Review Article

Impact of the "Bacteria-Parasite Interaction" in Animal Health and their Participation in the Control of Parasites

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Abstract

The parasite infections of animals (production and pets) affect the health and quality of animal life, the parasites frequently present a microbiome associated which play several functions, like nutrition, reproduction or defense against the host immune system, and in some cases are opportunistic microorganisms. These bacteria might cause secondary infections to animals, so the parasite can become a vector of pathogenic bacterial, reason why the understanding of the "bacteria-parasite interaction" is important to combating of parasitic infestations. The current resistance to conventional dewormers or ixodicides, are issue in parasitology; attack a vital bacteria of parasites through antibiotics possibly can be a control alternative, at the same way, the use of bacteria capable to control to parasitic diseases by antagonist interaction, like lethal toxins or adhesion at the site invasion of the parasites, are alternatives to explore. Understand the bacteria-parasite interaction will help us to the control of parasitic diseases in an integral form, as well know as the bacterial infections that can develop from the parasitic infestation. The use of antagonist bacterial is a biotechnological option in the control of parasites as therapy on the animal biomedicine, so in this review, we have a general idea of the "bacteria-parasite interaction" and their impact on the animal's health.

Keywords: Parasites; Probiotics; *Bacillus thuringiensis*; Animal health

1. Introduction

Parasitic infections are important in the livestock sector and pets because they affect the production and animal welfare, in addition to endangering human health by parasitosis called zoonoses, that generate economic losses focused on its control and prevention [1]. The resistance of ticks and helminths to a great variety of chemical substances used in the veterinary clinic, this is one of the main problems to be solved, because the resistant organisms increase the permanence of the parasitosis and its propagation [2]. Therefore, the search for new active principles or control strategies are the partial solution against the mentioned problem; micro-organisms such as the bacteria *Bacillus thuringiensis* (*B. thuringiensis*), whose basis is the production of spore-crystal complex and proteins with specific bioactivity, the toxins of the bacteria are mostly known for its ability insecticide, this has been used in the biochemical and biological control of nematodes, cestodes, trematodes, mites and ticks. However, currently *B. thuringiensis* is considered as a bacterium antagonistic of parasites used in investigations *in vitro* and *in vivo* therapeutic in laboratory and farm animals [3, 4].

Diverse bacteria have a symbiotic relationship with external and internal parasites, between the functions and most well-known properties of the symbiotic interaction between bacteria and parasite are the following; the nutritional role, immunomodulating property, and contribution to the pathogenesis [5-7], at the same time, the enteric helminths can increase or decrease the beneficial bacterial populations in the host, affecting the health of the animal [8]. So, it is of paramount importance to address the symbiosis and relationship that develop the bacteria with the intestinal parasites of pets and production animals by the side effects that can cause in animal health. It should be noted the keep symbiotic bacteria and parasites interaction can become an alternative method in therapies dewormers dependent on the presence or absence of the bacterial biota. For example, the appropriate use of antibiotics or probiotics in addition to pathogenic bacteria to parasites such as *B. thuringiensis* or bacteria capable of regulating the parasitic competition for nutrients and space that would allow the intestinal colonization; genders like *Lactobacillus* spp, can become part of the future treatment to conventional therapies in parasitized animals, thereby combating the emergence of resistance with conventional dewormers or ixodicides, for the benefit of animal health.

2. Helminths with bacterial interaction

Interaction of enteric helminths with bacteria can contribute to the permanence of bacterial infections, an example is the association that maintains the gastrointestinal nematode *Schistosoma* sp with the bacterial *Salmonella* sp, the parasite helps the maintenance of the bacteria in the small intestine of mice, attributed to bacterial attached to folds of the nematode [9]. However, the enteritis per *Salmonella* sp in chickens can decrease the number of *Ascaridia gallis* nematodes established when the infection is later [10], this parasitosis is sensitive to bacteria, such as *Pasteurella multocida* and *Escherichia coli* [11, 12], although this parasite is able to produce bactericide molecules [13]. The attachment of the Salmonella bacteria to the cuticle of *Schistosoma* sp allows it to evade of antibiotics [14]. Another similar example of adherence has referred for cestodiasis of fish *Esox lucius* in the intestinal tract, proteolytic and amylolytic bacterial symbionts take refuge in the tegument of the cestodes *Eubothrium rugosum* y *Ligula intestinalis*, the symbiosis presents a nutritional role, through the synthesis of amino acids and vitamins produced by the bacterial [15, 16].

In some enteric parasitosis, the parasite is capable of modulating the bacterial quorum through the segregation of bacteriostatic substances that alter the beneficial microflora in animals. For example, the nematode *Trichuris suis* that infects pigs, causes a low population of bacteria of the genus *Runimococcus* which present cellulolytic activity, in the colon of the pig [8]. The decrease is likely associated with the bactericidal activity of the excretion-secretion products of the adult parasite *T. suis*, the bactericidal activity of these bio-products is mentioned against Gram-negative bacteria (*Campylobacter jejuni*, *Campylobacter coli*, and *Escherichia coli*), as well as in the Gram-positive (*Staphylococcus aureus*) [17]. The ability to reduce the bacterial population has referred only to the adult stage of *T. suis*, because the larval stage is associated with bacteria surrounding epithelial tissue of the intestine, with spirochetes in minor infections to 35 days with *T. suis*, the alteration of ecological niche has come to associate with dysentery in pigs [18], thus promoting the pathogenesis of the parasitosis. Another example occurs during the parasitism by *Trichuris muris*, this nematode is able to modify the intestinal microbiota causing an increase of lactobacilli during chronic infection [19]. The interaction between nematodes and bacteria may exist through the adaptability related to the parasite and its environment microbial [20].

The bacteria-parasite interaction can modify the bacterial flora of the host by decreasing or increasing the number of bacteria, it is known that the nematode *Heligmosomoides polygyrus bakeri* modifies the bacteria populations in mice to lead to an increase in the group proteobacteria, in the intestinal regions of ileum, caecum and the increase *Prevotella* sp in colon; it is still not known why increased these bacterial populations, however, it has been proposed that interfere with immune processes to inhibit Th2 immune response that helps the expulsion of enteric parasites [21, 7]. The symbiotic association between bacteria and nematodes has been mentioned in the nutrition of larvae in soil in its two primary stages (rhabditiform) of development outside of egg for the genera *Ancylostoma* sp and *Haemonchus* sp [22]; in the case of the root-knot nematode *Mesodiplogaster* sp, is feeds of *Pseudomonas cepacia* in free life on fine-textured soils or thick [23], the diet can vary depending on the environment in which to develop the larval stages.

The bacteria-parasite association can be discussed even for hatching of nematode eggs, such is the case of *Trichuris* spp and the association that presents in the hatching in the presence of the bacteria *Enterococcus caccae*, *Streptococcus hyointestinalis* and *Escherichia coli* [20], concluding that the Gram-negative bacteria have an important role in the hatching of the nematode eggs. Also, some nematodes, includes bacteria endosymbionts for example, in the filariasis for the development of the nematode embryogenesis, the bacteria that take to this interaction belong to the genus Wolbachia, pathogenic bacteria for animals and humans, which is transmitted by the transovarial way in the parasite [24].The *Wolbachia* sp has an important role in the development of damage to cornea, in the rat model for river blindness (onchocerciasis) because of filarial worm infected with this bacteria, causes into the cornea an inflammatory response, and this infection is considered zoonosis [25].

Currently, the parasitology must encompass the microbiome of internal parasites, a recent publication refers the lack of information on internal bacteria of parasites such as tapeworms, these authors report the finding of the bacteria *Polynucleobacter* sp., considered as the most abundant and the prevalent in the microbiome of *Schistocephalus solidus* teniasis of fish, their presence in the parasite induces a change in the microbiota of the host in addition to intestinal presence,

[26] so that the impact on the bacterial quorum of the fish is similar to previously mentioned on the bacteria population in mammals.

3. Protozoa with bacterial interaction

The protozoan *Histomona meleagridis* is a parasite of birds, affects the liver and intestine with lesions, these lesions are associated whit the presence of bacteria such as *E. coli* and *Clostridium perfringens*, the relationship between *H. meleagridis* with bacteria is evident in the *in vitro* cultures, where cells of the parasite present deformity or death to apply antibiotic *in vitro* [27]. The parasite *Eimeria tenella* increases the populations of Enterobacteriaceae and *Salmonella* spp [28, 29], while the *Lactobacillus* spp and *Streptococcus* spp decrease in the intestine [30], in addition to the injuries caused by *Eimeria* spp the viscosity of the intestinal mucosa is affected and possibly the provision of nutrients for the bacteria [31].

4. Ectoparasites with bacterial interaction

In this section addresses to the interaction between external parasites and their bacterial flora, between the parasites are mentioned: mites, ticks, fleas and tsetse flies, considered important in the clinic veterinary by compromising the animal health. The bacteria-parasite interaction in ectoparasites, such as mites and ticks, is linked to opportunistic bacteria that can affect the animal health, for example, the mite *Psoroptes ovis*, etiologic agent of sheep scab, has been associated with the bacilli *Serratia marcescens* that contribute to the nutrition of the mite and the process of pathogenesis [32-34]. *S. marcescens* can affect the rabbit eye by keratitis of cornea [35], so scabies induced by mites of the genus *Psoroptes* sp frequently caused complications by secondary bacterial infections [36]. In addition to pathogenic bacteria, in *P. ovis* have been isolated various bacterial that have features that focus on the digestion of the mite, *Pseudomonas* spp have proteolytic activity and *Staphylococcus* spp is able to hydrolyze protein of animal origin [37], they can produce irritation of the dermis in animals, and the psoroptic mange with chronic otitis can be aggravated by meningitis caused by opportunistic bacteria [36]. The riketsia *Anaplasma marginale* is a bovine bacterial pathogen transmitted by ticks, such as *Dermacentor andersoni*, *Dermacentor variabilis* and *Rhipicephalus microplus*, considered important vectors in tropical and subtropical regions, the disease is characterized by damage to erythrocytes triggering anemia, fever, and death of the animal [38]. The importance of endosymbionts in ticks focus in the fact that both *Anaplasma marginale* as *Coxiella* sp. are pathogenic to animals so the bacteria-parasite interaction compromises the health of animals and humans who can be able to develop Q fever and riquetsiosis [39, 40], on the other hand, *Wolbachia persica* has been isolated from tick *Argas arboreus* (Persicargas), bacteria capable of infect cattle [41].

Another ectoparasite of importance in cats and dogs is the flea, this arthropod can harbor bacterial symbionts of the classes Firmicute and Proteobacteria capable of colonizing the species *Ctenocephalides felis* and *Xenopsylla cheopis*. It is important to mention that the fleas do not present peritrophic matrix, so that the epithelium of the midgut is vulnerable to the contact with microbes ingested during feeding, so that is believed the bacterial flora is necessary to the flea as a defense of the arthropod. The bacterium *Bartonella henselae* has been isolated from fleas, it is able to affect the health of domestic cat colonizing the erythrocytes and vascular endothelial cells and is the causal agent of “cat scratch” disease [42]. In the tissue of tsetse flies from the salivary glands, Gram-negative populations have been detected, the secondary bacteria commonly found in old flies, symbionts isolated by intra and extracellular way, among these the strain GP01 symbiont, provides a possible nutritional function [43].

5. Control of parasites with probiotic bacteria

The bacteria used as probiotics have the ability to stimulate the immune system and that this generates antibodies or cells that help decrease the parasitic infection [44]. The role of probiotics against parasitic diseases in animals is the utmost importance to be an alternative safe, organic and environmentally friendly in addition to help for a good bowel function, the probiotics have preventive and prophylactic antiparasitic effect, in Table 1 are listed certain parasitosis and use the of probiotics that showed an effect on the parasite population before and after in *in vivo* treatments. The use of probiotic bacteria against parasites are described *in vitro* and *in vivo*, for example, the *in vitro* study of *Lactobacillus* strains isolated from chicken shows that these are capable of preventing the invasion of *Eimeria tenella* in MDBK cell culture (Madin-Darby bovine kidney), the authors speculate that the inhibitory effect possibly is due to steric interference or competitive exclusion; *Lactobacillus salivarius* strain Lb16c6 produces extracellular elements in the supernatant that present significant activity by inhibiting the invasion by coccideas *Eimeria* spp, however, the mode of action is unknown [52]. An *in vivo* study a mixture was used, biomin® Poultry Star composed; *Bifidobacterium animals* (DSM16284), *Lactobacillus salivarius* (DSM16351) and *Enterococcus faecium* (DSM 21813), in the diet of broilers commercial chickens (Cobb 500) parasitized with Eimeria spp, the mixture caused to decrease the parasitic oocyst in feces by more than 40% [53]. It has also been referred to the evaluation of probiotics against nematodes, the compounds released in the supernatant by *Lactobacillus casei* has confirmed the anthelmintic efficiency in mice treated causes decreasing the *Trichinella spiralis* infection in 32.5%, the reduction was associated with the stimulation of IL-2 and nitric oxide production by *L. casei* [49].

Parasite	**NH/EH**	**Probiotics**	**Dosage**	**Time of treatment**	**Reduction of parasites/D.P.I**	**References**
Babesia microti	Dog/ Mice	*Lactobacillus casei*	1.8×10^9 cells	3 and 10 days (B)	–89%/10	[45]
Cryptosporidium parvum	Rat	Actimel (Danone, France)	2.107 CFU	12 days (B) 2 days (A)	–64%/12	[46]
Eimeria spp	Chicken	PoultryStar, BIOMIN®	2 mg (5 × 1012 per kg)	9 days (A)	–48.1%/9	[47]
Giardia intestnalisi	Human/ Gerbils	*Lactobacillus johnsonii*	1×10^8 CFU	7 days (A)	100%/14	[48]
Trichinella spiralis	Swine/ Mice	*Lactobacillus casei* ATCC7469	1.8×10^9 cells	7 days (B)	70.7%	[49]
Trichus muris	Mice	*Lactobacillus rhamnosus* (JB-1)	1×10^9 CFU	1 day (B) and 15 days (A)	–92%/21	[50]
Toxocara canis	Dog/ Mice	*Enterococcus faecalis* CECT 7121	[6.086×10^4 (2.376×10^4) CFU/g]	3 days (B)	89.6%/2	[51]

Note: NH/EH: natural host/experimental host in the study, D.P.I-days post infection; (A): after infection; (B): before infection.

Table 1: Probiotics used for the control of animal parasites.

Other bacteria used in the control of nematodes in animals is *Bacillus laterosporus*, the toxins produced by this bacillus are able to inhibit the hatching of eggs and larval development of the nematode *Trichostrongylus colubriformis* [54].

6. Control of parasites with *B. thuringiensis*

Another bacterium that has taken an important role in the control of parasites is *B. thuringiensis*, this microorganism is capable of producing a sub-apical spore and one or several parasporal bodies: inclusions composed of proteins that present specific insecticide activity, even to specie level, this microorganism is known such a potent bioinsecticide [55, 56]. The symptoms that develop the insects (larvae of Lepidoptera) after the ingestion of the spore-crystal complex are the following: the host presents inanition and diarrhea, intestinal paralysis and eventually death [57].

B. thuringiensis, is a viable alternative for the control of animals and plants parasites, because the Cry proteins produced by these bacteria are harmless to humans, vertebrates and plants, in addition to be biodegradable [57, 58]. *B. thuringiensis* presents toxic activity in parasites of animals as in the case of mites, cestodes, and nematodes with broad effects on different stages of the parasite (egg, larva, and adult). The strains GP123, GP138, GP130 and GP140 of *B. thuringiensis* was tested *in vitro* against *R. sanguineus* ticks, the strains presented a mortality rate of 75.15 to 95.8% [59]. In the same way, the strain GP532 of *B. thuringiensis*, proved to kill in vitro near of 50% after 72 h of ectoparasite *P. cuniculi* by contact and besides was able to damage intestinal tissue of the mite and generate vacuoles in ventricles [60].

In the case of gastrointestinal parasites, *B. thuringiensis* is toxic against larvae of *H. contortus* (Rudolphi), *T. colubriformis* and *Ostertagia circumcincta*, nematodes of livestock [61] Within the group of Cry proteins that possess nematicide action we have the following; Cry 5A, 5B, 6A, 6B, 12A, 13A, 14A and 21A [62]. So far there are few reports of activity of *B. thuringiensis* against platyhelminths, GP526 strain is presumed to be highly toxic against *Centrocestus formosanus* [63], so it also acts on the egg and the tegument of the *Dipylidium caninum* cestode of dogs [64]. The ovicidal activity of *B. thuringiensis* can be used in the treatment of wastewater, the contamination for helminths eggs is a problem because the wastewater is using for the vegetal culture in agriculture. And the dual activity of GP526 can disrupt the life cycle of the parasite, for example in their viability on intermedia host.

The high effectiveness of *B. thurinigiensis* against parasites *in vitro* and *in vivo* possibly might be used by pharmaceutical industry to develop next-generation anthelmintics from this bacterium, due to their toxic function against multiple parasitic infections such as those cited in Table 2. It is expected that *B. thuringiensis* will contribute to strengthening the health programs against parasitosis [3]. The toxicity of Cry 5B protein, has been studied on *H. contortus* nematode of ruminants [69], and nematode of pigs *Ascaris suum* with positive results, [66] as well as in *Ancylostoma ceylanicum*, parasite present in humans and hamsters, the toxin Cry 5B *in vitro* causes diminution on the motility in larvae (L1/L2) and adult death [65]. The application of *B. thuringiensis* in the veterinary clinic, is a current topic, the biodegradable proteins can be used in the production of organic meat, by replacing chemical dewormers that extends the time of sacrifice of the animal before being of consumption, so the use of this bacterium is a possible solution to the problem of chemical pollution of the meat.

Parasite	TP/ NH	Strain (*Bt*) or toxin	C-D	EF	References
Ancylostoma ceylanicum	Nematode/Hamster and human	Cry 5B	*200 µg/ml	100%	[65]
Ascaris suum	Nematode/Swine	Cry 5B	*1000 µg/ml	100%	[66]
Centrocestus formosanus	Cercarie/Fish	*Bt* GP308	*146.2 µg/ml LC_{50} (SC)	50%	[63]
Dipylidium caninum	Cestode/Dogs	*Bt* GP526	*10 mg/ml, ***600 µg/ml (SC)	100% and *75%	[64]
Eimeria tenella	Coccidia/ Chicken	*Bt* 6	*300 µg	100%	[67]
Haemonchus contortus	Nematode/Cattle and Sheep	*Bt* PS-52 A1	***LD_{90} =100 µg/ml (SC)	90%	[68]
Psoroptes cuniculi	Mite/Rabbit	*Bt* GP532	*LC_{50}= 11.3 mg/m (SC)	50%	[60]
Rhipicephalus microplus	Tick /Cattle	*Bt* GP138	*1.25 mg/ml (SC)	81.2%	[59]
Trichostrongylus colubriformis	Nematode/Rumians	*Bt. Kurstaki*	***LD_{50}=0.38 ng/ml, **1.1 µg/ml (SC)	50%	[69]
Varroa destructor	Mite/Bees	*Bt* EA26.1	*DL_{50}=1.50 µg/mL	50%	[70]

Note: TP/NH: type of parasite/natural host, *adult stage,**larvae stage and ***egg stage, C-D: concentration or dosage, SC: Spore-Crystal complex, CL_{50}: 50% Lethal Concentration, DL_{50}: 50% Lethal Dosage, EF:effect or afficacy parasitocidal.

Table 2: Use of *B. thuringiensis* against parasites of domestic animals *in vitro.*

The use of *B. thuringiensis* in ectoparasites has allowed the treatment of tick infestations of livestock through the implementation of the GP543 spore and crystal complex in cattle, it should be noted that this strain was isolated from the corpse of a tick, it is mentioned that the decrease of the parasite on day 14 came to be up to 99.56% and 99.21% at day 21, with only two applications [4]. In addition, other studies have evaluated three subspecies of *B. thuringiensis* (*kurstaki*, *thuringiensis* and *israeliensis*) spraying of spore-crystal complex in the ticks *Argas persicus* and *Hyalomma dromedarii* [70, 71]. The mite *P. cuniculi* is a parasite of veterinary importance, it is the cause of psoroptic scabies, the strain GP532 decreased the cutaneous damage caused by the mite *P. cuniculi*, with only two applications of bacterial treatment the decrease is 76.38% of clinical signs against natural infestations [72], so that in the future a mixture of toxins with acaricidal activity of broad- spectrum on the basis of *B. thuringiensis* can be used in ixodicidal shower by immersion. In the case of enteric parasites, the administration of *B. thuringiensis in vivo* for the treatment of helminthiasis has been extensively evaluated, the oral administration of Cry 5B for the control of *A. ceylanicum*, on the model of the golden hamster, had a powerful anthelmintic action by reducing the infection in the number of eggs released in feces [65].

In another study, the same protein was evaluated *in vivo* on mice against *Heligmosomoides bakeri* with positive results in chronic infection with 70% of reduction in worms and 98% in eggs. The authors mention the need to prepare a formulation of this protein to resist gastric fluids for best results, however, the effect of this protein compared with other chemical and natural alternatives, is considered as dewormer powerful [73]. The Cry 5B tested in hamsters infected with *A. ceylanicum* with different concentrations of protein in co-administration with anthelmintic drugs as pyrantel and tribendimidine, is able to completely eliminate the intestinal parasitosis. The therapeutic applications of Cry5B have been a positive effect anthelmintic in dogs infected with *Ancylostoma caninum* [74] so that this protein is considered to be highly effective against roundworms and a candidate anthelmintic on the pharmacology veterinary medicine. Also, the role of bacterial endosymbionts in the promotion of paratransgenesis is important with the use of genetically modified bacteria to induce damage to the host (for control of parasite).

7. Bacteria of parasites susceptible to antibiotics

An alternative in the parasitosis control is the use of antibiotics that diminish or cancel the presence of the symbionts bacteria of the parasite to control, an example of this tendency is the decrease of the bacteria of the *Wolbachia* spp genus, an obligate mutualist of stable coexistence with filarial nematodes. The elimination of Wolbachia with antibiotics has lethal consequences for the nematode, causing alterations in the development of worms, in response to the bacteria decrease, causes the blockage of the embryogenesis and eventual death of the worm [75]. Consequently, *Wolbachia* spp represents a new important pharmacological objective for the control of diseases caused by filariasis. This has led to the possibility of the use of tetracycline for the control of this parasite [76], until now the use of tetracycline in parasitized animals has achieved an attenuated and poor growth in larvae [77], while clinical trials with doxycycline in Africa and Asia are reported as positive [78]. The 47% of nematodes of the onchocercarie family have a relationship with *Wolbachia* spp as an endosymbiont [79], onchocercariae are filarial that affect cattle, other ungulates and are considered zoonoses [80], so the control of this parasitosis is important.

The use of doxycycline for the control of the adult stage of *Onchocerca gutturosa* has been shown *in vitro* to be successful [81]. However, the administration of antibiotics in some parasites is not clinically efficacy, for example, in the schistosomiasis, which can cause bladder cancer associated with uribacteremias [82], and liver abscess due to secondary infections with *Staphylococcus aureus* [83], in this parasitosis the antibiotics, not reduce the charge of schistosomes. So far the effect of antibiotic therapy has not been reported to control these bacterial infections associated with the parasite, possibly because the resistance of the bacteria to be eliminated with antibiotics happens when they adhered to the surface of the parasite, the adherence is due to the presence of a fimbrial protein (FimH) that recognizes the surface of the parasite, this union confers to the bacterium survival up to eight antibiotics [84].

The antibiotics can be used for the control of ectoparasites, for example the ticks of the genus *Dermacentor* sp, *Haemaphysalis* sp and *Amblyomma* sp [85] present *Coxiella* sp as a symbiont, the administration of antibiotics in the adult tick of *Amblyomma americanum* decreased the reproduction of the parasite, because the bacteria is transmitted transovarially [86,87], it is important to mention that *Coxiella* sp is potentially transmissible to humans and animals [85].

8. Disadvantages at the use of antibiotics in animals for parasites control

The intestinal bacterial flora in mammals plays a role in homeostasis, in the regulation of activation of the cito-protective genes, and have a stimulant function of the immune system [88, 89]. The diminution or increment of the intestinal bacteria causing health problems in the host [90]. So the application of antibiotics and dewormers is related to the appearance of diarrhea [91]. And the use of antibiotics in short periods generate resistant bacteria intestinal populations for years [92], and the deteriorate the native biota of vertebrates, causing digestive problems. In addition, the relationship of microflora (bacterial) and macroflora (parasites) their achieves a symbiotic control that favors the healthy state of the intestine. It should also consider that administration of antibiotics in therapies dewormers are not a very addressed, however, must be studied in order to understand the dosage of the antibiotic that is administered to the animal and antibiotic to amount gets really the parasite and their vital bacteria (symbionts), ensuring a more appropriate parasites control using dewormers in form integral and antibiotics in the control of parasitic diseases.

9. Conclusions

The bacteria-parasite interaction represents a vital role in some parasitic diseases since it is essential in the life cycle of the parasites and its survival, so this interaction can be an alternative target for the control using parasitic fighting bacteria, implementing the use of antibiotics and in opposite case, probiotic bacteria that compete for nutrients or same space of parasites in addition to enzymes or lethal effect toxins produced by *B. thuringiensis* Figure 1. The above highlights the importance of knowing the symbionts bacteria in the parasitic diseases and the use of bacteria agents versus parasitic diseases. Therefore, the anthelmintic effect of the "bacteria-parasite interaction" should be considered as a biotechnological application in animal biomedicine.

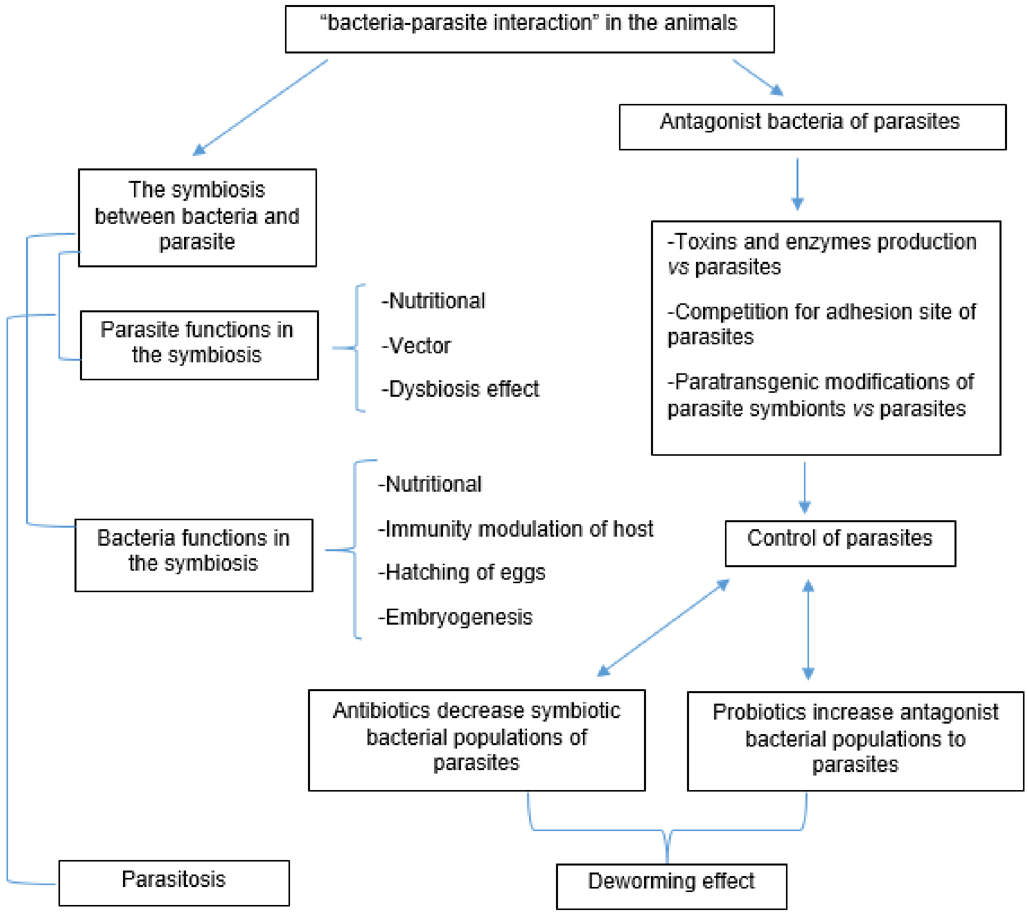

Figure 1: The "bacteria-parasite interaction" in the parasitosis of animals. The diagram shows the symbiont and antagonist bacterial of parasites in animals and the role of the decrease of symbiont bacteria in the parasite by antibiotics, as well as the increase of the parasite antagonist bacterial population as deworming therapy.

Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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