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Treatment of Organic Livestock with Medicinal Plants: A Systematic Review of European Ethnoveterinary Research

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Keywords
European ethnoveterinary research · Organic livestock · Medicinal plants · Veterinary phytotherapy

Summary
Background: The EC Regulation for Organic Farming states that organic livestock should be treated preferably with phytotherapeutic products. In spite of the high importance of organic livestock in Europe, primarily ruminants, today almost no phytotherapeutic product is registered for livestock. Also, scientific information regarding veterinary phytotherapy is rare. The aim of this paper is to find approaches to cope with health problems of organic ruminants in Europe on the basis of findings from the European ethnoveterinary medicine (EuEVM). **Methods:** A systematic review of ethno-biomedicinal papers was conducted with the aid of the Scopus database, and 75 papers, from European countries were analyzed regarding ethnoveterinary information. **Results:** A total of 590 plant species referring to 102 different plant families are reported to be used for animal treatment, with *Asteraceae*, *Fabaceae* and *Lamiaceae* being the most important families. The traditional use of some plant species (e.g. mallow, chamomile, wormwood) corresponds with findings from recent scientific literature. The large number of less studied plant species, such as white lupin as an antiparasitic herb, and *Helleborus* spp. as potential immunostimulatory agent, opens an interesting field for future research. **Conclusions:** In general, EuEVM provides interesting treatment approaches for gastrointestinal and dermatological disorders as well as parasitosis. Findings regarding disorders of female genital or respiratory tract are less consistent. Nevertheless, EuEVM offers a solid basis for stimulating research in veterinary phytotherapy in Europe with a perspective to solve animal health problems in organic or even nonorganic ruminant production.

Schlüsselwörter
Europäische ethnoveterinärmedizische Forschung · Ökologische Tierhaltung · Arzneipflanzen · Veteriärphytotherapie

Zusammenfassung
Hintergrund: Die EU-Verordnung zur biologischen Landwirtschaft fordert explizit den vorzüglichen Einsatz der Phytotherapie zur Therapie von Nutztiererkrankungen. Ungeachtet der großen Bedeutung der europäischen Biotierhaltung, insbesondere der Haltung von Wiederkäuern, sind aktuell kaum noch pflanzliche Arzneimittel für Nutztiere erhältlich. Darüber hinaus sind wissenschaftliche Informationen zur Veterinärphytotherapie rar. Das Ziel unserer Studie ist es, auf Basis von Erkenntnissen der europäischen Ethnoveterinärmedizin (EuEVM) Ansätze zur Lösung von Tiergesundheitsproblemen von Wiederkäuern im europäischen Biolandbau zu finden. **Methoden:** Auf Basis einer Kennwortsuche via der Scopus-Datenbank wurden ethnobiologische, ethnopharmakologische und ethno(-veterinär-)medizinische Peer-Review-Publikationen ermittelt und eine systematische Übersicht erstellt. Insgesamt enthielten 75 Publikationen ethnoveterinärmedizinische Informationen aus europäischen Ländern. **Ergebnisse:** In den ausgewerteten Publikationen wurden insgesamt 590 Pflanzenarten aus 102 Pflanzenfamilien zur Behandlung von Tieren beschrieben. *Asteraceae*, *Fabaceae* und *Lamiaceae* wurden hierbei als Pflanzenfamilien am häufigsten genannt. Bei einigen Pflanzenarten (z.B. wilde Malve, Kamille oder Wermut) bestand eine gute Übereinstimmung der beschriebenen traditionellen Anwendung mit der aktuellen wissenschaftlichen Literatur. Eine große Zahl bisher weniger intensiv untersuchter Pflanzenarten bietet ein breites Spektrum für zukünftige Forschung. Beispiele hierfür könnten die weiße Lupine zum antiparasitären Einsatz sowie *Heleborus* ssp. als potenzielle Immunstimulanzien sein. **Schlussfolgerung:** Die EuEVM bietet interessante Ansatzpunkte zur Behandlung von Magen-/Darm- und Hautkrankheiten sowie von Parasitosen. Weniger eindeutig waren die Resultate hinsichtlich der Anwendung von Arzneipflanzen zur Behandlung des weiblichen Genitale oder der Atemwege. Nichtsdestotrotz bietet die EuEVM eine gute Basis dafür, Forschungsarbeiten im Bereich der Veterinärphytotherapie anzuregen, woraus sich die Perspektive ergibt, einen Beitrag zur Lösung von Tiergesundheitsproblemen bei Wiederkäuern nicht nur für den europäischen Biolandbau zu leisten.

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Introduction

Sales of organic products continue to rise, with an actual global demand 170 times higher than 10 years ago [1]. Organic agriculture is practiced in 160 countries on a total of 37.2 million hectares of agricultural land worldwide (0.86%), with 29% being in Europe (5.4% of all European agricultural land). Detailed data concerning European organic livestock are still lacking [1]. However, out of all organic livestock, cattle and sheep are the most important species, with nearly 3% of the total EU livestock population [2]. Organic pigs represented lower proportions, with less than 1% of the total EU livestock in most of the EU member states [2].

As in non-organic production, mastitis, metabolic disorders, endo- and ectoparasitites (especially in young stock) are major problems in organic dairy or beef herds [3–5]. Also, claw and sole disorders, such as interdigital phlegmon, acute soul haemorrhage, and sole ulcers constitute major problems in organic and non-organic dairy herds [4, 6]. In sheep production parasitism seems to be the main problem, at least in young animals [3, 4, 7].

Considering the high amount of veterinary antimicrobials used each year to treat livestock in EU (4,802 tonnes of active ingredient) [8], and the possibility of cross-resistance between human and animal pathogens [9, 10], alternatives to treat veterinary infectious diseases such as diarrhoea and respiratory afflictions are urgently needed.

Medicinal plants may be considered as one of the most important alternatives to treat organic livestock. The EC Regulation for Organic Farming states that 'phytotherapeutic products (…) shall be used in preference to chemically-synthesized allopathic veterinary treatment or antibiotics' [11]. Nevertheless, allopathic drugs like antimicrobials and antiparasitics are still used in organic farming, with certain restrictions requested by the EC Regulation for Organic Farming and with considerable economic losses due to the doubled withdrawal period [12, 13]. Reliable and scientifically sound alternatives are largely lacking at the moment [14, 15].

Very few phytotherapeutic products are currently registered for the treatment of livestock. Nowadays, scientific literature relies on few books or manuals regarding veterinary phytotherapy [16, 17], but clinical data on animals are few, and many applications have been adapted from human phytotherapy [16]. Further sources of information might be historical books or ethnoveterinary knowledge from Asia and Africa where medicinal plant use has a continued tradition in veterinary medicine, and findings of recent ethnoveterinary research in Europe [18]. According to McCorkle [19], ethnoveterinary research is 'the systematic investigation and application of folk veterinary knowledge, theory and practice'. The traditional use of plants has been investigated in some parts of Europe [20–25]. Homemade herbal remedies, handed down over generations, may be a useful therapeutic alternative for treatment of livestock [9, 22, 26, 27], in particular on certified organic farms [24, 27, 28]. Although there are reviews regarding ethnoveterinary medicine (EVM) from other parts of the world [20, 29] and from European ethnomedicine [30], a comprehensive overview on EVM in Europe is still lacking.

Taking into account the ruminant-focused structure of European organic livestock production, main health problems, and the reasons for the use of antimicrobials and antiparasitics, the aim of our paper is to analyze previous findings from EVM research regarding treatment of inflammatory and infectious diseases (concerning respiratory and gastrointestinal tract and female genital tract including mastitis), claw disorders, and parasitosis of ruminants.

Material and Methods

Selection of Scientific Publications

This review was based upon field studies conducted in European countries, published in peer-reviewed journals between 1990 and 2013, and indexed by Scopus [30]. The search terms were selected from keyword indices of major ethnomedicinal/ethnobotanical journals (*Journal of Ethnopharmacology*, *Journal of Ethnobiology and Ethnomedicine*), matched with the Scopus search fields 'abstract', 'title', 'keywords', and 'text' (ethno* OR tradition* OR folk) AND (veterinar* OR animal OR livestock OR farm* OR sheep OR goat OR cattle OR cow OR pig OR calv* OR poultry) AND (plant OR herb* OR phyto*), and with each country of the EU, including candidate and affiliated countries (Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Kosovo, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Montenegro, Netherlands, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, the former Yugoslav Republic of Macedonia, Turkey, United Kingdom). From this first search 8,822 titles were extracted, which were reduced to a final set of 75 publications [20–23, 32–102] by a 2-step process (fig. 1) on the basis of a set of predefined criteria: The first selection was based on headlines and abstracts, the following on the entire paper. We only considered ethnoveterinary, ethnopharmacological, ethnomedicinal, and ethnobotanical papers containing information on at least 1 plant species which was unambiguously linked to a veterinary use. Information from review papers were only included if they did not refer to papers already included in our search. Zootherapeuticals as well as plant species which were reported to be toxic or main components of the basic ration were not included in our dataset.

Data Collection

From each paper, we collected – if available – the following information on plant species unambiguously directed to veterinary use: 1) Plant parts used (aerial part, bark, branches/stems, flower, flowered aerial part, fruits/seeds/berries, leaves, roots/bulb, whole plant, whole plant without roots, others); 2) Animal species treated; 3) Age classification of the treated animal (adult, young); and 4) Therapeutic use. Animals are reported at species level, except for 'equine' (horse, mule, asses) and 'poultry' (lying hens and broilers, turkeys). The term 'cattle' included also oxen and buffalos, while 'small ruminants' included sheep and goats. For the classification of the indication we used the Anatomical Therapeutic Chemical Classification System for veterinary medicinal products (ATCvet) [103]. Beside the ATCvet code, we followed the concept of 'food as medicine' [104] embracing any feed additive if it was clearly directed to one or more animal species. If no information for one of the categories mentioned above could be found, we classified it as 'information not available'.

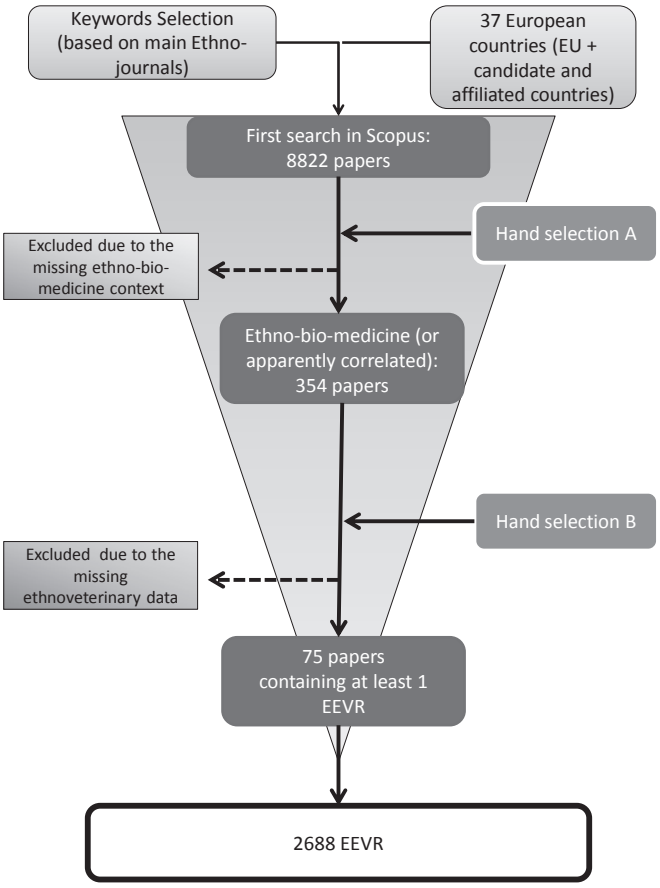

Fig. 1. Process of paper selection. Hand selection A: Selection based on headlines and abstracts; Hand selection B: Selection based on the entire paper. Papers including at least one plant species unambiguous connected to a veterinary use were presented; EEVR = European Ethnoveterinary use Reports.

Plants family assignment followed the APG III classification (Angiosperm Phylogeny Group III) [105], and subspecies were included where applicable. Abbreviations for country names were according to ISO 3166 –1 alpha-2 codes [106].

Definition of European Ethnoveterinary use Reports (EEVR)

In our outcomes each individual combination ((*mandatory*: 'scientific paper' x 'plant species unambiguously directed to veterinary use') x (*if available*: 'plant part used' x 'animal species treated' x 'age classification of the animal' x 'ATCvet code indication' x 'ATCvet sub-code indication')) was denominated as one EEVR. For example, if a *Malva sylvestris* L. infusion of leaves was described for dermatological use in adult cattle in one study, it was considered a different EEVR than administered on another animal species or the same animal species but different age in the same study. The same applied for a different plant part of the same plant species.

Results

Ethnoveterinary data are available for 12 of the 37 European countries included in the survey. The most comprehensive data were available from Italy, Spain, and Turkey (fig. 2). In total we identified 2,688 EEVR (appendix I; table 1; *www.karger.com/doi/10.1159/000370216*).

Reported Plants

A total of 590 plant species referring to 102 different plant families were reported to be used for animal treatment. *Asteraceae*, *Fabaceae* and *Lamiaceae* were most relevant families with more than 100 EEVR each. The 10 most often mentioned plant species represented 16% of total EEVR: *Malva sylvestris* L. (83 EEVR, 3%), *Vitis vinifera* L. (70 EEVR, 3%), *Urtica dioica* L. (50 EEVR, 2%), *Allium sativum* L. (43 EEVR, 2%), *Olea europeae* L. (37 EEVR, 1%), *Sambucus nigra* L. (34 EEVR, 1%), *Matricaria chamomilla* L. (33 EEVR, 1%), *Hypericum perforatum* L. (29 EEVR, 1%), *Fraxinus ornus* L. (28 EEVR, 1%), *Scrophularia canina* L. (28 EEVR, 1%); appendix II; *www.karger.com/doi/10.1159/000370216*).

Plant parts most frequently applied were aerial parts (391 EEVR), followed by leaves (370 EEVR), fruits, seeds, and berries (309 EEVR). However, in almost one third of cases (858 EEVR) no plant part was described.

Treatments of Animals

The most frequently treated animals were ruminants in general (1,115 EEVR, 44% of total EEVR) including cattle (652 EEVR), small ruminants (441 EEVR), and not specified ruminants (22 EEVR). The following animal species treated were equine (290 EEVR, 11%), pigs (188 EEVR, 7%), poultry (162 EEVR, 6%), and rabbits (93 EEVR, 3%). The category of 'other' (total of 98 EEVR, 4%) included all other livestock species, plus dogs and cats. In one quarter of use reports the treatment was not explicitly directed to a specific animal species (684 EEVR, 25%).

In 97% of EEVR, the age of target animal species was not explicitly reported. In particular, 90 EEVR were reported explicitly for young and 5 EEVR for adult animals.

We focused mainly on EEVR closely linked to a classification according to the ATCvet code (EEVRT: 1931; appendix II + appendix III; *www.karger.com/doi/10.1159/000370216*), excluding feed additives (347 EEVR), not further specified veterinary indications (313 EEVR), and indications that were not clearly connected to an ATCvet code (126 EEVR).

In the finally selected papers, 1,931 EEVRT could be related to 11 different ATCvet codes: The indication of alimentary tract and metabolism (QA) was addressed by 532 EEVRT (28%), dermatologicals (QD) by 441 EEVRT (23%), and genitourinary system and sex hormones (QG) by 308 EEVRT (16%). These 3 codes represented about two thirds of all EEVRT (fig. 3). Approximately half of the EEVRT were also related to a more specific subcode of ATCvet (1023 EEVRT, 53%). Most frequently cited plants related to our main indications and subindications are summarized in table 2 (*www.karger.com/doi/10.1159/000370216*).

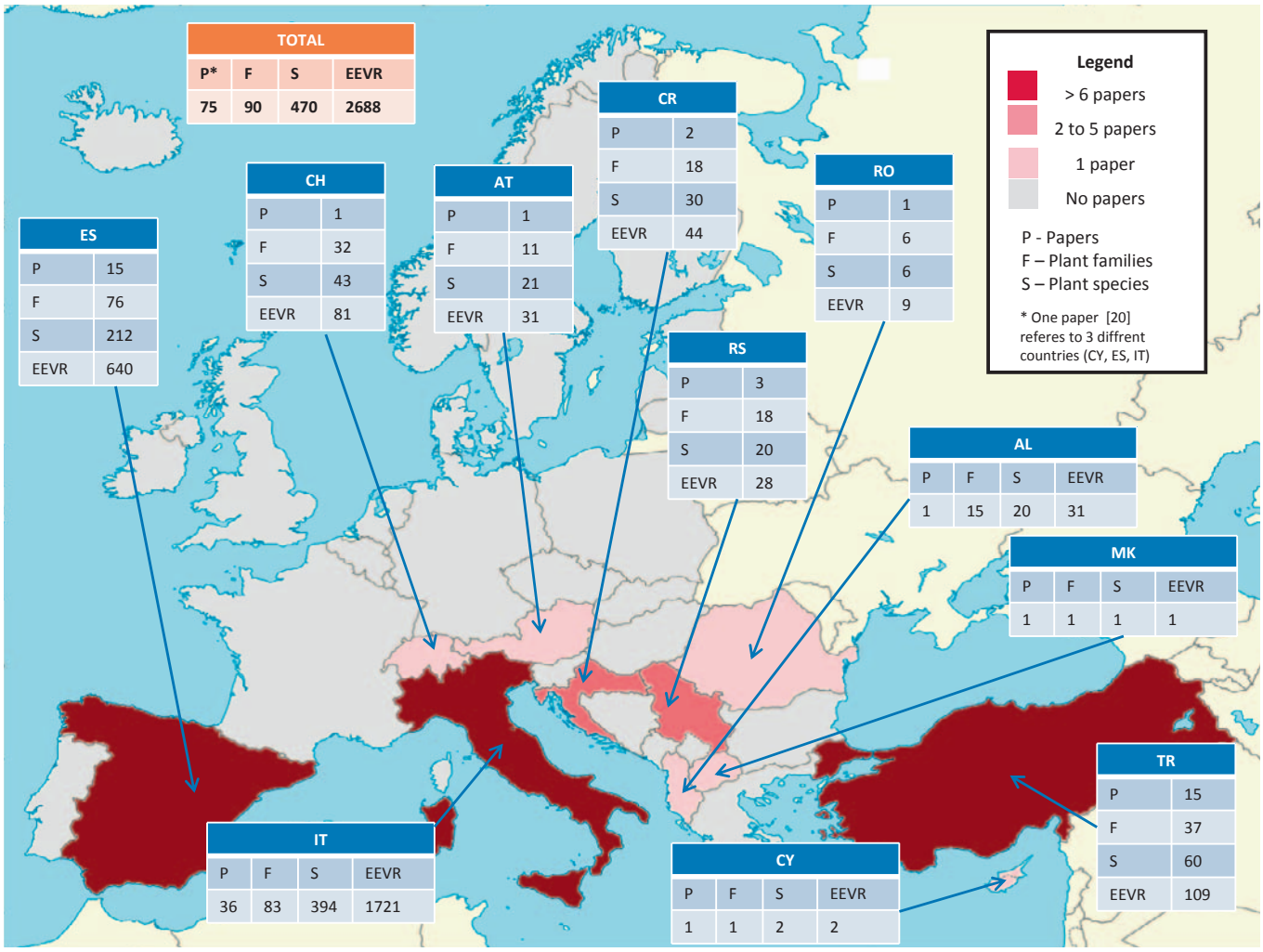

Fig. 2. European map of ethnoveterinary research. AL = Albania; AT = Austria; CH = Switzerland; CR = Croatia; CY = Cyprus; RO = Romania; IT = Italy; MK = Macedonia; RS = Serbia; TR = Turkey.

Discussion

Considering the growing importance of European organic livestock production, in particular ruminants, and the priority of phytotherapy for the treatment of organic livestock [1, 2, 107], solutions might be found in EuEVM. Surveys with more or less extensive ethnoveterinary information have been conducted only for a small number of European countries. A total of 2,688 EEVR were extracted from 75 original papers. 1,931 of them contained therapeutic indications (EEVRT), which were classified according to ATCvet. In our review, we focused diseases with a high relevance for organic ruminants, and/or closely connected to the use of antimicrobials and antiparasitics, namely infectious diseases of gastrointestinal, respiratory, and female genital system (including mastitis), claw disorders, and parasitosis.

Even if, according to Quave et al. [30], some less accessible studies could be important for the understanding of local traditional knowledge, we analyzed only peer-reviewed papers written in English, since they represent widely accessible knowledge for the scientific community, veterinarians, and pharmaceutical companies. However, we are aware that also nonscientific or scientific but not English sources can contain ethnoveterinary information. Maybe further reviews will focus particularly on these sources.

Among European countries, Italy is strongly represented in this survey, with a total of 38 papers and almost two third of all EEVR, while other countries are represented by only 1 paper (AT, AL, CH, CY, HU, MK) and, in some cases, by a single EEVR (MK). This underlines the necessity of further ethnoveterinary research, in particular in Central Northern, and Eastern Europe.

Due to the broad spectrum of study designs and inconsistent or even missing data, detailed information regarding the use of medicinal plants for veterinary purpose were not available in most publications. Even though preparation and way of administration might influence therapeutic efficacy strongly, these information are reported only fragmentary and incon-

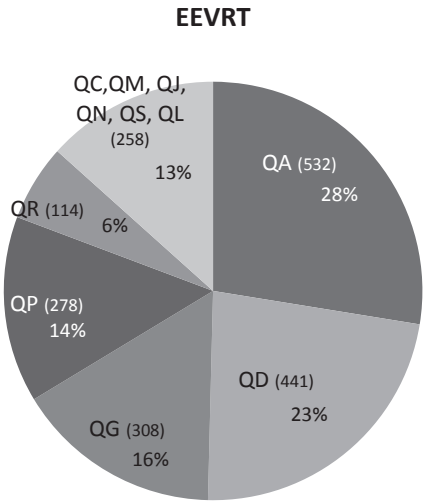

Fig. 3. Distribution of European Ethnoveterinary use Reports (EEVR) according to veterinary therapeutic indications of the Anatomical Therapeutic Chemical Classification system for veterinary medicinal products (EEVRT). ATCvet codes: QA = Alimentary tract and metabolism; QC = Cardiovascular system; QD = Dermatologicals; QG = Genito urinary system and sex hormones; QJ = Antiinfectives for systemic use; QL = Antineoplastic and immunomodulating agents; QM = Musculoskeletal system; QN = Nervous system; QP = Antiparasitic products, insecticides, and repellents; QR = Respiratory system; QS = Sensory organs. In brackets = Number of EEVRT per ACTvet code; percentage referred to a total of 1,931 EEVRT.

sistent for less than a half of EEVR. Only a few papers are focused on EVM [22, 35, 37, 38, 42, 52, 57, 81, 98, 101]. Since ethno-biomedical surveys are conducted usually in rural areas where farm animals are likely, future investigations should provide detailed information regarding veterinary treatment in order to enrich European ethnoveterinary knowledge.

From the plant species reported in the surveyed publications, in the following we discuss selected, very common (high number of EEVRT) and/or widely used (high number of referring papers or countries) plants for important ATCvet codes (alimentary tract and metabolism (QA), drugs for functional gastrointestinal disorders (QA03), antidiarrheals, intestinal anti-inflammatory/antiinfective agents (QA07), dermatologicals (QD), preparations for treatment of wounds and ulcers (QD03), products for the treatment of claws and hoofs (QD51), genitourinary system and sex hormones (QG), gynecological antiinfectives and antiseptics (QG01), products for teats and udder (QG52), antiparasitics, insecticides and repellents (QP), anthelmintics (QP52), ectoparasiticides, insecticides and repellents (QP53), and respiratory system (QR)) to discuss the significance of their use in the context of current pharmacological knowledge, human and veterinary clinical trials, and empirical studies (table 3; *www.karger.com/doi/10.1159/000370216*).

Gastrointestinal Disorders (QA – 532 EEVRT, 60 Plant Families, 205 Plant Species)

Diseases of the gastrointestinal tract were the main focus of EuEVM, with 28% of all EEVRT. *Malva sylvestris* L. (26 EEVRT), *Vitis vinifera* L., and *Matricaria chamomilla* L. were the most widely used species. *Vitis vinifera* L. is not discussed further, given the difficulties of distinguishing between its use as herbal drug, alcoholic product, or source for vinegar due to its acidic properties. We mainly focused functional gastrointestinal disorders (QA03), antidiarrheals, and intestinal antiinflammatory/antiinfective agents (QA07).

Mallow (Malva sylvestris *L.*)

Mucilaginous heteropolysaccharides are the major components responsible for therapeutic effects of mallow and are found mainly in leaves (6.0–7.2%), flowers (3,8–7,3%), and roots (7,5%) [107]. Leaves and aerial parts were mostly administered orally and considered helpful in case of various digestive disturbances, such as abdominal colic, tympanism, for reactivation of rumination in small and large ruminants, generic digestive problems, diarrhoea, and constipation. In a total of 12 Italian and Spanish publications, mallow was often referred to as functional gastrointestinal (QA03) agent for ruminants (6 EEVRT) and as general gastrointestinal (QA) agent (26 EEVRT). Mallow is a well-known medicinal plant, but its use in livestock and especially in rumen complaints should be further investigated.

Chamomile (Matricaria chamomilla *L.*)

The major constituents of chamomile flowers are a sesquiterpene-containing essential oil and flavones [109]. Chamomile flowers and aerial part were used in EuEVM mainly as decoction or infusion for the treatment of digestive problems in livestock and colic pain. The use is corroborated by scientific literature and veterinary phytotherapy text books and manuals [16, 17, 109]. However, no scientific data are available regarding its administration in ruminants; clinical research would be helpful to establish effective dosages.

Other Plants

Apart from *Mercurialis annua* L. which is traditionally used as an anti-constipation agent, probably due to its toxic properties [110], several plant species seem to be promising gastrointestinal (QA) agents.

EuEVM plants, such as wormwood (*Artemisia absinthium* L.), elderberry (*Sambucus nigra* L.), yarrow (*Achillea millefolium* L.), and lineseed (*Linum usitatissimum* L. seeds), may be effective for the treatment of gastrointestinal disorders, such as colic, impaired digestion, tympany, and meteorism. On the one hand, they are already well-known in human phytotherapy for treatment of similar complaints [109] and, on the other hand, some of these plants have also been mentioned in veterinary phytotherapy text books and manuals [16, 17]. Application of yarrow has been reported in 4 different countries (ES, IT, RO, RS). These reports are corroborated by pharmacological and human clinical research [111–113]. This herbal drug could be considered as a functional gastrointestinal (QA03) and possibly antidiarrheal, intestinal antiinflammatory/antiinfective (QA07) agent.

However, pharmacological data regarding possible use in the context of gastrointestinal disorders are lacking for some plants, such as for *Salix alba* L. (mainly branches and leaves). According to EuEVM reports from Turkey and Italy, chewing of willow by sheep increases salivary production [114], which in turn could lead to reactivation of rumination. However, these reports need to be substantiated by further pharmacological research. The same applies for garlic (*Allium sativum* L.), most commonly known as antiparasitic (QP), but reported from EVM in Italy also as gastrointestinal (QA) agent. Garlic was recently tested in sheep for improvement of digestion [115], but more basic research is needed here to substantiate this finding.

Regarding anti-diarrheals, EuEVM suggests a wide spectrum of different plants, without a consistent repetition of same species. *Quercus ilex* L. and *Hordeum vulgare* L. might be potentially useful due to their tannin content [116–118], but increased phytochemical knowledge and standardized preparations are needed for clinical trials in ruminants.

Dermatological Disorders (QD – 441 EEVRT, 60 Plant Families, 190 Plant Species)

A considerable percentage of EEVRT (23%) was directed to dermatological diseases. It seems quite common for farmers to treat these easily visible disorders on their own without recurring to a veterinarian, which might lead to a more frequent transfer of knowledge from generation to generation. Plant species mentioned for treatment of dermatological disorders (QD), and in particularly preparations for treatment of wounds and ulcers (QD03), may also have a potential to treat claw disorders.

EuEVM reports 3 plants against cattle ringworm (QD01). Of these, *Ilex aquifulium* L. and *Rhamnus catharticus* L. seem to have a more ritual use, while *Lupinus albus* L. is the only plant directly applied on the skin. Although cattle ringworm is not a major veterinary problem, it remains an important zoonotic fungal infection which requires therapeutic intervention [119].

Scrophularia canina *L.*

EuEVM frequently reports this plant species for treatment of dermatological disorders, as preparation for treatment of wounds and ulcers (QD03) as well as claws and hoofs (QD51). There is little published data, and one can only speculate that iridoid glycosides as component of *Scrophulariaceae* may play a role as active principle [120–122].

Aleppo pine resin (Pinus halepensis *L.*)

According to recent studies [123–125], there is scientific basis for the traditional use of conifer resins for treatment of wounds and ulcers. Aleppo pine (needles, twigs, and buds) possesses antibacterial activity against different bacterial pathogens [125]. These studies may justify the use of Aleppo pine resin as preparation for treatment of wounds and ulcers (QD03), and of macerated buds for treatment of claw diseases (QD51).

Other Plants

Broadleaf plantain (*Plantago major* L.) was also frequently cited in EuEVM as a vulnerary drug (QD03). Books or manuals regarding veterinary phytotherapy and phytochemical research seem to corroborate its therapeutical use. Thus, a specific veterinary evaluation would be indicated since clinical research into veterinary use is still lacking [17, 126]. The same applies for mallow and St. John's wort (*Hypericum perforatum* L.), which are both well-known in EuEVM and also documented in scientific literature as a vulnerary drug (QD03) [16, 108, 128–131]. Also, studies concerning treatment of claws and hoofs (QD51) should be conducted.

Disorders of Female Genital and Udder (QG – 308 EEVRT, 53 Plant Families, 150 Plant Species)

Mastitis and genital internal infections occur mostly after calving, and represent a considerable economic loss for organic dairy herds, considering that the withdrawal period after a treatment with antibiotics is twice as long compared to conventional farming [107, 132–134]. Replacement by herbal preparations could be helpful. Although 62 EEVRT are referred to subcode QG52 (products for teats and udder), none of all QG plant species received a particularly high number of citations in EuEVM (appendix III; *www.karger.com/doi/10.1159/000370216*).

Internal Female Genital Organs

Mallow is used in Spain as an antiinfective and antiseptic after delivery (QG01– 10 EEVRT), while in Italy mallow decoction is used to expel the placenta after giving birth (QG02 – 3 EEVRT). In both cases, a decoction or infusion is orally administered to treat animals. Further research is needed to substantiate this particular use of mallow.

Mastitis

The emollient properties of mallow may justify its use as a topical agent for udder skin; its antibacterial properties are known to be effective against mastitis-causing pathogens (*Staphylococcus aureus* and *S. agalactiae*) [109, 135]. Veterinary clinical research is needed to investigate whether topical application may mitigate intramammary infection. The same is true for St. John's wort which is also topically used and possesses distinct anti-bacterial and anti-inflammatory properties [17, 136, 137].

Respiratory Diseases (QR – 114 EEVRT, 29 Plant Families, 67 Plant Species)

Respiratory diseases are not the main issue in organic dairy farming, but they are largely responsible for the use of antibiotics in conventional farms [15, 138], and in other livestock species, such as poultry and pigs [15].

Mallow and chamomile are most frequently reported in EuEVM as respiratory (QR) agents. Their use may be justified by their antimicrobial properties, but further studies should specifically address effects on the respiratory tract. In humans, inhalation of chamomile oil shows beneficial properties [139].

Widespread use of *Helleborus* ssp. in EuEVM is surprising if one considers the distinct toxicity of cardiac glycosides contained in the plants [140]. In Italy, Romania, Serbia, and Turkey a root or branch of *Helleborus* spp. is inserted under the skin of sick animals to treat respiratory problems. The use of *Hellborus* as an immunostimulating drug has been reported [141, 142], but further research is needed for this traditional use.

Antiparasitic Products (QP – 278 EEVRT, 49 Plant Families, 111 Plant Species)

Annual expenditures for treatment of ruminants in Europe with anthelmintics amount to approximately EUR 53 Million [143]. Increasing resistance to current drugs requires alternative solutions both in conventional and organic farming [15]. Moreover, gastrointestinal parasites are a potentially serious threat, especially to organic sheep and goat production [12, 15].

Garlic (Allium sativum *L.*)

The effects of garlic bulbs are well-known in EuEVM (19 EEVRT). Activity on different endoparasites has been shown both in vitro and in vivo (round and flatworm, flagellates) [144–148]. Topical application of garlic also showed some activity against chicken mites [149]. *Allium sativum* L. is mentioned as anthelmintic (QP52) and antiprotozoal agend in a text book regarding veterinary phytotherapy [16], but more research is needed [150], particularly clinical veterinary trials.

Wormwood (Artemisia absinthium *L.*)

Aerial parts and leaves of wormwood are used in EuEVM against ecto- and endoparasites, mainly in cattle. In vitro and in vivo data suggest that wormwood might be effective as anthelmintic (QP52) [151, 152], but its use as ectoparasitic or repellent agent (QP53) needs to be substantiated [153].

Other Plants

EuEVM indicates some further interesting although less known antiparasitics plants: white lupin (*Lupinus albus* L.) and cade (*Juniperus oxicedrus* L.) as most promising agents against ectoparasites (QP53). Seeds of white lupins are boiled and applied onto the skin of animals, probably due the richness in alkaloids of the bitter varieties of this plant (e.g., lupanin) [154], and are reportedly effective as crop parasite repellent and aphicide [155, 156]. Cade essential oil was found to be effective against poultry red mites [157]. Cultivated tobacco (*Nicotiana tabacum* L.) is also used against ectoparasites (QP53). Given the pharmacological and toxicological properties of its major alkaloid, nicotine [158], further studies are needed to clarify if a safe use of this plant might be possible. Infusions of branches, leaves, and flowers of *Fraxinus ornus* L. are used in Italian EVM against ectoparasites and diarrhea. Anti-coccidial properties have been demonstrated in broilers [159], but the use in QP52 (anthelmintics) and QP53 (ectoparasites) indications requires further investigation. *Ruta chalepensis* L. and *Ruta graveolens* L. are used in EuEVM as antiparasitic herbs (QP – 9 EEVRT each). *R. chalepensis* is mainly used against endoparasites in ruminants (6 EEVRT). There is preliminary evidence, especially regarding their possible use against endoparasitosis (QP52) [160], but further studies are needed, in particular regarding their metabolization in rumen.

Conclusion

This systematic review highlights the relevance of research in EuEVM as a source of information regarding a diversification and substantiation of medicinal plant use in the treatment of organic livestock. Even though large areas of Europe remain to be mapped for their traditional ethnoveterinary knowledge, an impressive number of plant species has already been reported. EuEVM may provide promising and new approaches for the treatment of gastrointestinal and dermatological disorders as well as parasitosis. Regarding female genital and respiratory disorders, our findings are less consistent. For a series of plant species (e.g., mallow, chamomile, wormwood), traditional ethnoveterinary use and scientific evidence based on pharmacological and (human) clinical research corresponded very well. A number of less studied plants may offer promising starting points for future research, such as white lupin as a potential antiparasitic agent. We hope that this review will stimulate further ethnoveterinary research, particularly in central-eastern and northern Europe, and clinical research in livestock with promising plant species, in a larger effort to re-establish veterinary phytotherapy as an integral part of sustainable treatments for health problems in organic and maybe even in non-organic livestock.

Disclosure Statement

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Supplemental Material

To access the supplemental material please refer to *www.karger.com/doi/10.1159/000370216*.

Table 1. Therapeutic classification, medicinal plants, and target animal species of European Ethnoveterinary use Reports (EEVR)

Table 2. Plant species most frequently mentioned in European Ethnoveterinary use Reports (EEVR) linked to a classification according to the ATCvet code1 (EEVRT) and their number of referring papers and countries

Table 3. Selected plant species frequently mentioned in European Ethnoveterinary use Reports (EEVR) and their levels of pharmacological and therapeutic evidence (pharmacologic studies, in vitro and in vivo studies, human and veterinary clinical trials)

Appendix I: European Ethnoveterinary use Reports (EEVR).

Appendix II: European Ethnoveterinary use Reports (EEVR) and EEVR according to veterinary therapeutic indications of the Anatomical Therapeutic Chemical Classification system for veterinary medicinal products (EEVRT) per plant species and plant family.

Appendix III: Plant species per therapeutic indications and number of European ethnoveterinary use Reports (EEVR) according to veterinary therapeutic indications of the Anatomical Therapeutic Chemical Classification system for veterinary medicinal products (EEVRT).

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