

Biological Control of Tick Populations: Review and Reflections

Controle Biológico da População de Carrapatos: Revisão e Reflexões

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This study is concerned with aspects of the relationship between ticks and their hosts that have a bearing on biological control of tick populations. It proposes control methods based on a program that would combine development of an effective vaccine with genetic selection of hosts.

Key words: Resistance to Ticks; Boophilus microplus; Dermacentor andersoni; Rhipicephalus sanguineus

Ticks constitute one of the most important groups of arthropods in terms of effects on animal health. They debilitate the host by feeding on it (Kaufman & Philips, 1973); they can cause paralysis (Murnaghan & O'Rourke, 1978) and immunological disturbances (Rossi, 1990) through direct effects resulting from inoculation of their saliva; and they can also transmit high-morbidity pathogenic agents (Hoogstraal, 1985). In addition, they can act as vectors between domestic animals, sylvatic animals, and humans (Hoogstraal, 1991).

Given the scale of the harmful effects of ticks, it is essential that their population be controlled. Present control methods involve the undesirable expedient of indiscriminate application of acaricides. To reduce our reliance on these chemical products, it is necessary to embark on programs that include habitat management, genetic selection of hosts, and development of a vaccine capable of inducing host resistance to ticks.

LITERATURE REVIEW

The first account of host immunity to ticks appears to be one written by Nuttall (1911), which refers to the phenomenon of natural immunity in humans. From the 1930's

onwards, the first investigations into host resistance to ticks began to appear, and since then innumerable studies on the immunological aspects of the host-tick relationship have been carried out.

Trager (1939a) carried out pioneering studies that gave evidence of acquired immunity to ticks. Later, Feldman-Muhsam (1964) observed that rats, after successive infestations with *Rhipicephalus sanguineus*, became immune to ticks, a process that was considered to constitute immunization of the host.

Wikel & Allen (1976) transferred resistance against *Dermacentor andersoni* by passing lymph node cells from resistant guinea-pigs to susceptible guinea-pigs. Later, Wikel & Allen (1977) also observed that complement depletion did not affect acquisition of resistance to *D. andersoni*, but that it did block that expression of already acquired resistance.

Allen et al. (1977) demonstrated that salivary gland antigens of *D. andersoni* were present in the skin of infested guinea pigs. Allen et al. (1979) also noted that these salivary gland antigens were associated with dendritic cells in the epidermis, and suggested that the latter were Langerhans' cells. Nithiuthai & Allen (1984a) observed that the number of Langerhans' cells decreased in areas where ticks were attached to susceptible guinea pigs, while in resistant animals the number of Langerhans' cells in the epidermis increased. Later, Nithiuthai & Allen (1984b)

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showed that depletion of Langerhans' cells made it impossible for animals to acquire or express resistance to ticks. Nithiuthai & Allen (1985) also suggested that Langerhans' cells, like Ia positive macrophages, could act as presenting cells for salivary antigens, assisting in the development of an immune response to ticks.

Whellen (1986) observed that levels of resistance to ixodid ticks were not necessarily directly correlated to serum immunoglobulin titres, suggesting the possible presence of other mechanisms that might be important in the immune response.

Worms et al. (1988) transferred different fractions of serum from resistant guinea pigs to susceptible guinea pigs, and observed that purified IgG₁ or purified IgG₂ did not, on their own, confer resistance, whereas whole serum did. Worms therefore suggested that both subclasses of IgG were necessary for the expression of resistance, or that IgG₁ required IgE in order to induce resistance.

Studies on the heritability of resistance to ticks showed that individual potential for resistance is partly determined by a genetic component.

Villares (1941) observed that the degree of acquired immunity to ticks is an individual characteristic, that it is linked to breed, and that, in the case of cattle, breeds of European origin are more susceptible to ticks than those of Indian origin (Brahma cattle). Roberts (1968) demonstrated that different breeds of cattle are equally susceptible to initial infestation with *Boophilus microplus*.

However, over time, resistance is expressed in different ways, as parasitization proceeds. Roberts therefore concluded that individual potential for resistance is innate, and that tick infestation is the necessary stimulus that leads to the acquisition of resistance.

Wharton et al. (1970) studied the heritability of the *B. microplus* resistance factor in cattle, and concluded that heritability is sufficiently high to promote rapid progress towards resistance in a herd.

Stear et al. (1982) went further in their research into genetic host resistance to ticks, with a study of the Major Histocompatibility

System (MHs). They studied 199 cattle and concluded that at least two antigens are linked to bovine resistance to *B. microplus*, and one to susceptibility. Soon after, Newman & Antczak (1983) considered it surprising that resistance to an ectoparasite should be so strongly associated with MHs, given that previous studies on other associations had failed to yield any significant results. Despite this, they considered that the association might be important, given that it is known that bovine resistance to ticks involves important genetic and immunological factors.

At the same time as it was being concluded that natural host resistance to ticks involves the expression of a genetically orientated immune response, researchers began to look for antigens that might induce artificial resistance in hosts.

Trager (1939b) inoculated guinea pigs with various extracts of tissue from *D. variabilis*, and concluded that an antigenic substance was present in the digestive tract and cephalic glands of partially engorged females, in the salivary glands of fed and unfed ticks, and in total larvae extracts. Since then, various studies have been carried out using different hosts, ticks, and tissues as antigenic sources. Researchers have used extracts of eggs, of larvae, of nymphs, of partially engorged females of adult ticks, of salivary glands, of saliva and the cement as antigenic sources. These antigens produced an immune response, but a challenge with a homologous tick rarely showed a positive correlation with the response obtained (Gregson, 1941, 1970; Riek, 1958; 1959; Tornado & Gutierrez, 1967; McGowan et al., 1980; Labarthe, 1981; Berne, 1982, Wilkinson & Allen, 1983; Brown et al., 1984; Johnston et al., 1986; Gordon & Allen, 1987).

From 1981, assays were developed adding adjuvants to these different antigens.

Researchers used Freund's complete adjuvant (FCA), Freund's incomplete adjuvant (FIA), and aluminium hydroxide. All the adjuvants were effective in modulating the immune response to the antigens, but were ineffective in terms of inducing resistance to ticks (McGowan et al., 1981; Labarthe, 1981;

Berne, 1982; Wilkinson & Allen, 1983; Willadsen et al., 1988). Only Brown et al. (1984) described the induction of a satisfactory response in the host, with FIA emulsion and salivary antigens; this approach conferred a similar level of resistance to that obtained through active sensitization with ticks.

In parallel, various studies were carried out in an attempt to purify and identify the antigen fractions that were most effective in inducing resistance (Tatchell & Binnington, 1971; Geczy et al., 1971; O'Hagan et al., 1973; Dickinson et al., 1976; Scheleger & Lincoln, 1976; Higgs et al., 1976; Willadsen, 1976; Willadsen & Riding, 1979; Kemp et al., 1983; Willadsen & McKenna, 1983; Brown et al., 1984; Johnston et al., 1986), but no progress was reported in terms of obtaining an effective vaccine.

aAgbede & Kemp (1986) observed that ticks fed on cattle immunized with fractions of an extract derived from adult female *B. microplus* had more leucocytes in their intestine than ticks fed on susceptible cattle. They detected granulocytes associated with lesions in the tick intestine, suggesting that this reaction had played a part in the success of the vaccination. They proposed that the primary intestinal lesion could lead to possibly significant reactions against other tissues in the tick.

Opedebeeck et al. (1988) immunized cattle with FIA emulsion and intestinal extract from partially engorged female *B. microplus*. They observed a protection rate of 87%, demonstrated significant levels of antibodies in the serum of immunized animals, and showed that there was a positive correlation between protection levels and antibody levels.

DISCUSSION

Ticks are ectoparasites that act as vectors for various disease agents that attack different hosts. These agents often cause high morbidity and mortality, which together with the damage inflicted by the tick itself lead to significant losses. In spite of the growing

importance of ticks, and in spite of the large numbers of studies and wide variety of information on the subject, none of the relevant host-parasite systems is as yet fully understood. However, it seems clear that the achievement of biological control will largely depend on efforts to bring about genetic improvements, and on the development of an affective vaccine.

Programs aimed at genetic improvement should make use of animals that can transmit resistance to their offspring, thus reducing the susceptibility of a population in a given enzootic area. This would bring about a decline in the region's parasite load, which would in turn contribute to reducing the need for chemical control methods. To carry out the genetic program, it would be necessary to have greater knowledge of genetic indicators implicated in resistance, such as the Major Histocompatibility Antigens (MHs). This would make it possible to identify reproductive animals with high innate resistance at an early age, and these animals could then be recommended for genetic dissemination of resistance in enzootic areas.

Development of a vaccine would aid in the control of ticks, conferring resistance on hosts with no previous contact with the parasite, and also maintaining resistance in hosts that had spent long periods of time away from ticks. Developing such a vaccine would depend on producing both an antigen capable of stimulating a satisfactory immune response and an adjuvant to guarantee the intensity and duration of the immune response obtained. However, since the vaccine would have to be produced in large quantities, it would not be feasible to obtain the antigen from a process that used ticks themselves as a source. Thus, as well as identifying an effective antigen, it would be necessary to develop technology capable of synthesizing it in large quantities.

Biological control of ticks, carried out through a coordinated program using a variety of methods, would lead to a decline in the use of chemical control techniques. The latter, when used improperly, not only cause certain strains of ticks to develop drug resistance, but are also responsible for environmental

pollution. With regard to immunity, it is essential that the development of a vaccine be linked to a program of genetic selection designed to improve host resistance to ticks.

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RESUMO

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Este artigo estuda os aspectos da relação hospedeiro-parasita que têm significado no controle da população de carrapato. São propostos métodos de controle baseados em um programa que combinaria o desenvolvimento de uma vacina efetiva com a seleção genética dos hospedeiros.

Palavras-Chave: Resistência aos Carrapatos; *Boophilus microplus*; *Dermacentor andersoni*; *Rhipicephalus sanguineus*

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