from urine-treated grassland soil. *Environ. Sci. Pollut. Res.* 2022, 1–10. [CrossRef] [PubMed]
64. van Cleef, F.O.S.; Dubeux, J.C.B.; Ciriaco, F.M.; Henry, D.D.; Ruiz-Moreno, M.; Jaramillo, D.M.; Garcia, L.; Santos, E.R.S.; DiLorenzo, N.; Vendramini, J.M.B.; et al. Inclusion of a tannin-rich legume in the diet of beef steers reduces greenhouse gas emissions from their excreta. *Sci. Rep.* 2022, 12, 1–11.
65. Ologhobo, A.D.; Akangbe, E.; Adejumo, I.O.; Ere, R.; Agboola, B. Haematological and histological evaluation of African mistletoe (*Viscum album*) leaf meal as feed additive for broilers. *Annu. Res. Rev. Biol.* 2017, 15, 1–7. [CrossRef]
66. Malada, P.M.; Mogashoa, M.M.; Masoko, P. The evaluation of cytotoxic effects, antimicrobial activity, antioxidant activity and combination effect of *Viscum rotundifolium* and *Mystroxylon aethiopicum*. *S. Afr. J. Bot.* 2022, 147, 790–798. [CrossRef]
67. Ishiwu, C.N.; Obiegbuna, J.E.; Aniagolu, N.M. Evaluation of chemical properties of mistletoe leaves from three trees (avocado, African oil bean and kola). *Niger. Food J.* 2013, 31, 1–7. [CrossRef]
68. Szurpnicka, A.; Kowalczuk, A.; Szterk, A. Biological activity of mistletoe: In vitro and in vivo studies and mechanisms of action. *Arch. Pharmacal. Res.* 2020, 43, 593–629. [CrossRef] [PubMed]
69. Drury, S. Herbal remedies for livestock in seventeenth and eighteenth century England: Some examples. *Folklore* 1985, 96, 243–247. [CrossRef]
70. Iso, I.E.; Kennedy, O.O.O. Growth performance, carcass and meat quality of rabbits fed mistletoe leaf meal diet. *J. Livest. Sci.* 2021, 12, 220–228. [CrossRef]
71. Letso, M.; Thela, N. The substitution of a parasitic plant (*Viscum verrucosum*) for lucerne hay in sheep diets. *Int. J. Livest. Res.* 2013, 3, 33–41.
72. Madibela, O.R.; Jansen, K. The use of indigenous parasitic plant (*Viscum verrocosum*) in reducing faecal egg counts in female Tswana goats. *Livest. Res. Rural Dev.* 2003, 15, 9.
73. Kim, J.H.; Kim, D.W.; Kang, K.H.; Jang, B.G.; Yu, D.J.; Na, J.C.; Kim, S.H.; Lee, D.S.; Suh, O.S.; Choi, K.D.; et al. Effects on dietary Korean mistletoe on performance and blood characteristics in broilers. *Korean J. Poult. Sci.* 2007, 34, 129–136. [CrossRef]
74. Saleh, I.; Maigandi, S.A.; Hudu, M.I.; Abubakar, M.I.; Shehu, A.U. Uses and chemical composition of Misletoe (*Viscum album*) obtained from different species. *Dutse J. Agric. Food Sec.* 2015, 2, 8–12.
75. Ologhobo, A.D.; Oluseun, A.I.; Owoeye, T.; Esther, A. Influence of mistletoe (*Viscum album*) leaf meal on growth performance, carcass characteristics and biochemical profile of broiler chickens. *Food Feed Res.* 2017, 44, 163–171. [CrossRef]