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Sustainable Animal Production, Systemic Prevention Strategies in Parasitic Diseases of Ruminants

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Abstract

Integrated parasitic veterinary control strategy and holistic vision is a sanitary program which aims at reducing the usage of drugs, protecting animal welfare, ecological balance and farmers' income. Internal parasitic diseases of ruminants constitute one of the most important health issues in extensive livestock farming. Despite the environmental toxic effects, anti-parasitic chemical pharmaceuticals are frequently used. In order to limit the employment of these drugs, it is necessary to establish an integrated control strategy, including managerial and agronomic activities, as well as non-conventional medicine. A monitoring plan of action of the farm must be implemented, whereby parasitological, clinical, productive and environmental indicators are evaluated. Considerations emerging from such an analysis would inevitably require a scheme of interventions, with the intent of maintaining equilibrium between parasite and host. This objective may include all agronomical activities, managerial actions and the application of alternative medication. Homeopathic medicine is particularly indicated thanks to the absence of drug residues in food animal products, the drug-resistance phenomenon, the low costs and the easy administration of remedies.

Keywords: Agro-ecological system; Biological control; Parasitic diseases

Introduction

Extensive farming of ruminants is a managerial cornerstone of animal health and welfare, as well as quality food production. In fact, grazing and the possibility of movement constitute vital elements for a correct physiology and expression of animal behavior. Man has the duty to assure such conditions if he aims at supporting the ethics whereby animals are recognized as sentient beings, possessing the right to a dignified life. However, such husbandry practice increases the correlated risks of parasitic infection, as the relationship between a parasite and its host is enhanced.

Internal parasites today, are one of the most important hurdles of health management in extensive animal breeding and are capable of causing productivity losses; around the entire world [1]. The cost of infection includes reduced welfare and productivity, increased mortality, diffused usage of anthelmintics and increased management requirements [2]. Disease eradication is not a realistic option in illnesses which depend greatly upon environmental factors, for their survival and development [3,4].

Traditionally, man would intervene by prescribing a drug after having examined the animals and carried out a parasitological analysis, when following good clinical standards. This non preventive but reductive procedure is essentially problematic since this type of interference aims at suppressing the parasite, leading to an immense employment of chemical substances which have serious repercussions on the environment and public health [5]. A sanitary program which aims at reducing the usage of drugs, protecting both animal welfare and farmers' income; requires a more articulated and complex type of management.

The host-parasite bond needs to be limited within a threshold of both husbandry and sanitary risks, through the research and analysis of innovative solutions. A holistic, preventive attitude is thus proposed, in which the core contribution is offered by one's reasoning and capacity to inter-relate and integrate different kinds of expertise, in order to maintain a well-balanced, predictive, preventive and sustainable interaction between man, animal and environment [6-8].

Through the analysis of risk factors present in an agro-ecosystem, one can attempt to predict the contact between a parasite and their host and/or the onset of a certain pathological state-predictive veterinary medicine [9]. Subsequently, one can establish adequate preventive measures in order to avoid the contact and/or the onset of a disease-preventive veterinary medicine [8,10].

Conventional Anti-parasitic Treatments in Ruminants

Former organic farming regulation EU n. 2092/91 and Reg. 1804/99 imposed a limited number of permitted anti-parasitic treatments, as well as the type of molecule allowed, which needed to be "of low environmental impact, rapid metabolization, limited toxic effects and possess withdrawal times inferior to a period of 10 days".

The EU Regulation n. 889/2008 has abolished those limitations regarding the usage of anti-parasitic treatments. In addition, the frequent administration of these drugs has been permitted as exceptional commercial usage in organic farming.

Anti-parasitic chemical drugs of large spectrum are often administered to production animals, such as cattle and small ruminants from 2 to 4 times a year. In fact, chemical treatments are employed widespread, even without laboratory findings [2,11]. However, they are

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known to possess several negative collateral effects, which have been identified.

Avermectins, the major class of anthelmintics used, are mainly excreted with stool of treated animals and have a long persistence in the environment [12-14]. Avermectins are harmful towards many invertebrate species, profoundly influencing the conservation and balance of both the terrestrial and aquatic ecosystems, belonging to the following taxonomic orders: Dictyoptera, Anoplura, Homoptera, Thysanoptera, Colaptera, Siphonaptera, Diptera, Lepidoptera and Hymenoptera, as well as some species of fish [5,15,16].

A large usage of avermectins tends to decrease the biodiversity. Insects contribute to the recycling of nutrients, the maintenance of organic substances in soil and thus soil fertility. They are also an essential source of nutritional requirement for vertebrate animals, such as birds, amphibians and mammals. Animal manure is used to fertilize the fields. Therefore, when administering eco-toxicological substances that reach animal excretions, this has an environmental impact [13,14].

In the past, control of parasites relied almost exclusively on multiple and regular anthelmintic drenching, with the aim to maximize livestock productivity and profitability. However, as it has been established by various authors, that the use of anthelmintics has several drawbacks such as: the increasing incidence of parasite resistance against the available anthelmintics; consumer concerns regarding drug residues in food products and in the environment; the negative effect of preventive treatments on the development of natural immunity against helminths [17,18].

Earliest sings of anthelmintic resistance date back to the late 1950s and 1960s. Presently, multi-drug resistant worms (to all three major drug classes) have been documented throughout the world, threatening the viability of small ruminant industries in most tropical and sub-tropical areas [19,20]. These worrying issues are of particular importance throughout developing countries since nutritional resources available to small ruminant livestock are often inadequate and thus natural immunity is unfortunately compromised [20].

This situation implies that it is now imperative to change our general concept of the usage of anthelmintics in farm conditions and to seek alternative "group" medicine, as well as formulate solutions for chemical treatments [4,21]. This crisis situation has pushed many farmers and parasitologists to form of preventive medicine, such as an integrated worm management that combines anthelmintics plus alternative methods of control [18]. Farmers and veterinarians must abandon the notion that internal parasites need to be totally eradicated, and start raising animals to be fit for the environment, in order to attain optimum productivity [22].

Nonetheless, the consumers' attention is always more centered on food production with respect of animal welfare, ethics and eco-sustainability.

Parasite-host Relationship

The dilemma that farmers often encounter is represented by the economic losses associated with gastrointestinal parasitism, almost endemic in breeds that are raised under extensive systems. This type of environment allows internal parasites to complete their biological cycle and grass helps survive the larvae, which then re-infest grazing animals [11].

The intensity of helminths infection is furthermore influenced by a number of management factors such as: stocking rate and species diversity [23]. Indeed, a negative relationship has been established between species diversity of helminths and helminths infection both in sheep and goats. This can be explained by the theory whereby the diversity of a community of organisms, threatens the stability within an agro-eco-system [8,9,24].

An animal without worms is not an ideal to strive for at any cost, at least not in organic farming. An animal that never has a preventive contact with worms cannot develop resistance and is thus extremely vulnerable when exposed to a parasite. Resistance or immunity is the ability to prevent or limit the establishment or subsequent development of worm infections. Tolerance or resilience is the ability to maintain good productivity despite infection. Contrarily, susceptibility to parasites is defined by how easily the animal becomes infected. Ideally, grazing animals - especially the youngest ones - should ingest parasites in small quantities so that they may progressively develop immunity [23-25].

It is not recommended to expose animals to continuous treatments and re-infestations, as occurs in grazing animals. Instead, it is more convenient to exploit best managerial practices with the aim to restrict parasitic burden on pastures, associated with predictive and preventive medical strategies that enhance the natural resistance of animals [7,8]. As some studies have inferred, specific "group" homeopathic treatments as a group-focused medicine, can favor the restriction of parasitic counts below the threshold of animal husbandry and sanitary risks [26-29].

In a given geographical region, several factors such as climatic conditions (such as temperature, relative humidity and rainfall), husbandry practices, nutrition and the physiological status of animals are known to affect the level of pasture contamination and seasonal fluctuation of larvae [30].

In south-east Asia, helminths parasitism in small ruminants can cause high incidence and high mortality, where grazing is the predominant husbandry practice [31].

Holistic Management of Animal Health

In order to reach the maximum usage of predictive, preventive, systematic and integrated strategies, one's medical proficiency must be confronted with sectors of competence such as ecology, ethology and animal husbandry. Thus, the most common medical scheme "diagnosis-prognosis-therapy" needs to be expanded [6,7].

Human and animal nature is more complex than our genetic make-up and includes psychological and emotional aspects as well as physical ones [32]. To be individualised, diagnosis and treatment need to take into consideration the animal in full expression in its environment [33,34].

The treatments of Non Conventional Medicine systems preserve, protect, promote, study, hand on and apply the cultural heritage of such anthropological medical expertise [8,32,35].

The agro-ecological system is composed of numerous components: earth, plant, animal and man; where each element is held together thanks to a web of complex reciprocal bonds. The analysis of such a system is based mainly upon the scrutiny of the bonds linking each element. Such an approach does not focus on detail as such, but the behavior of the intertwined elements in total [9,33,36]. The complex pattern of any ecosystem cannot be understood by simply breaking down each part, but only by studying and measuring the interactions between each component: its non-reducible properties. A new property

emerges from an ecosystem because the interactions are modified, not because the basic nature has been changed or a new element has been introduced [32,33,36].

It needs to be personalised to take into account cultural and environmental differences of populations, down to individuals in their biographical context [6,35].

Animal farms are agro-ecological systems, in which animal health is directly linked to all other elements composing the system. In an agricultural ecosystem, man usually establishes very strict restrictions concerning the interactions between various species of animals and plants [33]. For instance, man tends to concentrate one species in a given area and create hazardous conditions, which typically lead to an imbalance and rapid failure [34].

On the other hand, human contribution can also facilitate the installation of virtuous circles, determined by the bonding between subsystems and in turn, can guarantee an excellent and efficient state of balance. Hence the necessity for a comprehensive sanitary evaluation focused on the entire animal farm; a monitoring scheme and an exemplary preventive and corrective plan of resolution [37]. This kind of design requires an excellent understanding of all aspects and elements of a system and an efficient communication between the practitioner, manager and staff [9,33].

When regarding animal parasitism, predictive types of analyses include the study of factors which influence an increased presence and/or persistence of parasitical larvae in the environment. Such factors regard soil characteristics, pasture management, nutrition etc. and are correlated to qualitative and quantitative data of parasites in the ecosystem as well as the responsive capacities of animals, both depending upon genetics, physical constitution etc. [9,34].

In this way, one can foresee both the increase of certain parasitic species and/or their contact with hosts, as well as the decrease of resistance of reared animals, thus enabling the implementation of adequate preventive measures (predictive medicine applied to veterinary species).

Preventive strategies as monitoring are mandatory, in order to carry out a constant and more accurate control of the situation, in combining more than one method of data collection regarding health, production and reproduction.

The importance of integrating numerous understandings within an agro-ecosystem, has been underlined more than once: examples regard the more traditional abilities cultivated in a certain territory; the farmer's competences; nurturing an inclination towards learning the adaptive techniques animals and plants employ; as well as the ability to confront oneself with forms of knowledge other than medicine. Medical expertise needs to be integrated with other qualifications, within a scheme of constructive collaboration [33-35,37].

The solutions may not necessarily originate from energetic and/or chemical input, which are external to the system, but may surprisingly lie within a predictive and innovative comprehension, as for example in the search of a design which can result more advantageous in keeping a balanced system. Clear examples of such an ideology refer to applied methods such as genetic selection, which aims at increasing resistance towards parasitism through increased rusticity; the development of a new diet composition; or a modified management of grazing pastures [38].

In this view, mankind, the environment, one's envision and the mutual collaboration towards a commercial product, all represent cornerstones of a system that needs constant nurturing, support and safeguard.

Preventive Integrated Control of Internal Parasitism in an Agro-ecological System

The availability of a sustainable control of gastrointestinal parasites along with limited use of chemotherapy, could prove to be of great value to farmers and beneficial to the environment [11]. Breeders have to learn to farm with internal parasites, trying to prevent only the unacceptable production losses while simultaneously breeding animals fit for the environment, rather than making the environment fit for existing animals [22].

One must consider preventive integrated methods of parasite control, able to contain the problem below a hazardous threshold and subsequently combine them together. A few of these methods aim at increasing the resistance of the host: homeopathic medicine, genetic breeding, nutrition; whereas other methods influence the direct contact between the parasite and its host i.e. grazing management and biological control [7,8].

In order to distinguish the more suitable method, one must examine the relation between each element that composes the system (nutrition, soil, humidity, agricultural practices); the animal genetics and predict their environmental adaptability and the relationship between parasites and their host, based on parasitological, productive and clinical data [28,29].

To begin with, it is fundamental to identify the "critical points", defined as any element which may represent an obstacle or a weaker link and focus on regulating it or rectifying it. Contemporarily, one should evaluate and record how the system responds to each modulation. In this way, each corrective intervention is preceded by close and attentive observations. These interventions need to be integrated between them and modified based on the farm characteristics [7]. They need to be sustained by a preventive monitoring plan which keeps the problem constantly under tight control and should evaluate the efficiency of the methods employed. Generally, diversification tends to increase the balance of a system which in a way is the empiric definition of biodiversity.

Preventive plans need to be adopted to improve parasite control schemes and need to be based on the principles of integrated preventive management which incorporates:

- Monitoring
- Grazing management
- Homeopathic treatment
- Phytotherapeutic treatment
- Diet composition
- Breeding parasite-resistant animals
- Biological control

An integrated control of parasites should include several novel control strategies, which ideally should meet the minimal performance and welfare expectations, able to justify the use of such method. In this view, such performance expectations should reflect not only an acceptable efficacy but also a positive economic outcome [17].

Monitoring

Monitoring should include parasitological, clinical, environmental and managerial investigations.

Parasitological monitoring: Parasitological investigations are carried out in a systematic manner, resulting in the discovery of the types of parasites present and possibly, its exact burden (Fecal Egg Count).

A monitoring plan is elaborated on the basis of the sanitary anamnesis collected and the farm characteristics, aiming at evaluating the dynamics of the parasitic counts recorded over time. Ideally, it would indicate the frequency with which laboratory findings should be effectuated and in which way, depending on the parasitic species found.

Examinations can be carried out using a "pool" of fecal samples or else including only a certain significant percentage of individual.

Clinical investigations: Results obtained from parasitological investigations must be evaluated in correlation with the health status of animals, in order to guarantee a low level of sanitary risk. Therefore, it is essential that the practitioner examine the clinical pattern typically related to parasitism such as anemia, diarrhea and weight loss.

Investigating environment, management and animal husbandry: Productive and reproductive parameters are recorded, such as growth and fertility, in relation with clinical, environmental and managerial data.

The analysis of environmental and managerial aspects is very important in attempting to identify any possible factors linked to diet, soil, climate or intermediate biological hosts, contributing to an increase of the parasitic level [8].

Grazing management

Pasture rotation consists in subdividing a pasture in smaller plots, available for limited periods of grazing. In this way, heavy infestations can be avoided and animals are supplied with an excellent diet through grazing of pastures.

Rotations are planned according to the biological cycles of parasites and their free-living stages, after considering the level of farm management.

Rotational strategies can be defined as "preventive", "evasive" and "diluting" [39]. The first technique is obtained by drenching animals, which become worm-free and moving them onto clean pastures: sometimes referred to as "clean grazing". Evasive strategies rely on moving livestock to another pasture just before larvae burdens are likely to increase significantly on the original pasture, often combined with treatment. Diluting strategies exploit mixing susceptible animals with a population of animals resistant to parasites, of the same species (for e.g. with older stock) or of different species (mostly cattle and sheep), in order to reduce the pasture contamination [40].

Today, organic sheep farmers, as well as conventional, should rely mostly on grazing management procedures; like turn-out on clean pastures, low stocking rates and repeated moves onto clean pastures [41]. Increasing stocking rate leads to increasing levels of parasitism in grazing livestock. The effects of parasitic infection may be modified by nutrition but are nevertheless directly proportionate to the number of parasites present, which approximately reflects the number of larvae present on pasture [40]. A trial study in Sweden on a cattle farm demonstrated how parasitic infections may be adequately controlled by grazing management, without the use of anthelmintic prophylaxis [42].

A plot of land must remain "at rest" for a length of time, depending entirely upon the time of survival of parasites in the environment, which is ultimately influenced by climate, temperature and humidity. Certain agricultural practices allow limiting parasitic burdens on pastures such as: superficial plowing, alternating grazing with plant cultivation and mowing of weeds. Alternating different grazing species also allows reducing parasitic counts considerably, seeing as cattle, horses and pigs are notably affected by different parasites.

Homeopathic treatment

The application of homeopathic medicine is beneficial for its absence of residual substances, toxicity, environmental impact and drug-resistance phenomena. Furthermore, it entails a holistic approach to health and deeply explores the interactions between man, environment and animal, harmonized with a systemic vision of phenomena [9,36].

Is has been hypothesized that homeopathic medicine can determine an efficient immune response in the host with a consequential reduction of parasitic burden, as well as a better tolerability towards the parasite [27,43] The immune system is indeed capable in interfering with the worm metabolism, resulting in a slower growth rate as well as vitality and fertility reduction [23].

When considering production animals, it is recommended to apply the methodology aimed at identifying the group remedy as animals bred together share the same environment, part of their genetic mapping and have the tendency to express similar emotions, behavior and pathologies [28,29]. Furthermore, according to the systemic method [36], the observer defines the borders of the object in analysis [9,33] which in the case of a farm should be limited to the entire agro-ecosystem, containing profound inter-related bonds with animal health and welfare [7,26]. The group remedy is specific and different for each group and can increase the general reactivity of animals.

A preventive homeopathic examination includes an accurate observation of the pedoclimate, structure, diet composition, human-animal relationship and the dynamics within a herd. The observer must complete the recent and remote anamnesis of the herd, a behavioral analysis in relation to the species considered and the ways in which such individuals relate towards their environment [7,28,29]. The prescription is based upon the principle of similarity in relation to the final description presented by the group and the remedy, combined with specific professional experience and relevant competence/proficiency [27-29,43].

Phytotherapeutic treatment

Phytotherapeutic prescription is based on the administration of a drug which derives from a plant or part of a plant. Dosage is of particular importance, considering the various metabolisms throughout different species [44]. Unfortunately, research regarding pharmacokinetics in veterinary medicine is extremely scarce and often numerous attempts must be made without guarantees.

In veterinary medicine, there are several examples of phytotherapeutic treatments applied to traditional medicine, both in Italy and abroad [45,46].

Effective veterinary medical prescriptions can be finalized when combining knowledge derived from popular medicine, along with the theoretical notions of pharmacological properties botanical active ingredients possess.

In conclusion, one must consider how variably these preparations are available on the market, the correlated issues linked to the quality of the product and the possibility of phyto-chemical residual compounds in food animal products.

Diet composition

Nutritional supplementation is a technique that aims at boosting the immune response within the host. Enhancing immunological function provides benefits both to the individual and also to the flock, by reducing pasture contamination while requiring little or no chemical input [47-49].

Late pregnant and lactating ewes often demonstrate a rise in fecal egg counts, acting as a reservoir for lambs. During periods of increased energetic demands, alongside the acquisition of immunity, a nutritional supplementation must be provided in order to guarantee an efficient expression of immunity and reduce the degree of parasitic infection [47,49].

The interactions between composition of feed or pastures and ruminant nematode infections have been extensively studied and it is now recognized that certain forages reduce the establishment of incoming nematodes or reduce existing worms [40,48]. However, researchers are still not quite sure whether bioactive forages exert a direct anti-parasitic effect with the surface of parasites, or an indirect effect whereby providing the host with readily absorbed proteins, thus increasing resilience [50].

The examples reported illustrate in which way preventive managerial decisions carried out on a farm may influence the immunity of parasitized animals, their productivity and health status. Nutritional supplementation is not always beneficial per se but instead, requires an intelligent and strategic targeting. When deciding on the nutritional supplementation schemes of sheep, it is essential to target the provision of limiting nutrients. For instance, if a flock were grazing areas of dry grasses and crop stubble, an addition of nitrogen to the diet may be beneficial in order to utilize the carbohydrate source [20].

Breeding parasite-resistant animals

In the southern hemisphere, selection for genetic resistance is practised as a preventive method on commercial farms. Examples of sheep selectively bred for resistance include "Rylington Merino", in Australia and a Romney selection line in New Zealand [1]. Tendentiously, resistant animals expel lower FEC than the susceptible controls and selection of sire using this criterion, may result in more resistant lambs. Over time, as susceptible animals with higher FEC are culled, pasture contamination should decrease and overall GIN infection in flocks should lessen [25].

In organic farming, the selection of the best suited breed should always be kept in mind [40]. The majority of autochthonous breeds are indeed more genetically resistant towards almost all parasitic species. Even those parasites that survive within the hosts and reproduce need to find a balance with the genetic traits of resistance, expressed by the organism. However, livestock husbandry has shifted the equilibrium with the intent of reaching maximum productivity, leading undoubtedly to an alteration in the relationship between parasites and their host, in favor of the parasites [51]. The usually difficult systems of raising sheep has required that these animals develop a significant adaptability towards the environment conditions of their territory, thereby enhancing a natural resistance towards whichever parasitic infections are characteristic of such terrains [11,52].

Biological control

Biological control is a preventive method obtained via two main approaches: natural and applied biological control. The first is brought about by the effective use of natural enemies whereas the second, by enhancing these natural enemies. The latter tends to give better results and an example is described here below [53].

A haematophagous fungi denominated *Duddingtonia flagrans*, has the ability to kill nematode larvae in the faeces, considerably reducing pasture contamination [21]. Undoubtedly, the employment of *D. flagrans* is accompanied by certain economic benefits such as a reduced usage of anthelmintics, lower host infections in the late season and increased weight gain compared to untreated animals [17]. Biological control methods are highly effective when implemented at times when contamination of pastures produce seasonal peaks of larval counts.

The second method of biological control influences the rate of fecal breakdown or degradation in order to accelerate the exposure of the larvae to hostile or inclement weather. Fecal degradation depends upon the type of forage. In fact, it has been demonstrated that sheep grazing on pasture containing some plant species such as chicory (*Chicorium intybus*) and birdsfoot trefoil (*Lotus corniculatus*), have lower egg outputs than sheep grazing on Lucerne (*Medicago sativa*) [54]. These forages contain high concentrations of plant secondary metabolites (PSM) named condensed tannins, which have demonstrated to possess a direct antiparasitic effect and an indirect nutritional mechanism. Plants such as *Hedysarium coronarium* (Sulla spp.), *Lotus pedunculatus* and *corniculatus* (Birdsfoot trefoil), sainfoin and quebracho may indirectly improve host resistance and resilience to nematode infections [39,50].

Discussing each one of these methods, in the light of an integrated control of parasitic infections, has the objective to enlighten the reader on the importance of designing a tailor-made plan for the management of each farm, seen as an agro-ecosystem.

Designing a Strategy of Interventions

Once a thorough investigation has been made combining parasitological monitoring, clinical and environmental examinations, a preventive plan of adequate interventions can be developed. If the parasitic counts were to be low, this would indicate a good health status and satisfactory productive performances. In this case, it would not be recommended to treat the animals, not even with herbal compounds, in order to fully respect the natural parasite-host balance. On the other hand, it is not totally erroneous to administer preventive homeopathic remedies, which would not modify such equilibrium.

Homeopathy and environmental measures, such as rotation of grazing pastures, are recommended when parasitic counts are medium-high but if the conditions were to become unsatisfactory, other preventive methods need to be employed. If the parasitic burdens were to heavily increase, an expert practitioner in Non-Conventional Medicine should consider treating with homeopathy or phytotherapy in order to limit the correlated risks and recommend a short-term follow-up, or proceed by prescribing a chemical drug, depending on the clinical symptoms observed.

Pharmacological treatment must be a targeted one and not become a mere routine, where each anti-parasitic prescription is evaluated by a veterinarian doctor in relation to the health status of animals; to the quality and quantity of parasitic burden found (after quantitative parasitological analysis), using molecules with a limited spectrum

having a lower eco-toxicological effect than those with a wider spectrum.

Conclusions

The massive and habitual utilization of anthelmintics in extensive farming has serious environmental consequences and public health-related issues, thus a valid alternative must be identified based on predictive, preventive and systemic medical principles, which limit both the sanitary and zoo-technical risks under an acceptable threshold.

Total elimination of naturally-present parasites within a healthy environment is not a realistic objective, but rather the attainment of an equilibrium among an agro-ecosystem, further promoting sustainable and harmonious bonds among man, environment and animals.

Such practices include an attentive monitoring of the group of animals raised and the environment; the implication of agronomic and managerial tools such as a correct pasture management and nutrition scheme; the wise choice of breed and genetically-resistant lines; the usage of medication which reinforces the adaptive reactions of a host, such as homeopathy.

The balance of an entire system, based on the bonding between each subsystem, is largely enforced by an exchange of information and the combination of numerous areas of expertise. Communication, intended as the exchange of information, is the central node of biological systematic. The cooperation between a physician, patient, owner, other clinicians and/or technicians in close collaboration, can induce major modifications within this system. The broader the system in question, the more stable, long-lasting and advantageous the solutions will be for every component considered.

"With the exception of vaccinations, treatments for parasites and any compulsory eradication schemes established by Member States, where an animal or group of animals receive more than two or a maximum of three courses of treatments with chemically-synthesized allopathic veterinary medicinal products or antibiotics within one year (or more than one course of treatment if their productive lifecycle is less than one year) the livestock concerned, or produce derived from them, may not be sold as being products produced in accordance with this Regulation, and the livestock must undergo the conversion periods laid down in Section 2 of this Annex, subject to the agreement of the inspection authority or body".

Competing Interests

The Authors declare that they have no competing interests.

Authors' Contributions

The Authors worked together on the article, planning the article and writing it. All Authors read and approved the final manuscript.

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