

# Control of parasitic disease using vaccines: an answer to drug resistance?

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## Summary

Antiparasitic drugs have been used successfully to control parasitic diseases in animals for many years, as they are safe, cheap and effective against a broad spectrum of parasites. One drawback of this success appears to be the emergence of drug resistance in many target parasites. Moreover, issues of residues in the food chain and environment have arisen, which threaten their sustained use. Control methods in which vaccines would have a central role provide attractive alternatives. However, while attenuated parasite vaccines have been successful, sub-unit vaccines are still rare. The advent of new techniques in molecular biology allows the elucidation of entire parasite genomes and the identification of individual genes. It is envisaged that a further understanding of parasite genes and the role of their products in parasite biology may lead to the identification of useful antigens, which could then be produced in recombinant systems. However, for this aim to be realised, continued investment in basic research on the complex interplay between parasite and host will be necessary.

## Keywords

Antiparasitic drug – Control – Drug resistance – Host – Parasite – Parasite vaccine – Residue – Vaccine.

## Introduction

Until now, chemotherapeutic drugs have predominated over vaccines in the prevention and treatment of parasitic disease in livestock and companion animals (63). Traditionally, a *therapeutic cure* was sought for diseased animals and people, an approach which is still reflected in traditional medicine. The realisation that disease could be *prevented* (e.g. through such measures as hygiene) developed much later, and the principle of vaccination was systematically exploited only from the beginning of the 20th Century. When chemical industries expanded in the second half of the last century, a series of chemical compounds were developed to protect crops. A number of

these compounds were also tested in screening assays for antiparasitic activity, and highly effective compounds were further developed as parasitic drugs. In contrast, the science of immunology, which provides the basic knowledge for the development of vaccines, was only defined as a discipline in the mid-1900s. Although there has been a continuous flow of vaccines to the market, the number of antiparasitic vaccines has remained low (63). This is a point of concern, in light of the alarming increase in drug resistance among different parasite species. In this review, the authors discuss the opportunities and obstacles in the development of antiparasitic vaccines. Together with drugs and other management practices, such vaccines could form part of an integrated strategy to control parasitic disease.

## Resistance against antiparasitic drugs

In almost every use of antiparasitic drugs, the emergence of resistant strains has been reported. It is not known whether resistance is induced by the drug or whether the use of that drug leads to the selection of resistant strains that were present in the initial population. Whatever the case, the net result is the occurrence of drug-resistant parasite strains. Resistance has been reported among endoparasites (from unicellular protozoa to multicellular metazoa) as well as ectoparasites (Table I).

Resistance to coccidiostatic drugs among *Eimeria* parasites, which infect chickens, is widespread. To delay further development/selection for resistance, alternating rotation and shuttle programmes, using different coccidiostatic drugs, have been implemented (58). Drug resistance is now reported in *Trypanosoma* (19) and resistance to the anti-babesial drug, diminazene, has been implied in a survey of canine babesiosis in South Africa (7), while resistance to anti-malarials in humans is long established.

Anthelmintic resistance is widespread in the gastrointestinal nematodes of sheep and goats. The efficacy of the three major classes of anthelmintics against *Haemonchus contortus*, the most important gastrointestinal

sheep nematode, has fallen to disastrous levels (25). Worryingly, drug resistance is now also prevalent in *Teladorsagia circumcincta* in sheep, *Cooperia* spp. and *Trichostrongylus* spp. in cattle (26). In horses, benzimidazole resistance is increasingly recognised as a problem that requires careful management of anthelmintic use (6).

In ectoparasites, multi-drug resistance has been reported in *Boophilus microplus* ticks. It has also been shown that these ticks have a reduced sensitivity to the older acaricides, organophosphates, synthetic pyrethroids and amidines. Resistance against the newer acaricide, ivermectin, has been reported in Brazil (33) and suspected in Colombia. In addition, resistance against organophosphates has been found in the sheep blowfly (*Lucilia cuprina*) in Australia.

The intensive use of antiparasitic drugs also increases the risk of drug residues in animal products (13). There is now considerable public concern about such residues, as demonstrated by increasing consumer demand for organic food products (17). Although it can be scientifically argued that such consumer concerns are overstated, their commercial impact is real.

Antiparasitics and their metabolites also accumulate in the environment through animal excretion. Although the environmental impact is not high (3, 57), this has been highlighted as a major source of public concern by the Organisation for Economic Co-operation and Development (OECD) (40, 42). Clearly, current parasite control strategies are not sustainable, and preventing these infections must become the objective. To comply with the requirement for prime quality animal products, farmed in a way that is minimally harmful to the environment, immunological control of these infections is the most rational way forward. The World Health Organization, the Food and Agriculture Organization and the OECD all regard vaccines as among the most cost-effective methods for promoting human and animal health (16, 41, 72, 73).

The prospects for discovering new antiparasitic drugs may be diminished by the increased difficulties of discovery in a time of mechanism-based screening (66). To date, existing drugs have been identified by random screening of existing molecules with no definition of the mode of action. There has been a perception that expanding knowledge, at the molecular level, of how the parasite survives in the host would readily lead to targeted approaches to drug design. However, this approach has proven to be time consuming. Moreover, it has led to the development of more complex drugs (18), with associated increases in production costs, which affect profitability and their adoption ('uptake') by the livestock producer.

**Table I**  
**Reported emergence of parasite resistance to drug treatment**

Parasite	Host	Compound
<i>Eimeria</i> species	Poultry	Chemical drugs, ionophores
<i>Trypanosoma brucei</i>	Cattle	Diminazene, isometamidium
<i>Trypanosoma congolense</i>	Cattle	Diminazene, isometamidium
<i>Babesia rossi</i>	Canines	Diminazene aceturate
<i>Plasmodium falciparum</i>	Humans	Multi-drug resistance
<i>Haemonchus contortus</i>	Sheep, goats	Multi-drug resistance*
<i>Teladorsagia circumcincta</i>	Sheep	Multi-drug resistance*
<i>Trichostrongylus</i> species	Cattle	Benzimidazoles, levamisole, macrocyclic lactones
<i>Cooperia oncophora</i>	Cattle	Benzimidazoles, macrocyclic lactones
Small strongyles	Horses	Benzimidazoles
<i>Boophilus microplus</i>	Cattle	Multi-drug resistance
<i>Lucilia cuprina</i>	Sheep	Organophosphates
<i>Psoroptes ovis</i>	Cattle, sheep	Organophosphates, pyrethroids
<i>Ctenocephalides felis</i>	Canines, felines	Carbaryl, chlorpyrifos, malathion, pyrethroids

\* Combined resistance to benzimidazoles, levamisole and macrocyclic lactones

## Current status of parasitic vaccines

With the advent of recombinant deoxyribonucleic acid (DNA) technology in the early 1980s, there was general optimism that sub-unit vaccines against many of the major parasitic diseases affecting humans and animals were very near, in fact, 'just around the corner'. The reality is that this early confidence has dissipated. Table II highlights the fact that most parasitic vaccines are still live vaccines that stimulate an immune reaction in the hosts, mimicking natural infections. Table II also shows that progress in developing commercial vaccines against protozoa far outstrips progress in vaccines against metazoa. However, it is worth drawing attention to the spectacular achievements in vaccines against cestodes and ticks (see below). These studies emphatically demonstrate that it is possible to develop recombinant sub-unit vaccines against complex metazoans.

### Protozoa

Vaccination by controlled low-level infection that stimulates the development of protective immunity has

been used successfully, as reviewed by Cornelissen and Schetters (8). In the case of protozoal vaccines, this has been achieved by using parasite strains selected for:

- complete but shortened life cycles (e.g. precocious *Eimeria* strains) (65, 71)
- truncated life cycles (e.g. the *Toxoplasma gondii* S48 strain, which does not form tissue cysts) (4)
- virulence attenuated by repeated passage through splenectomised calves (e.g. *Babesia bovis* and *B. bigemina* strains) (14, 53) or *in vitro* culture (e.g. *Theileria annulata* and *T. hirci*) (53).

Alternatively, infections can be controlled by the simultaneous administration of chemotherapeutic drugs, as in the case of East Coast fever in cattle, caused by *T. parva* (36). Except for coccidiosis vaccines, the majority of live vaccines are not produced commercially, but manufactured and distributed by governmental organisations, mainly for reasons of market failure. There are an increasing number of antiprotozoal vaccines available that are based on killed parasites or refined parasite antigen fractions. A vaccine based on killed *Neospora caninum* tachyzoites is available, which reduces *N. caninum*-induced abortion (48). Sub-unit vaccines

**Table II**  
**Antiparasitic vaccines commercially produced and/or manufactured or distributed by governmental organisations**

Parasite	Host	Type of vaccine	Comments	References
<i>Eimeria</i> spp.	Poultry	Non-attenuated	Low (non-pathogenic) dose infection immunity	65, 71
<i>Eimeria</i> spp.	Poultry	Attenuated for precocity	Infection immunity	65, 71
<i>Eimeria maxima</i>	Poultry	Sub-unit vaccine of gametocyte antigen	Induction of maternal immunity	67
<i>Toxoplasma gondii</i>	Sheep	Attenuated for truncated life cycle	Reduces abortion	4
<i>Neospora caninum</i>	Cattle	Killed tachyzoites	Reduces abortion	48
<i>Babesia canis</i>	Canines	Antigens from <i>in vitro</i> culture supernatants	Reduces disease	35, 49
<i>Babesia bovis</i> and <i>B. bigemina</i>	Cattle	Attenuated by repeated passage through splenectomised calves	Live infection immunity Manufactured locally	14, 53
<i>Theileria parva</i>	Cattle	Non-attenuated wild type	Chemotherapeutically controlled infection Manufactured locally	36
<i>Theileria annulata</i>	Cattle	Attenuated by <i>in vitro</i> culture	Manufactured locally	53
<i>Giardia duodenalis</i>	Canines	Disrupted axenically cultured whole trophozoites	Reduces disease and cyst shedding Commercially available in the USA	39
<i>Leishmania infantum</i>	Canines	Sub-unit vaccine (FML)	Antiparasite activity and possibly therapeutic	11
<i>Taenia ovis</i>	Sheep	Recombinant antigen	Registered but not marketed	30, 46
<i>Dictyocaulus viviparus</i>	Cattle	Irradiated L3 larvae (truncated life cycle)	Limited to Europe	44
<i>Boophilus microplus</i>	Cattle	Recombinant tick gut antigen (Bm86)	Limited to Australia, Cuba and some countries in Central and South America	69

FML: fucose mannose ligand

based on soluble parasite antigens from one or more *Babesia* species reduce clinical disease in dogs due to *B. canis* (35, 49). A vaccine to prevent clinical signs of giardiasis and reduce cyst shedding in dogs and cats is commercially available (39). The vaccine was obtained by disrupting axenically cultured *Giardia* whole trophozoites. At the end of 2004, a vaccine against canine leishmaniosis, caused by *Leishmania infantum*, was introduced onto the market. The vaccine is based on the fucose mannose ligand (FML) of *L. infantum* (11). Finally, a sub-unit vaccine that induces maternal immunity in broiler breeders against coccidiosis, and is based on gametocyte antigens of *E. maxima*, has been developed and marketed (67).

### Helminths

A vaccine against the bovine lungworm, *Dictyocaulus viviparus*, was the first available anti-metazoan vaccine and is still used in Europe today (44). The vaccine contains irradiated L3-larvae that do not mature to adult worms. A similar approach was used to develop a vaccine against the canine intestinal nematode *Ancylostoma caninum* (34). Irradiation-attenuated larval vaccines were also developed against several gastrointestinal nematodes but they did not protect young, susceptible stock against infection and were, therefore, never commercialised (27). In general, these vaccines are difficult to produce as larvae must be harvested from the manure of infected animals.

Effective recombinant vaccines were developed against the cestodes *Taenia ovis*, *T. saginata*, *T. solium* and *Echinococcus granulosus*. These vaccines are based on antigens of the parasite stage that adheres to the gut wall. When used for vaccination, these antigens induce immune responses that interfere with successful attachment. To date, although the vaccine against the cestode *T. ovis* has been registered in Australia and New Zealand, it has not been marketed. This could reflect the marginal commercial benefit of this vaccine and/or debate about the fundamental principles of cestode control in the intermediate versus the primary host. However, such developments prove that it is possible to achieve a reliable, high level of protection against a complex metazoan parasite, using defined recombinant antigens (30, 46).

### Ticks

The vaccine against the cattle tick, *B. microplus*, is a recombinant vaccine based on a protein (abbreviated as Bm86) found in the tick at the surface of the gut wall. This protein is an example, along with several derived from *H. contortus*, of a 'hidden' antigen (the term 'hidden' meaning that the protein is not recognised by the systemic antibody response during natural infection). Vaccination

stimulates the production of specific circulating antibodies that are ingested by the target parasite during blood feeding (28). The vaccine effectively suppresses the population of tick larvae available for infestation, rather than protecting individual cattle (69), with a chemical control being applied if tick numbers rise above acceptable limits (70). Vaccinating cattle with the recombinant *B. microplus* vaccine induces almost total immunity to *B. annulatus*, demonstrating immunological cross-protection. This immunity is sufficiently strong to inhibit *Babesia* transmission (43).

## Barriers to vaccine development

Apart from the fact that vaccines began to be developed much later than chemotherapeutic drugs, a number of additional factors have affected the progress of parasitic vaccine development. Not least was the implementation in the 1990s of legislation on the authorisation of veterinary medicinal products in Europe (50). Moreover, and in contrast to viruses and bacteria, even the simplest parasites and their life cycles are highly complex, and there is a general lack of precise understanding of the host/parasite interaction.

### Scientific challenges

Owing to the complex nature of parasites, the immune system is confronted with a highly diverse and plastic antigen repertoire. A number of biological characteristics perpetuate this diversity. First, many parasites go through a phase of sexual reproduction, with the associated exchange of genetic material from the parent strains (e.g. crossing-over). This results in progeny with a different genetic and phenotypic make-up. Secondly, there is a differential expression of genes during the successive life-cycle stages, as if the host has been infected with a number of different parasites. Finally, a number of species can express antigenically distinct variants of stage-specific molecules. This ability allows them to avoid the defensive responses of the host. These factors impose considerable challenges in screening for potential vaccine antigens.

In addition, the site of infection affects the nature of the protective immune response and may constrain research on vaccine development. For instance, many gastrointestinal parasites are not invasive and dwell only in the gastrointestinal tract, the interface with the host being the epithelial lining of the gut lumen. Since little is known about the immune effector mechanisms that function in immune hosts, there are few immunological tools to aid in selecting potential vaccine antigens. Consequently, research is guided by general biological criteria (e.g. mucosal antigen delivery) and has been mainly empirical. More basic research in mucosal immunology is required.

Clearly, the ability to produce parasite antigens through genetically modified micro-organisms has improved the feasibility of some parasitic vaccines. However, producing protective recombinant parasite antigens has proven difficult. Efforts have been inhibited by the fact that recombinant proteins may be incorrectly folded and/or lack critical post-translational modifications, particularly the glycans that are attached to several of the native candidate antigens. This issue is a major challenge in vaccine production and has been discussed recently (10).

Finally, in general, vaccines can be expected to induce a narrow spectrum of protection, often restricted to a single species or strain, whereas, in many cases, the actions of chemotherapeutics transcend the species level. Broadening the spectrum of protective immunity is a major issue in vaccine development.

### The marketplace

The market size for products that control these parasites is often not impressive. The commercial viability of a vaccine depends on such factors as development and production costs, and specific characteristics, such as storage/transport conditions and shelf life. Perhaps the biggest barrier is the fact that current drugs have efficacies approaching 100%. It will not be easy to persuade users that a vaccine which is less than 100% effective can usefully control the disease. In addition, as patents expire on many anti-parasiticides, there is a market trend in favour of generic drug companies, which spend little on research and development and essentially do not invest in discovering new drugs or vaccines (18). Reasons for this are many and varied, with the demand for quick, high returns on investment reducing the opportunity for long-term discovery projects. As a result, very few animal health companies are currently committed to the discovery and development of antiparasitic vaccines.

## Reasons for optimism

Progress in science and technology, along with political trends and economic forces, creates new opportunities for vaccine development.

### Continued vaccine development

Experimental and first generation vaccines against a number of protozoal diseases have been described (Table II), and it is likely that, of these, the sub-unit vaccines will be developed further to improve not only efficacy profiles but also production processes. *Giardia*, *Babesia* and *Leishmania* vaccines based on antigens from *in vitro* culture, for example, are likely to be developed into recombinant

antigen vaccines (22). A recombinant sub-unit vaccine against *Theileria* spp. is probable in the near future (24).

Effective vaccine candidates have been identified and tested, in native form, from:

i) *H. contortus*:

- H11 (37)
- H-gal-GP (55)

ii) *Ostertagia ostertagi*:

- sub-fractions from parasite excretory-secretory products (20, 60)

iii) *Fasciola hepatica*:

- cathepsin Ls and haemoglobin (9).

The levels of protection (60% to 90% reduction in egg output and/or worm burdens) are higher than those required to provide full disease control, as predicted by epidemiological analyses and mathematical modelling (2, 62). Developing equally effective recombinant versions of these vaccines, however, is proving elusive. It is suggested that post-translational processing and, in particular, glycosylation, is crucial (29). Further research is being devoted to these issues and it is expected that improved expression systems will become available (54).

In the field of tick vaccines, most success has been recorded with slow-feeding species, which have prolonged contact with the host immune system. There are grounds to think that better tick vaccines could be developed fairly easily. The potential for increased efficacy, by using more than one recombinant antigen in a formulation, has been demonstrated experimentally, while the number of antigens available for trial is steadily increasing (68).

### New scientific developments

In the meantime, the search for new useful antigens continues (22, 45, 54, 68). In principle, the available genomes provide access, *in silico*, to the full complement of potential protein antigens and/or novel targets, as well as supplying the database needed for micro-array and proteomics-based analyses of expression. The number of genomes being fully sequenced is rapidly increasing. Gene knockout and ribonucleic acid interference offer the prospect of performing *in vitro* and *in vivo* gene 'knockdown', which may identify possible targets (see Scarselli *et al.* for a review [47]). Proteomic approaches could also be used to define protein/protein interactions, including those between parasite protein and immune effector molecules (the area of 'immunomics') (12).

Another factor which appears crucial for the induction of protective immunity, along with the identification of

protective antigens, is the way in which these antigens are delivered to and/or presented at the host interface. A variety of microbial vectors are being used to target antigens to specific sites in the host; e.g. *Salmonella* spp. are being employed to target *Eimeria* antigens to the gut epithelium (64). The inclusion of genes encoding molecules with adjuvant- or immuno-modulating activity is being intensively studied to improve the effectiveness of recombinant vaccines (15, 38). In addition, more effort is being devoted to understanding how parasites evade the host immune response, with these effector molecules themselves becoming vaccine targets (32).

### Economic factors

In the developed world, by far the greatest losses associated with parasitic infections are sub-clinical or economic. Antiparasitic drugs are used more often to maximise profits than to salvage clinically sick animals (61). Such practices may be threatened in the future, due to a growing awareness that the extensive use of antibiotics could lead to the rapid emergence of drug-resistant pathogens, some of which could also pose a threat to humans. Consequently, a more recent approach has been to reduce the prophylactic use of drugs as much as possible, with a concomitant reduction of drug residues in biological products. The reasonable alternative is disease prevention by improved management practices, in which vaccination could play a pivotal role.

It will be important to tailor the vaccination regime to normal farm management procedures for the target species, and to deliver vaccines at an acceptable cost. There is considerable scope for improving vaccine delivery. First, the vaccination schedule should not impose significant management constraints on the producer, over and above those associated with current control practices. As an example, the conventional method of delivering a live coccidiosis vaccine to chickens was through their drinking water, or by spraying the vaccine onto their feed. To facilitate broiler production management, these vaccines are now preferably administered by spraying the chickens at one day of age. In the future, administration *in ovo* is a clear possibility (52). Secondly, alternatives have been developed to replace the use of needles for vaccines that must be administered parentally, such as DNA vaccines (21). These alternative devices can also be used to administer conventional vaccines, and are convenient in pig farming. Oral and mucosal delivery systems are also being exploited (for example, delivering vaccines to grazing ruminants in their forage is one exciting possibility) (1, 51). Vaccines are preferably delivered as a single shot, i.e. not requiring repeated booster vaccinations, to reduce the costs of animal handling and veterinary services. Different delivery systems, such as microspheres, liposomes, pumps and implants, have been

used. The results indicate that, contrary to conventional thinking in immunology, continuous antigen delivery is capable of inducing immunity and providing affinity maturation, isotype switching and immune memory (31). It is highly likely that, given the short life span of many food animal species, single dose delivery will become a reality for selected veterinary vaccines.

In conclusion, it is reasonable to assume that, in the near future, more parasitic vaccines will become available for use as a practical tool in the control of parasitic disease.

## The role of vaccines and drugs in parasite control

At present, vaccines against parasitic diseases are relatively expensive when compared to the costs associated with drug treatment. The incentive to use vaccines is, in some cases, related to a lack of efficacy in the parasitic drug. This is particularly evident in controlling coccidiosis in broilers. The emergence of drug-resistant *Eimeria* parasites has been well documented.

To reduce the emergence of resistant strains, it has been suggested that coccidiostat treatment and vaccination should be alternated in successive rounds. Vaccination with live parasites could lead to the replacement of field strains with drug-sensitive vaccine strains (5). It is more likely, however, that large-scale use of the live coccidiosis vaccines will eventually replace the use of coccidiostatic drugs.

Another example comes from the retrospective analysis of the use of a vaccine against *B. microplus* in Cuba. Its introduction was accompanied by a change in approach to the disease: the objective was no longer the total eradication of ticks; treatment was conducted only when the number of adult ticks per animal exceeded a low threshold. The result was an 87% reduction in acaricide treatments and an 82% reduction in the national consumption of acaricides, accompanied by an overall reduction in the incidence of clinical babesiosis. The large number of cattle involved – more than half a million – gave confidence in the results (59). The long-term impact on drug resistance is suggested by work in Australia, where a statistical analysis of factors associated with acaricide resistance identified the frequency of treatment as a major factor. The integrated use of a vaccine, plus restricted drug treatment as needed, should postpone the emergence of resistance (23).

Combination vaccines against *Haemonchus* that contained two highly protective antigen complexes expressed in the intestine of L4 and adult worms, namely H11 and

H-gal-GP, were evaluated under field conditions in South Africa (56). Vaccination reduced the mean egg output by >82% and, simultaneously, the degree of anaemia and number of deaths due to haemonchosis. There was a surge in egg output during a period of irrigation, but revaccination cleared the animals of the newly acquired infection, restoring protection to the levels observed beforehand. Anthelmintic intervention was required to control the infection in some control animals but not in the vaccinated animals. Thus, it seems probable that vaccination against haemonchosis would also dramatically reduce dependency on anthelmintic drugs and selection pressure towards drug-resistant worms.

## Conclusions

Antiparasitic drugs will remain important for a long time yet, though the development of resistance could limit their use. The continuous threat of drug resistance, the issue of

residues entering the food chain and a lack of new drugs are all major reasons to focus research (and money) on vaccine development. Indeed, efforts towards vaccine development should be pursued intensively while drug-based infection control persists; it is pointless to wait until effective control is lost. Many vaccines may find their greatest and most immediate application in integrated control strategies. The synergies offered by a combination of vaccines and parasiticides should be thoroughly explored, as this approach may lead to a substantial reduction in the use of parasiticides.

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# Prophylaxie des maladies parasitaires au moyen de la vaccination : une réponse à la résistance aux médicaments ?

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## Résumé

Les médicaments antiparasitaires sont utilisés avec succès depuis longtemps pour lutter contre les maladies parasitaires affectant les animaux, car ce sont des produits sans danger, peu onéreux et à large spectre. L'inconvénient de ce succès semble être l'apparition, chez plusieurs espèces de parasites, d'une résistance aux médicaments. Le problème de la persistance de résidus dans la chaîne alimentaire et dans l'environnement se pose également, suscitant des doutes quant au bien-fondé d'une utilisation durable de ces médicaments. Des méthodes prophylactiques centrées sur la vaccination semblent offrir une alternative prometteuse. Or, si les vaccins basés sur des parasites atténués ont une efficacité avérée, très peu de vaccins sous-unitaires ont été mis au point. Grâce au développement des nouvelles techniques de la biologie moléculaire, il est désormais possible de séquencer des génomes entiers de parasites et de caractériser certains gènes en particulier. L'approfondissement de nos connaissances sur les gènes des parasites et sur le rôle joué par leurs produits dans la biologie des parasites devrait nous permettre de caractériser des antigènes intéressants, lesquels pourront ensuite être produits dans des systèmes recombinants. Néanmoins, avant de réaliser cet objectif il sera nécessaire de continuer à investir dans la recherche fondamentale sur les interactions complexes entre le parasite et son hôte.

## Mots-clés

Hôte – Médicament antiparasitaire – Parasite – Prophylaxie – Résidu – Résistance aux médicaments – Vaccin – Vaccin antiparasitaire.

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## El control de enfermedades parasitarias por las vacunas como posible solución al problema de la farmacorresistencia

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### Resumen

Hace ya muchos años que se vienen empleando con buenos resultados medicamentos antiparasitarios para luchar contra las infestaciones en los animales, puesto que esos fármacos son seguros, baratos y eficaces contra un amplio espectro de parásitos. Uno de los inconvenientes del éxito obtenido parece ser la aparición de farmacorresistencias en muchos de los parásitos en cuestión. Además, han surgido problemas ligados a la presencia de residuos de esos fármacos en la cadena alimentaria y el medio físico, hecho que pone en peligro su utilización sostenida en el futuro. Los métodos de lucha basados en el uso de vacunas ofrecen interesantes alternativas. Sin embargo, aunque las vacunas basadas en parásitos atenuados se han demostrado eficaces, aún hay pocas vacunas de subunidades. Gracias al advenimiento de nuevas técnicas de biología molecular, es posible ahora caracterizar la totalidad del genoma de un parásito e identificar genes concretos. Se espera que el hecho de conocer mejor esos genes y la función de las correspondientes proteínas en la biología del parásito sirva para encontrar antígenos útiles, que después cabría sintetizar con sistemas de ADN recombinante. Tal objetivo, sin embargo, requiere una inversión duradera en investigación fundamental para estudiar las complejas relaciones entre los parásitos y sus huéspedes.

### Palabras clave

Control – Farmacorresistencia – Huésped – Medicamento antiparasitario – Parásito – Residuo – Vacuna – Vacuna antiparasitaria.



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