Ecological bases of the epizootic process of brucellosis and its control in small ruminants

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Abstract. The article analyzes the ecological foundations of the epizootic process of brucellosis and its control in small ruminants. Epizootic process of brucellosis in populations of small ruminants with a low level of immunity is characterized by the intensive formation of epizootic strains of brucellosis melitensis with a high level of virulence and is accompanied by a high incidence of animals with acute cases of acute brucellosis human contact. Brucella, parasitizing in animal populations with a high level of immunity are as a rule in the stage of reservation have reduced virulent properties and this circumstance provides along with the stabilization of the epizootic situation a favorable epidemic situation. In other words the epizootic process of brucellosis at large territories in the zones of occurrence of the disease can be controlled due to the leading role of specific prophylaxis provided that immunity against brucellosis is provided for livestock for the longest possible period.

1. Introduction

Epizootology is a science that studies the epizootic process. The acquired knowledge is a source for the development of theoretical and practical principles of combating infectious animal diseases.

Many formulations of the concepts of the epizootic process, proposed by different researchers, are essentially reduced to the ecological mechanisms of interaction between the populations of the parasite and the host [1-3].

So, one of the concepts of the epizootic process is known as "evolutionarily established regular infection of animals - obligate hosts of the corresponding parasite, leading to a chronic course of the disease or "carriage"of the pathogen. In this case, the degree of manifestation of the disease depends on the duration of the parallel evolution of the parasite and the host, and changes in environmental factors. The main cause and driving force of the epizootic process is the peculiarities of the host-parasite relations of infectious agents with the organism of the obligate and potential hosts. These relations are significantly influenced by external conditions - economic and natural" [3]. In subsequent
publications, the development and improvement of the advanced theoretical and practical provisions regarding the ecological essence of the epizootic process were continued [4-5].

Another formulation of the epizootic process, consonant in meaning with the simultaneously proposed formulations of the epidemic and epiphytotic processes, is the process of interaction between the population of the pathogen-parasite and the animal population, which manifests itself under certain social and (or) natural conditions by single and (or) multiple animal diseases, as well as asymptomatic forms of infections [6].

Thus, according to the results of a retrospective analysis of literature data, modern ideas about the epizootic process are associated with dynamic host-parasite relations at the population and territorial levels, depending on a variety of internal and external factors.

A number of researchers [2 and 6] substantiate the high resistance of parasitic systems by many factors:

- Multilevel organization of parasitic systems: the organismic level in the form of an infectious process; biocenotic level in the form of epidemic, epizootic or epiphytotic processes; biostromatic level in the form of pandemic, panzootic or panphytotic processes;
- Flexibility of parasitic systems (use of different hosts by the parasite, host replacement, etc.);
- The heterogeneity of the populations of the parasite (primarily in terms of virulence and antigenic structure) and the host (primarily in terms of its sensitivity to the pathogen);
- Parasite reservation (the ability, in the absence of opportunities for active circulation, to experience both in animal organisms and outside them);
- Multiplicity of hosts and polyhostality of the parasite;
- The ambiguous dependence of the parasite on the hosts (survival in water and soil).

Taking into account the obviousness of the existence of parasite-host systems or parasitic systems, the presence of the phenomenon of self-regulation of parasitic systems is indisputable [2 and 6].

Four provisions of this self-regulation are formulated:

- Genotypic and phenotypic heterogeneity of the populations of the parasite and the host in terms of attitudes towards each other;
- Interdependent variability of biological properties of interacting populations;
- Phase self-reconstruction of the parasite populations, which determines the uneven development of the epidemic process;
- The regulating role of social and natural conditions in the phase transformations of the epidemic process.

On the basis of the theory of self-regulation of parasitic systems, the concepts of managing the epidemic process, uncontrollable and controllable infections are proposed.

The group of "infectious diseases, for the fight against which potentially effective measures have not yet been developed, is classified as uncontrollable infections. Controlled infections are infectious diseases for which scientifically based measures have been developed and their effectiveness has been shown. "Further, it is emphasized that, ideally, the elimination of the infection is possible due to measures that have a detrimental effect on the pathogen both in the phase of epidemic spread and in the phase of reservation. "Most of the anti-epidemic measures are aimed at preventing diseases. However, the creation and long-term maintenance of conditions that prevent the transition of the pathogen from the reservation phase to the phase of epidemic spread, ensures the elimination of the pathogen".

Infections can be managed in two ways: using specific protective equipment; general sanitary measures. Devastation, as the elimination of the causative agent of that other disease as a biological species on a global scale, seems possible only if the stages of its regional elimination are consistently
implemented. In this regard, the leading role of specific prophylaxis with the rational use of vaccines is obvious [6].

The concept of vaccine-preventable infections, the management of the epidemiological process, substantiated by epidemiological researchers, was supported by many epizootic scientists who introduced the concept of "management of the epizootic process" [7-10].

When characterizing the system of antiepizootic measures, in accordance with these concepts, it is more expedient to use the scientifically grounded concept of control of an epizootic process (consisting of two links: control and monitoring) [10].

Despite the existence of the fundamental provisions of the theory and practice of control of the epizootic process in general and, in particular, in certain diseases, this problem remains relevant, including in such a dangerous chronic infectious disease for animals and humans as brucellosis.

The purpose of the research, the results of which are presented in this article, is to substantiate the possibility of effective control of the epizootic process of brucellosis in the zones of the disease, taking into account the above evidence of its ecological essence.

Brucellosis of farm animals is still a global problem, although there are significant successes in the fight against it. The disease is also of great epidemiological significance.

The epizootic process of brucellosis in its manifestation is characterized by tendencies of both expansion and narrowing of the boundaries of distribution, depending in a number of countries, regions, zones and districts on the level of economic and economic structure and, mainly, on the level of implementation of measures aimed at identifying and isolating from herds and a flock of infected animals, for the destruction of the pathogen in the external environment and animal products [7].

A comprehensive study of the problem of variability of brucella has become a new scientific direction. For brucellosis, the latent asymptomatic course of infection, associated with the characteristics of persistence and changes in the biological properties of the pathogen, turned out to be very characteristic. The processes of dissociation and reversion of brucella were epizootologically significant. Virulent typical brucellae cause a long-term active course of acute infection in herds when new susceptible animals arrive. In herds, where new susceptible animals do not enter, the dissociation of circulating brucella inevitably occurs and the severity of the process disappears. Where the entry of new susceptible animals cannot be avoided, reversions of the pathogen occur and, as a result, an exacerbation of the epizootic process [7].

Taking into account the above data, it became obvious that the epizootic process of brucellosis, like any other epizootic process, obeys the well-known principles of self-regulation of parasitic systems.

However, along with the mechanisms of self-regulation, it is necessary to have a good understanding of the mechanisms of artificial regulation of parasite-host relations, and on the basis of the latter, to develop optimal systems of antiepizootic measures.

In the process of implementing anti-brucellosis measures in different animal species, without resorting to a complete replacement of the entire compromised livestock, it became clear that it is impossible to identify all infected animals even with multiple studies and using a complex of diagnostic methods. Relapses of infection in many rehabilitated herds and flocks became inevitable against the background of negative serological test results, and a significant number of new outbreaks of brucellosis occurred in livestock that were not immune to brucellosis. In other words, it turned out to be practically impossible to achieve the necessary long-term and reliable biological equilibrium in the "parasite – host" systems with brucellosis without vaccination [10-18].

2. Materials and methods
In one of the regions of the Russian Federation, a retrospective analysis of the epizootic situation of brucellosis in small cattle and epidemiological indicators in relation to the level of specific prevention for the period from 1976 to 2003 was carried out.

The analysis used the following data obtained during the study period:
• The number of small ruminants immunized against brucellosis and indicators of the level of vaccination, indicating the degree of coverage of the livestock with vaccination both in the whole region and in the context of individual areas and epizootic foci;
• The number of acute cases of human brucellosis both in the region as a whole and in the context of individual regions and epizootic foci, as well as incidence rates calculated per 100,000 population;
• The results of studies on brucellosis in the reaction of immunodiffusion (RID) in agar gel with O-polysaccharide antigen (O-PS antigen) of blood serum from small cattle immunized with a live vaccine from the agglutinogenic strain B. abortus 19 by the subcutaneous method from 15 epizootic foci brucellosis.

3. Results and discussion
Since 1976 in the region the public adult broodstock of sheep and goats have been immunized with a vaccine from strain 19, and the current year of birth until 1983 - with a vaccine from strain Rev-1. It should be emphasized that in the period from 1979 to 1982 ewes and goats were not immunized at all. And only since 1983 the adult breeding stock as well as the bright and the pereyarok, began to be vaccinated again with the vaccine from strain 19. In general for the region in the period 1986-1990 the highest average annual vaccination rate of small ruminants against brucellosis (60%) was achieved with the lowest rates of diagnosis (11.5%), response (0.8%), number of disadvantaged points (11) and human morbidity (21.8). According to our data, the indicator of acute cases of human disease with brucellosis was the only reliable indicator of the epizootic state of a certain territory or farm for brucellosis in small cattle, which promptly reflects the effectiveness of anti-brucellosis measures, since animals with brucellosis are the source of human infection. The use of other indicators for these purposes (data on abortions of brucellosis etiology in cattle, the results of diagnostic studies of both vaccinated and unvaccinated livestock, etc.) is not always possible due to objective and subjective reasons. So, if in 1976 the incidence rate of people per 100 thousand of the population in the whole region was 77.9, then in 1979 it was 25.1. There is a decrease in its level, which, in our opinion, is associated with a high degree of coverage of small ruminants with vaccinations during this period. In 1980-1982 there was a slight increase in the average annual incidence of human disease (33.8), which can be explained by residual immunity in animals from previous vaccinations. In 1983, the incidence rate of people increased in comparison with the above period by almost 1.5 times (52). By 1985, it had changed slightly (51).

Thus, even with certain violations of the general economic, technological, sanitary and special veterinary rules stipulated by the current directive documents, it was possible to achieve a sufficiently effective management of the epizootic process of brucellosis in small ruminants due to the widespread use of specific prophylaxis.

Since 1991, due to the disintegration of the existing forms of management and the organization of farms and other private peasant farms, the economic and technological opportunities for the implementation of the bulk replacement of unsuccessful livestock have been lost. In the region, this work was further complicated by the territorial disunity of the livestock. Private flocks of sheep and goats (as a rule, 100-250 heads each), in which animals of all sex and age groups (uterus, broodstock and offspring from them) are together, are located at a distance of 25-50 km from each other. With an acute shortage of transport, financial resources, personnel, this created additional difficulties in the fight against brucellosis. Therefore, the level of vaccination of small ruminants against brucellosis in the region as a whole decreased from 1991 to 1997 from 53.9 to 35.2%, and then in 2000, was respectively 69.1; 52.0 and 45.4%. The incidence of brucellosis in people in 1991-1996 increased from 6.7 per 100 thousand population to 33.9 and then by 2000 it reached 15.0. As a result, in 1996-2000, with approximately the same level of vaccination of small ruminants with a similar indicator for the period 1991-1995 (48.6 and 46.9%), the incidence of people has increased more than 2 times (the average annual rate per 100 thousand population in 1996-2000 - 26 instead of 11.1 in 1991-1995).
In 2001 and 2002 in general, across the region, the level of vaccination of small ruminants against brucellosis was 48.9 and 56.1%, respectively (in 2000 – 47.8%). In 2001 the rate of newly diagnosed incidence of brucellosis in people per 100 thousand of the population in the whole region was 8.6, and in 2002 – 20.6 (in 2000 - 15).

When analyzing data for 1992-2002 on the incidence of acute brucellosis in people on a regional scale, and in the context of its individual territories, it was found that the most difficult epidemic situation for brucellosis was found in two territories (B and M).

In territory B the indicators of the sharply increased incidence of brucellosis by 1998 (in 1992 – 21.5 cases per 100 thousand population; in 1993 – 45.0; in 1994 – 18.7; in 1995 – 26.7; in 1996 – 23.8; in 1997 – 37.5; in 1998 – 124.1) correlate (r = 0.9) with indicators reflecting the period from 1992 to 1998 in relation to the level of immunization of animals (in 1992 it was 50.3%; in 1993 – 35.0; in 1994 – 42.1; in 1995 – 38.4; in 1996 – 29.0%; in 1997 – 33.9%, in 1998 – 90.2%). This can be explained by only one circumstance - the sharply increased level of vaccination of sheep and goats, primarily in the private sector 1998 is associated with an epidemic situation: it was she who, having aggravated in this territory, forced to take emergency, forced measures to ensure maximum coverage of small ruminants with vaccinations against brucellosis, and above all in those epizootic foci where cases of human disease with brucellosis were detected. A number of circumstances prevented the planned annual vaccination of the entire population of sheep and goats, of which the most serious were difficulties with the implementation of such a large amount of work due to a lack of veterinary specialists and a lack of necessary funds, as well as the reluctance of animal owners. Considering that in the period 1998-2002 the average level of immunization of sheep and goats was only 63.8%, and in 2002 – 57.7%, the incidence of brucellosis in humans in 2002 returned to 123.7 (i.e., to the level of 1998).

The studies covered primarily all animals of epizootic foci.

In connection with the fact of immunization of animals against brucellosis with an agglutininogenic vaccine and the lack of opportunities to use traditional RA and CFR in diagnostics, which are not able to differentiate post-vaccination reactions from post-infectious ones, only the immunodiffusion reaction was used in agar gel with O-polysaccharide antigen (RID with O-PS antigen) possessing, unlike them, such an ability since this antigen is inherent in brucella with high virulence [10-20].

In 2002, in territory B, among the livestock of small ruminants 3.6% of the number of those surveyed was identified whereas before that from 1998 to 2001 the level of response in RID of the studied vaccinated livestock of animals steadily decreased (from 5.8 to 0,9%). This can be explained by the fact that in 15 acute epizootic foci registered in 2002, the dysfunctional flocks of animals had practically no anti-brucellosis immunity (animals in them have not been vaccinated against brucellosis in most cases during the last years). During the epidemiological and epizootic analysis, it was found that the vast majority of people with brucellosis during this period had direct contact with animals from these epizootic foci. In 2002 due to the further deterioration of the situation and the emergence of an epidemic emergency (32 acute cases of human disease) all livestock of epizootic foci were immunized with the vaccine from strain 19 with full coverage.

Vaccination had a positive effect on the epidemiological indicators (in 2003 only 8 acute cases of human brucellosis were detected in only four out of 15 existing epizootic foci), as well as on the results of serological studies of animals (0.8% of respondents).

Thus 11 old epizootic foci were promptly stopped by immunizing the entire population of sheep and goats with the vaccine from strain 19 subcutaneously at a full dose with preliminary (before vaccination) and subsequent studies for brucellosis in RID with O-PS antigen. New foci did not appear.

So, it is obvious that there is an antiepizootic and (which is very important) antiepidemic effect due to immunizations (including multiple immunizations) of a livestock of sheep and goats with a vaccine from strain 19 subcutaneously at a dose of 40 billion m.k. With the provocative properties of the vaccine) with the help of RID and their slaughter. As for the early post-vaccination diagnosis using RID (already 3 months after vaccination), it should be noted that, even if there were costs associated
with the post-vaccination nature of the reactions, they were not comparable with the positive effect associated primarily with the relief of epizootic foci as sources of infection and disease in humans.

In territory M, the incidence of people in 1992-1994 was not noted. In 1995, 2 people fell ill with acute brucellosis (30.6 cases per 100 thousand population), and in 1996 - already 64 (1093.7 cases per 100 thousand population). The level of immunization of sheep and goats during this period was: in 1992 – 11.1%, in 1993 – 57.9, in 1994 – 39.5, in 1995 – 39.0, in 1996 - 52.6%. It was in 1996 that the level of immunization of the sheep and goat population increased, in comparison with 1995, by almost 1.5 times. It should be noted that the number of small ruminants in the private sector in 1992-1995 brucellosis was not vaccinated at all, and in 1996 its immunization rate was 31.9%.

The incidence of brucellosis in people (per 100 thousand population) in 1997 was 406.2 - in fact, 2.5 times lower than in 1996; in 1998 – 93.7; in 1999 – 79.8; in 2000 – 97.5; in 2001 – 5.8; in 2002 - 0. The level of immunization of sheep and goats in 1997 decreased, compared with 1996, more than 2 times (from 52.6 to 24.2%). In 1998, the level of immunization of sheep and goats increased again and amounted to 41.3%, including in the private sector - 60%. In 1999, the level of immunization of livestock was only 37.1%, including in the private sector – 12.2%, in 2000, respectively, 49.1 and 34.0%, in 2001 – 57.6 and 42.1%, in 2002 – 47.7 and 16.0%, respectively.

An outbreak of acute brucellosis among animals of the public and private sector (among the latter - to a greater extent) and people occurred in 1996 at the «M-B» farm. The contamination of sheep and goats was facilitated by their contact with a disadvantaged herd of small ruminants from the neighboring region.

The relief of epizootic foci was carried out by immunizing the entire susceptible livestock with the vaccine from strain 19 and subsequent post-vaccination studies 3-4 months later using RID with O-PS antigen. At the same time, from 5 to 43% of the responding animals were found. All reactive livestock were delivered for slaughter first. Then, gradually, all the compromised livestock - animals of dysfunctional flocks - were handed over for slaughter. This was carried out faster than, for example, in territory B, since due to the presence of a large number of public livestock, it was easier to replace the unsuccessful removed livestock with healthy ones. The result of this work is the absence of the incidence of brucellosis in humans in 2002: (since 1998, only a few cases of human disease have been noted, whereas in 1996 there were 70, and in 1997 - 26).

4. Conclusion
The basis for the existence and development of any epizootic process is the ecological mechanisms of interaction between the populations of the parasite and the host. Taking into account the obviousness of the existence of «parasite – host» systems or parasitic systems in which the processes of self-regulation and artificial regulation can occur, the concept of «controllable infections» is legitimate, which is fundamentally related to the possibility of artificially creating a «biological balance» between parasites and hosts for a long period. in most cases, through the rational use of vaccines.

In the territories considered in the article, the epizootic process of brucellosis in small ruminants, developing in animal populations with a low level of immunity, is characterized by the intensive formation of epizootic strains of brucellosis with a high level of virulence, which ultimately leads to massive acute cases of brucellosis in people in contact with them. Brucella, parasitizing in populations of animals with a high level of immunity, are, as a rule, in the stage of reservation, have reduced virulent properties, and this circumstance is accompanied by a favorable epidemic situation, and acute cases of human disease with brucellosis during contact with animals of such populations are rare.

In other words, the potential possibility of managing the epizootic process of brucellosis in large areas in the zones of disease occurrence due to the leading role of specific prevention is obvious. Moreover, it is necessary to create permanent immunity against brucellosis in animals of dysfunctional and threatened herds (flock) for the longest possible period.

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