CHAPTER 6

MEASURES TO CONTROL PARASITIC INFECTIONS OF PIGS IN THE PRODUCTION CHAIN FROM THE FARMS BREEDER TO THE CONSUMER

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ABSTRACT: The main goal of the control program of parasite infection is to raise the health status of pigs in the Republic of Serbia. By preventing the appearance and spread of parasitic infections by taking certain preventive measures, the basic task is to reduce the prevalence of parasites, which achieves that as few infected animals reach the slaughterhouse as possible. In addition, taking prescribed measures at the slaughterhouse aims to keep the risk of parasitic zoonoses in meat and pork products at zero level. The application of this integrated concept of parasite infection control required the systematic monitoring of infection on farms and slaughterhouses before and after the applied measures. Certainly, the complexity of the problem required the involvement of all relevant entities, primarily veterinary services, starting from farms to slaughterhouses.
KEYWORDS: swine, parasites, control

INTRODUCTION

Parasitic infections are constant companions of pig production, regardless of the method of keeping. Caused by several parasitic species, they endanger the health of animals and cause significant economic losses due to lower growth, reduction in body weight of fattening animals and loss of daily gain, poorer feed conversion, and finally, a problem appears in the slaughterhouse industry in the form of confiscation or conditionally usable meat.

The origin, course and diseases of pigs in general are determined by the

presence of causative agents, susceptible hosts and the environment. In intensive keeping, all the mentioned elements are emphasized, often in a negative sense, considering that intensive upbringing has both advantages and disadvantages. In this breeding, there are large agglomerations of animals in a limited space, and the danger of the occurrence and spread of diseases increases along with the density of the population of animals in the lenses and boxes. The greater number of animals in a smaller space, take chance and the greater possibility of spreading infections. Housing and feeding conditions at a certain time are the same and have an equally favorable or negative effect on all animals.

The problem of the transmission of parasitic infections from older to younger categories of pigs on farms of different capacities and on individual farms with a larger number of animals arises during the keeping of pigs in facilities where infections of breeding animals occur with ecto- and endoparasites, and they bring it into the harrowing house and infect the piglets immediately after harrowing.

Apart from the immediate harmful effect on pigs and the large economic losses they cause, certain types of parasites are significant zoonoses that can cause the death of infected people. Pork meat and meat products are widely distributed and appreciated in the world. For these reasons, food safety is a very important aspect in epidemiology, and that is why the control of pork meat and products must be included in the mandatory monitoring of parasitic infections in pigs.

THE ZOONOTIC ASPECT OF PARASITES OF PIGS

In addition to the already well-known diseases of trichinosis and cysticercosis, pigs are carriers of parasites that cause toxoplasmosis, sarcocystosis, balantidiosis and cryptosporidiosis, which also directly threaten human health. Trichinellosis, cysticercosis, sarcocystosis and toxoplasmosis are transmitted by meat and meat products of pigs, balantidiosis and cryptosporidiosis are transmitted by infected feces. A big problem in this case is the fact that little is said about trichinellosis and cysticercosis, and there is not enough knowledge about their importance neither among consumers of pork meat and products nor among pig breeders. How significant a health problem this is can best be illustrated by showing toxoplasmosis and balantidiosis, which are present in an extremely high percentage in pigs.

Toxoplasmosis

Toxoplasmosis is one of the most widespread parasitic zoonoses in the world, which in most cases is asymptomatic in pigs, but that is why pork is an extremely important source of human infection (in the USA it is in first place). The causative agent is *Toxoplasma gondii*, a cyst-forming coccidia whose first host is cats, and mammals, reptiles and birds persist as

intermediate hosts (more than 280 species, including humans). According to estimates by the World Health Organization, based on serological examinations, more than 700 million people in the world are infected with *T. gondii.*

Balantidiosis

Balantidiosis is a zoonotic disease present all over the world, and the prevalence of pig infection ranges up to 100% of infected animals, although the disease is rarely present. The causative agent is the ciliate *Balantidium coli*, the cysts and vegetative forms of which are found in pig feces. People become infected by introducing developmental forms of the protozoan B.coli, through unwashed hands, etc. Balantidium synthesizes the enzyme hyaluronidase, which damages human tissues. After infection, Balantidium causes an inflammatory reaction similar to dysentery caused by amoebas. The most common symptoms are colitis and diarrhea. Extraintestinal spread of the parasite leads to damage to the liver, pleura, lymph nodes, lungs and urogenital system, but it is very rare. Cases with a fatal outcome have also been recorded.

Sarcocystosis

Sarcocystosis is caused by protozoa from the genus Sarcocystis, which includes several species of these parasites. The names sarcocyst indicate the true and transitional host. In pig infections with the protozoan *S.suihomini*, the transitional host is the pig and the real host is the human. Infections of the true hosts are usually asymptomatic, and diarrhea may occur as a clinical symptom. In humans, intestinal sarcocystosis most often occurs in immunodeficient patients (AIDS) with diarrhea, nausea, vomiting, fever, chills, acute abdominal pain, and necrotizing enterocolitis. In the muscular form, discomfort, weakness, swelling and pain in the muscles may occur.

Cryptosporidiosis

Cryptosporidiosis has long been considered a commissural stain, to establish that it represents a dangerous zoonotic pathogen. The most common causative agents of piglet infections are *Cryptosporidium parvum, C. suis* and *C. muris*. The mode of transmission is peroral infection with oocysts. Older animals are the source of infection in piglets. Autoinfections are also possible - when oocysts release sporozoites into the colon of the host. Human infection occurs with cryptospora oocysts, most often through the fecal-oral route. Intestinal cryptosporidiosis is mostly chronic. In immunodeficient patients (AIDS sufferers), debilitating diarrhea occurs, accompanied by vomiting, loss of appetite and periods of constipation, and the mortality rate ranges up to 35% in some areas. Respiratory cryptosporidiosis of humans is caused by inhalation of oocysts, while infection of the biliary tract occurs due to penetration of the parasite from the digestive tract (autoinfection).

Cysticercus suum

Cysticercus suum is the encysted larval form of the tapeworm *Taenia solium*, which has a human as its first host. The spread of this taeniasis is directly related to the economic conditions and hygiene habits of the population. According to data from around the world, it is most present in people in Africa, while it is least represented in Europe. The prevalence in our environment is not higher than 2-3%. The disease is extremely significant and is on the list of diseases that are controlled by WHO and OIE. The eggs of the parasite are found in the feces of infected people, and the infection of pigs and wild boars occurs through the ingestion of eggs and articles of tapeworms (due to the coprophagous habit of pigs), contaminated food or water. After the infection of pigs, embryos are released in the intestines, which break through the intestinal wall and through the bloodstream, less often with lymphoma, reach the muscle tissue, where cystic formations known as pig berries (*Cysticercus cellulosae*) develop. They are most abundant in the chewing muscles, heart, diaphragm, gluteal, neck and intercostal muscles, tongue, and can also be found in the brain, lungs, liver and other organs. In pigs, there are usually no clinical symptoms of the disease, except for extremely strong infections. Human infection is caused by insufficiently thermally processed infected pork meat and leads to the complete development of the parasite.

Trichinosis

Trichinosis is a parasitic disease of animals and humans, most often caused by the larvae of *Trichinella spiralis*. The infection occurs through the consumption of insufficiently thermally processed meat and meat products, in which *T.spiralis* larvae are cocooned. In pigs, trichinosis cannot be observed during life. Infection, development and cocooning of larvae in muscles occur without visible clinical signs, so apparently healthy animals can be infected with Trichinella. In humans, the first signs of the disease appear 8-30 days after eating infected meat. In the case of infection with a large number of larvae, the signs of the disease appear in 24-48 hours, and in the case of a weaker infection later, and occur in a milder form. The second stage of the disease coincides with the migration of the larvae into the muscles. In humans, the larvae are most often found in the eye, neck, intercostal, pectoral, thigh, masticatory and diaphragm muscles. This phase begins with an elevated temperature (up to 40°C) and swelling of the eyelids and face that last 3-11 days. If the larvae enter the heart muscle or brain, death is possible. In the last stage of the disease, when a cocoon forms around the larva in the patient's muscles, gradual recovery begins.

Ascariasis

Ascariasis is the most common and arguably the most important parasitic disease of pigs. The disease has recently been confirmed as a zoonosis. Recent serological screening studies for specific antibodies to *A. suum* conducted in the Netherlands and Sweden have shown extremely high seroprevalences, while numerous case reports from Japan report pulmonary, hepatic and cerebral symptoms caused by *A. suum* larvae after eating infected raw meat (liver) or vegetables contaminated with *A. suum* eggs.

In swine, it is widespread in all parts of the world and in all conditions of keeping, the causative agent is Ascaris suum. The pathogenic action of the parasite begins already with the larvae, which, released from the eggs, penetrate the mucous membrane of the small intestine and reach the liver through the portal bloodstream. By breaking through the liver parenchyma, lesions are created, and the liver becomes hyperemic, enlarged and in the late stage with characteristic milky white spots on the surface. At the slaughter line, these livers are discarded, causing significant economic losses. Adult parasites mechanically injure the intestinal mucosa, causing catarrhal enteritis and sometimes intestinal rupture.

Echinoccocosis / Hydatidosis

Echinococcosis is caused by tapeworms from the genus Echinoccocus in the true hosts - dogs, and hydatidosis is a disease of transitional hosts caused by encysted larvae of Echinococcus. This disease is very widespread in our country. The highest percentage of infected pigs is found in the individual sector (up to 75%), but the percentage of farm-raised pigs, where the degree of infection ranges up to 10% or more, is not negligible. Echinococcosis (hydatidosis) is a zoonosis. *Echinococcus granulosus* is a tapeworm 2-6 mm long and only occurs in adult form in dogs. Mature articles loaded with eggs are eliminated into the environment and thus contaminate food, water and soil. Eggs are very resistant in the external environment. When pigs ingest eggs, oncospheres are released from their intestines, which break through the intestinal wall and reach the liver via blood and lymph. One part stays here and develops into cysts, while the other part passes through the liver and reaches the large blood stream and then all the organs (spleen, kidneys, heart). The pathogenic effect depends on the size of the cysts, their number and localization. In pigs, the most common localization is on the liver. During their growth, the cysts exert pressure on the surrounding tissue, causing atrophy. In humans, the way of infection is identical to that in pigs but the pathological changes are much more drastic with a possible fatal outcome. for these reasons, it is necessary to eliminate dogs from pig farms.

DISTRIBUTION OF PIG PARASITES IN THE WORLD AND IN SERBIA

Today's industrial production of pigs is based on the implementation of biosecurity measures, as well as solving environmental problems, which significantly burden production. Good pig health is a condition for good reproduction, i.e. profitable production. Health depends on conditions of keeping, care, nutrition, health control and health care. A large number of diseases that are present on industrial type pig farms can be kept under control by applying prophylactic and therapeutic measures, as well as by increased control of professional services.

With the flexible cooperation of farm owners/individual breeders with professional services (veterinary stations, institutes), with respect and implementation of expert knowledge, and the application of a series of biotechnical measures and emphasizing the prevention of pig diseases, with the aim of promoting the good health of pigs, it is possible to improve production.

Biosecurity, welfare, good production practice and risk analysis at critical control points are very important elements for intensive pig production. The planned application of biosecurity measures is crucial in protecting the health of pigs and the success of production. Parasites are present in pigs all over the world in large and small farms, regardless of the level of applied zootechnical and hygienic measures. The clinical symptoms of parasitosis in pigs are usually not clear or pathognomonic and are hidden by subpneumonia and diarrhea of different etiology.

Research conducted in countries that are the largest pork producers and use the most modern technology best illustrates this. In the USA, they determined that the prevalence of *Ascaris suum* on farms is between 12-31%, *Strongyloides* spp., 16-27%, *Trichuris suis* 12-19%, *Oesophagostomum* spp. 11-21%, *Coccidia* spp. 10.5-19%.

European countries are not without these problems either. They are world-renowned pork producers, with the most modern technology, the best housing conditions and the genetic makeup of pigs. However, research conducted in the past decade established the presence of *A. suum, Oesophagostomum* spp, *I. suis* and *Eimeria* spp on their farms. The presence of parasites was found on 25–35% of farms in Denmark, 13% of farms in Norway and Sweden and 5% of farms in Iceland and Finland. Finally, in the Netherlands, the presence of parasites was established on 35% of farms, namely, 67% *Strongyloides* spp., 17% *Trichuris suis* and 17% *Ascaris suum.*

Research from China, which is the largest producer of pork in Asia, indicated that the most common parasitic infections on pig farms were infections with *Ascaris suum* (12.18%), *Trichuris suis* (10.13%), *Oesophagostomum* spp. (10.13%), *Eimeria* spp. (16.53%), *Cystoisospora suis* (5.02%), *Cryptosporidium* spp. (6.60%) and *B.coli* (22.7%). *Ascaris suum* is found throughout Asia, even in Nepal.

In Brazil, the leading producer of pork in South America, B.coli is the most common parasite found in 77.6%, followed by *Coccidia* sp. found in 71.1%, followed by *Strongyloides ransomi* (36.9%), *A. suum* (27.6%), *T. suis* (14.3%) and *Metastrongylus spp.* (3.7%).

In Africa, such research was also done, but the problem is that there the method of keeping is semi-extensive or with minifarms, so these results are not comparable with the results obtained in industrial keeping with large agglomerations of pigs. For farms on African soil, South Africa is leading with 51% of infected pig.

On the basis of inspections carried out on a large number of farms and on individual holdings with a large number of pigs in Serbia, we found that not a single age category of pigs is spared from parasitic infections, and that their incidence and morbidity. At the same time, an important moment in the occurrence of infections is the first infection of piglets that entered the farrowing area through sows infected with parasites, and then those piglets with parasites go to fattening.

In piglets, the presence of protozoan infections occurs most often, so we found the presence of *Balantidium coli* (95-100%), *Cryptosporidum* sp. (17-32%), *Eimeria perminuta* (27-31%), *E. debliecki* (3-24%), *E. polita* (4-9%) and *Isospora suis* (3-13%). In the older categories, infections with the helminths *Ascaris suum* (39-41%), *Oesophagostomum dentatum* (6-8%), *Strongyloideus ransomi* (1-17%) and *Trichuris suis* (1-7%) were found. Scabies caused by *Sarcoptes scabiei var. suis* we found in 3-37% of pigs of this age.

In the rearing phase, the following parasite species *Ascaris suum* (39-41%), *Oesophagostomum dentatum* (6-8%), *Strongyloideus ransomi* (1-17%) and *Trichuris suis* (1-7%) were established. We found scabies in 3-37% of piglets.

The fattening was found presence of *Eimeria perminuta* (27-31%), *E. debliecki* (3-24%), *E. polita* (4-9%) *Balantidium coli* (90-95%), *Ascaris suum* (9-16%), *Oesophagostomum dentatum* (2-8%), *Hyostrongylus rubidum* (3-6%), *Strongyloideus ransomi* (1-17%) and *Trichuris suis* (1-7%). On the slaughter line, ascariasis was found in 34 - 52% and hydatidosis in 1-2 % of fattening animals. Scabies is found in 15-35% of animals. Lice were found in 3-7% of pigs.

In breeding pigs, *Balantidium coli* (95-99%), *Eimeria perminuta* (17-21%), *E. debliecki* (12-23%), *E. polita* (14-19%), *Cryptosporidum* sp. (3-12%) were found), *Ascaris suum* (2-16%), *Oesophagostomum dentatum* (2-16%), *Hyostrongylus rubidum* (2-15%), *Strongyloideus ransomi* (1-3%), *Trichuris suis* (2-13%) and *Metastrongylus* sp. (1%).

These findings point to the fact that the problem of parasitic infections in farms and on individual farms with a large number of animals is approached in a general, unprofessional and inadequate manner, so that these infections appear as stationary infections.

Thanks to zoohygiene and biosecurity measures that are also applied on individual farms with a larger number of animals, zoonoses such as trichinosis and cysticercosis have been largely brought under control or eliminated from this type of production. But the future of pig production, which strives for organic production, has the possibility that this risk will be set again as an unavoidable reality, especially on individual farms with a larger number of animals.

PROGRAM TO CONTROL PARASITIC INFECTIONS

The main goal of the parasite infection control program is to raise the health status of pigs in the Republic of Serbia. By preventing the occurrence and spread of parasitic infections by taking certain preventive measures on farms, the main task is to reduce the prevalence of parasites, which is achieved by reducing the number of infected pigs to slaughterhouses. In addition, taking prescribed measures at the slaughterhouse aims to keep the risk of parasitic zoonoses in meat and pork products at zero level. The application of this integrated concept of parasite infection control required the systematic monitoring of infection on farms and slaughterhouses before and after the applied measures. Certainly, the complexity of the problem required the involvement of all relevant entities, primarily veterinary services, starting from farms to slaughterhouses.

Parasitic infection control measures were applied to seven test commercial pig farms, starting from the second half of 2016. The examined farms had a capacity of 600 to 1,500 breeding sows and had a closed production cycle, and individual farms also raised 40 or more pigs. Piglets reared on farms were placed in cages or boxes with a wire floor or with a floor made of perforated plastic, while fattening pigs were in boxes with a lattice floor. In individual farms with a larger number of animals, they are most often kept on straw, which is the trend of modern pig production, especially within the framework of animal welfare and organic production. Feeding was done with a complete fodder mixture for certain production categories from automatic feeders (*ad libitum*).

In order to establish the prevalence of parasitic infections and the biodiversity of the causative agent in the pig population, samples of feces and scarifications were collected from all categories of pigs. On each of the farms, 80 samples of faeces were sampled, 80 scarified samples, 20 from each production category - suckling piglets (from 0 to 28 days of age), rearing piglets (from 28 to 75 days), pigs from fattening (from 75 to 150 days of age) and breeding animals (gilts, sows and boars). On individual farms with a larger number of animals, samples were taken from 20% of the animals kept.

Excrement samples were taken and scarifications from all categories of pigs were processed using the usual parasitological examination methods. We performed examinations for parasites both during the necropsy of dead animals and in pigs on the slaughter line. Examination for ectoparasites was performed by scarification as well as the collection of adult parasites. All applied diagnostic methods were in accordance with WFP-EFP, WHO, FAO and OIE recommendations.

All parasites are determined on the basis of morphological characteristics, according to the keys given by Euzeby and Soulsby. On the basis of the obtained findings, the application of a number of solutions was started, which as a whole were incorporated into a single entity whose goal is the control of parasitic infections on pig farms and finally their eradication.

Based on the place of application of individual segments of this technological solution, they can be grouped into two basic units - measures taken on farms and measures taken at slaughterhouses.

MEASURES TAKEN ON THE FARM AND ON INDIVIDUAL FARMS WITH A LARGER NUMBER OF ANIMALS

The following measures are applied on farms and individual holdings with a large number of animals where the presence of parasitic infections has been determined or for the purpose of regular control for the presence of parasites:

1. Adherence to the principles of good production and hygiene practices

The problem of transmission of parasitic infections from older to younger categories of pigs on farms arises during the keeping of pigs in other facilities of the farm, where breeding animals become infected with ecto- and endoparasites, and they bring it into the farrowing house and infect the piglets immediately after parturition. For these reasons, their control is approached from several aspects that are essentially connected into one whole. Breeding animals should be cleared of parasites before being introduced into the farrowing house. Good results were always achieved when it was possible on the farms, after weaning the piglets and transferring them to other technological stages of production, it was impossible to mix piglets from different litters in the same pens, thus preventing the potential spread of parasites from infected litters. Groups in the nursery were formed from piglets from the same litter (with the cage system), or from piglets from neighboring litters (when rearing piglets in group boxes). In addition to the above, other stressful factors such as for example a change in food and eating habits can affect the spread of infection.

Epizootiological studies have shown that in more than 95% of cases, the infection of pigs with endoparasites occurs in the first weeks of life, and the clinical manifestation depends on the preparatory period of the parasite. that infections with ectoparasites occur from the age of 15 days and that the possibility of infection is low on the 180th day, when fattening animals are usually sent to slaughter. However, in the case of a significant increase in the incidence of infection, this limit could be moved towards the older categories of pigs that remain for breeding. In case of endoparasites, the same postulate is valid with the fact that it gives potential possibilities of transmission of infection from pigs to humans, especially in protozoan infections with *B.coli* and *Cryptoyporidium* sp. transmitted by faeces and soiled equipment are constantly present in infected zapatas. If the incidence of infection started to increase, it would be necessary to implement radical measures, such as separating healthy from infected pigs at the end of the lactation period in order to reduce the number of infected animals at the end of the fattening period.

2. Production process management

Management of the production process in the farrowing house has a significant impact on the health status of the piglets. Given that piglets are born without protective antibodies, efforts were made to suck colostrum immediately after birth and thereby acquire passive natural immunity that will protect them in the first weeks of life against various infectious agents.

But this moment is also the initial point of infection of piglets with infectious forms of parasites (protozoa, helminths, worms) in case the sows were not parasitologically cleaned before being introduced into the farrowing house. They are then cascaded through all production segments from rearing to fattening or breeding animals.

3. Parasitological diagnostics

Regular parasitological examinations must be included in regular preventive health care measures for pigs. Timely detection of parasitic infections and targeted therapy are the basic measure of successful suppression of parasitic infections on pig farms and, therefore, the achievement of better production results.

Preventive coprological and dermatological diagnostics should include all animals on the farm and on individual holdings with a larger number of animals and should be performed at least twice a year in all age and production categories. Breeding animals, if they are positive, should be dewormed and treated with acaricides before being introduced into the farrowing house, thus preventing the initial infection of the piglets.

Before transferring the piglet to fattening, we must perform a parasitological examination and, if necessary, treat it. For fattening animals and breeding cows on the farm, the same principles apply - regular and periodic controls.

Also, newly acquired breeding animals must undergo parasitological control twice during their stay in quarantine. It is recommended that when giving fattening material for cooperative fattening, it must be controlled for the presence of parasites, as well as fattening material purchased for service fattening.

Coprological examinations in pigs are performed using the methods of Patakij, Stoll and McMaster, as well as the modified method of Whitlook and Euzeby. Considering the high fecundity of females of certain species of helminths (Ascaris suum) to assess the infection, we used the subjective method of descriptive description according to McMaster, taking the correction factor described by Kelly and Smith as well as the counting method according to Stoll with the correction factor (coefficient 2 for softened feces, 3 for diarrhea and 4 for completely liquid feces). Examination for ectoparasites (scabies) is performed by taking scarifications and examining them by boiling with KOH. The determination of parasite eggs and parasite adults is done morphometrically according to the keys given by Soulsby and Euzeby.

In all cases of a positive finding, parasite control must be carried out in all animals.

Special care should be taken to periodically inspect the slaughter line in order to observe the pathological changes that occur in the migratory phase of the parasite (hepatopulmonary migration). In this way, adult parasites in certain organs (ascarids, lung flukes) as well as encysted larval forms of certain parasites (echinococcal cysts, etc.) can be observed.

4. Application of antiparasitics drugs

During drug therapy, we expel adult parasites from the pig's digestive tract, so after therapy we have to remove the parasites together with the garbage. Antiparasitic drugs are applied by injection, through food and by spraying.

From anthelmintics that interfere with neuromuscular coordination, we use cholinesterase inhibitors (organophosphates - coumaphos, crufomate, dichlorovos, haloxone, naphthalphos and trichlorophen), cholinergic antagonists (imidazole-levamisole, tetrimizole, pyrimidine-morantel and pyrantel), antagonists of GABK mediators (ivermectin, sydectin, doramectin) and muscle depolarizers (piperazine). Ectoparasite therapy starts from the basic postulate that the anthelmintics used are selectively toxic to the parasite.

Among the anthelmintics that directly or indirectly damage the parasite's energy metabolism, polymerization inhibitors in the tubules (benzimidazoles and probenzimidazoles), inhibitors of oxidative phosphorylation (salicylates and substituted phenols) and inhibitors of enzymes in the glycolytic cycle (chlorsulons) are used.

Preventive antiparasitic therapy is applied cyclically on farms that have had successful control of parasitic infections. The goal of this therapy is to prevent the introduction of parasitic agents into the farm and maintain the current status of the farm. Certain antiparasitics can be given preventively in food (ivermectin preparations) or in water and ectantiparasitics by spraying animals or through food (ivermectin preparations).

In our case, after the diagnosis of parasitic infections, the therapy of all animals on the farm was carried out twice for five days with an interval of 21 days after the first one, considering the period of hepato-pulmonary migration of the parasite larvae. For therapy, ivermectin mixed in food was given in an oral daily therapeutic dose of 3 ppm/kg of body weight (1.5 g of powder-3 mg of ivermectin-per 10 kg of body weight), according to the manufacturer's instructions. Breeding animals were treated once with ivermectin s/c in a dose of 1 ml/33 kg of body weight, so the sows received ivermectin 3 weeks before farrowing. Ivermectin was chosen because of its anthelmintic and ectoparasitic effect.

The choice of ivermectin preparations was made on the basis of our and world experience, which showed that pig parasites have the lowest degree of developed resistance to ivermectins (in contrast to ruminants). Ivermectin is a broad-spectrum antiparasitic that is administered orally against adult and larval forms (stage IV) of nematodes and

adult ectoparasites (worms). Ivermectin is a synthetic derivative of abamectin, which is a fermentation product of Streptomyces avermectis (it differs from abemectin only by the chemical bonds between the 22 and 23 C atoms in the macrocyclic structure, where it has a single bond and one added hydrogen atom each). The entire group of avermectins are macrocyclic lactone compounds (macrolides), but unlike macrolide antibiotics, they have no antibacterial activity. The mechanism of their penetration into the parasite's organism is transcuticular, and this method of drug entry is more significant than oral ingestion (which is characteristic of indigestible anthelmintic molecules). The lipophilicity of the molecule and the relatively large molecules of ivermectin also favor the transcuticular penetration of the drug, with the fact that it is somewhat slower considering the cuticular collagen matrix that contains the lipoid biophase of the parasite's cuticle. The basic principle of action of ivermectin is to increase the release of GABA and its binding to GABAergic receptors in the synapses of the nervous system. As GABA is an inhibitory neurotransmitter in the nervous system of nematodes, arthropods and mammals, this effect results in the opening of GABA-dependent ion channels (chlorine) which increases the entry of chlorine into nerve cells and their hyperpolarization, and in parasites these are synapses between interneurons and excitatory motoneurons. This action leads to the ionic influx reducing the resistance of the cell membrane and causing hyperpolarization of the postsynaptic cells, which results in paralysis and death of the parasite.

Control examinations were performed 14 days after the first and 14, 21 and 35 days after the second drug application.

After remediation of the infection, the same procedure was applied for preventive purposes on the investigated farms with monthly coprological and ectoparasitic control, and observation of organs on the slaughter line.

In the case when protozoan infections of piglets caused by Isospora suis, Eimeria spp. and Cryptosporidium spp. oral application of 5% toltrazuril - 0.7 ml on the 3rd or 4th day of the pig's life was very effective. The time of application is important, because it must be just before the invasion of the oocysts into the enterocytes. You should pay attention to the grace period, which is up to 77 days.

5. Strict compliance with biosecurity measures

Biosecurity measures are intended to prevent unwanted situations and improve the operations of farms and individual farms with a larger number of animals, and in essence enable effective disease prevention. In order to properly define biosecurity protocols, biosecurity measures themselves are classified into external and internal. The objective of external measures is to prevent infections from entering the farm and to reduce the risk of the possibility of introducing infections with daily routine measures. These are general measures that also refer to the correct choice of location for the construction of buildings, only the structure and functionality of the building and the technology of holding it.

When it comes to external biosecurity measures, it is necessary to pay particular attention to preventing the introduction and spread of infection, which is achieved by health control of newly acquired pigs. By respecting the concept “all in, all out”, as well as preventing contact between different productions groups of pigs. As part of this program, an inter-tournament break, or so-called “facility rest” that had beneficial effects. Appropriate cleaning equipment was used in each facility, which was not allowed to be used in other facilities.

The installation of disinfection barriers in front of the facilities as well as between certain sections in the facility was aimed at preventing the transmission of parasites. If the transport took place, the vehicles had to be always disinfected, and the visitors had to comply with biosecurity measures by changing clothes, showering, and using clean clothes on the farm as well as protective equipment.

In addition to these measures, biosecurity measures related to the transport of animals, proper storage of garbage and harmless disposal of carcasses are also very important.

Internal biosecurity measures are defined in all biosecurity protocols on farms, through sanitary procedure plans that are continuously implemented. A sanitary procedure plan is made individually for each facility, depending on the capacity of the facility, construction and technical characteristics and type of production.

6. General animal hygiene measures

General hygiene measures primarily involve keeping production facilities in a clean state, especially farrowing and rearing areas. It is necessary to pay special attention to these measures. After each production cycle in certain stages of production, it is necessary to carry out mechanical cleaning, sanitary washing with warm water and the disinfection procedure.

The problem of transmission of parasitic infections from older to younger categories of pigs on farms arises during the keeping of pigs in other facilities, where breeding animals become infected with ecto- and endoparasites, and they bring it into the farrowing house and infect the piglets immediately after parturition. For these reasons, their control is approached from several aspects that are essentially connected into one whole. Breeding animals should be cleared of parasites before being introduced into the farrowing house. During drug therapy, we expel adult parasites from the pig’s digestive tract, so after therapy we have to remove the parasites together with the garbage. On the other hand, mechanical cleaning, and then washing the litter box or cage is a basic hygiene measure after therapy. After that, the disinfection of these spaces can be started, whereby the 2% NaOH solution has always been the most effective for these needs. Before and after parturition, attention should be paid to the hygiene of the sow’s udders, because if the papillae are infected with excrement, oral infection of the piglets with bacterial and parasitic pathogens occurs.

In facilities for rearing, on farms where old technology is present, we most often encounter the cage holding system. Here there is already a large agglomeration of animals in a small space, which certainly favors the spread of parasitic infections. In facilities, parasite eggs remain in feces on floors, corrals, boxes and all other places where pigs stay. Animals ingest the eggs of the parasite through constant scratching and due to coprophagy and are inevitably infected. If they are infected with scabies by scratching the walls of the cage, they infest these surfaces making them a source of infection for healthy individuals, and by direct contact they will also quickly and easily infect healthy piglets. For these reasons, cleaning and fertilizing proved to be a suitable preventive measure here as well. The fact that the eggs are sensitive to the external temperature (hot water kills them), the washing of objects must be done with water above 60°C, which destroys the eggs of ascaris and other parasites. After that, the disinfection of these spaces can be started, whereby the 2% NaOH solution has always been the most effective for these needs. Among other measures of zoohygiene prevention, it is necessary to optimize humidity and ventilation in facilities.

The fact that parasite eggs are sensitive to external temperature (hot water kills them) washing objects must be done with water above 60°C, which destroys the eggs of ascaris and other parasites. The embryogenesis of the eggs of roundworms and other types of parasites is proportional to heat and humidity, which favorably affects the rate of larval development. For these reasons, the reduction of humidity, along with the removal of excrement and washing (daily) of facilities are the basic measures to combat endoparasites of pigs, which, with regular parasitological control and deworming, lead to the suppression of this parasitosis from the pigs' mouths on farms.

In the control of ectoparasites, hygiene measures are also indispensable in view of contact transmission. After mechanical cleaning and washing, liquid acaricides are sprayed under pressure, after washing and disinfection, on buildings, boxes, equipment and other segments that were in direct contact with sick animals, but also on all farm buildings. Pigs are sprayed with liquid acaricides or bathed in them, where the toxicity and shelf life of the applied preparations must be taken into account (pyrethrin preparations have the least toxicity and a high degree of efficiency).

In general, the general disinfection procedure of farms is reduced first to mechanical cleaning, the aim of which is to remove all visible dirt from the floors of the facility and other surfaces, which most often consists of fecal waste and food residues. When cleaning dry surfaces, i.e. dry material, it is necessary to first wet it with water or disinfectant. This is necessary so that dust does not rise during cleaning, and with it, microorganisms or parasite eggs. Collected garbage is taken to a designated place (50 meters away from the farm building) and stored. After the mechanical cleaning is completed, sanitary washing is used to remove the rest of the dirt. It is preferable to do this in buildings with water whose temperature exceeds 60oC. This procedure removes the remaining dirt, and with it, considerable amounts of microorganisms. Sanitary washing should be carried out

particularly thoroughly on floors, lower parts of walls and boxes in stables, work surfaces, etc. Only after that, chemical disinfection is carried out.

After finishing the cleaning of the building, all roads inside the farm's economic yard are cleaned.

7. Deratization and disinsection

Pest control is one of the very important measures in the implementation of animal hygiene protocols. In addition to the application of chemical rodenticides, it is necessary to undertake construction technical and preventive measures in order to reduce the entry of rodents into farm buildings. Proper maintenance of the economic yard is necessary, which means regular mowing and removal of weeds and vegetation. Eliminating rodents is extremely important, considering that they are the main carriers of trichinosis.

Disinsection of buildings should be carried out continuously, bearing in mind the presence of a large population of insects, primarily flies, in the buildings themselves and in the immediate surroundings. Hygienic and protective measures should be used on the farm, primarily proper storage of garbage, installation of protective nets on windows and ventilation openings, as well as the use of chemical agents (adulticides and larvicides).

8. Control of stray dogs and cats on the farm and control of birds

The presence of non-owned animals, dogs and cats, is a frequent phenomenon on a large number of farms and on individual holdings with a large number of animals. The attitude of employees towards them cannot be ignored, considering that these animals have a proven anti-stress effect, especially in the urban population. However, these animal species should be denied access to farm facilities because we must not forget that dogs are carriers of echinococcosis, cats are carriers of toxoplasmosis, and both species are carrier of cryptosporidiosis. And if we ignore the basic postulates that they have no place on farms, then we must implement regular preventive health care measures (cleaning from helminths and protozoa and vaccination) and monitoring for certain diseases.

The control of birds found on pig farms and on individual farms with a large number of animals (pigeons, sparrows, starlings, swallows, crows, magpies, etc.) must be rigorously carried out, considering that they can be carriers of infectious material on their legs or through their organs, for digestion or breathing (tuberculosis, salmonellosis, ornytosis, giardiasis, etc.). Therefore, it is recommended to close nesting holes, place nets on windows and ventilation openings, close silo openings and cover edges under roofs and eaves suitable for nesting and bird retention.

9. Removal of carcasses

Removal of carcasses of dead animals from production facilities was the duty of employed workers. On the farms, cooling chambers or containers were built for the collection of pig carcasses from the farm, i.e. all materials belonging to category 1. Their processing was carried out in rendering plants, so it was necessary for each farm to have a signed contract with the rendering plant for the removal of category 1 materials. This way, the risk of dead pig carcasses being a source of infection for healthy pigs was reduced.

10. Removal of waste

The location of the manure pit within the farm and on individual farms with a larger number of animals and manure management organizations provide a lot of information about the level of biosecurity and employee awareness. The application of digestion, solarization or any other acceptable form of biological degradation is considered desirable, and they are very important for raising the level of biosecurity on the farm. The use of manure originating from pig farms, for the purposes of fertilizing agricultural areas, represents a significant risk for animal health as well as human health. In this way, potentially present parasites and pathogenic microorganisms are distributed in the environment and there is a possibility of surface water contamination, and zoonotic pathogens (*Balantidium coli*, *Cryptosporidium* spp., *Salmonella* spp., *Campylobacter jejuni /coli*, HEV, etc.) spread in the environment. . Researchers in the world and in our country have shown that in surface water and sediment, the evident presence of oocysts of Cryptosporidium spp. and various types of pathogenic bacteria including E. coli, Salmonella spp., Staphylococcus aureus, Enterococcus spp. Adequate management and handling of manure originating from pig farms can reduce the risk of spreading pathogens to domestic and wild animals and humans. For these reasons, it was recommended that the manure be deposited and treated under aerobic conditions, or that it be used for the production of biogas in anaerobic digesters.

11. The educational program

The training of veterinarians who provide health care for pigs was carried out during each visit to the stations, and as part of the contractual cooperation. Special emphasis is placed on the application of good veterinary practice. In this way, a contribution was made to preventing the spread of infection, but also veterinarians were educated on how to protect themselves from balantidiosis and cryptosporidiosis, which in some countries have the status of professional diseases.

MEASURES TO BE TAKEN AT THE SLAUGHTERHOUSE

Slaughterhouses are the places where the presence of parasitic infections in pigs is most often detected. Characteristic changes in the organs caused by the larval migration of parasites, the presence of encysted parasites or the finding of adults in certain organ systems (digestive tract, lungs) are most often found on the slaughter line and reflect the parasitological picture of the farm that could not be determined by coprological examinations.

The preparation period of helminths can lead to the fact that although pigs are infected, they do not yet have sexually mature adults (due to the fattening period which is too short for the unhindered development of certain parasites). On the other hand, the taeniases that we meet in pigs do not have adult forms, but only incised larval forms, so that cysticercosis or echinococcosis / hydatidosis can only be diagnosed post mortem on the slaughter line, incistered on predilection organs.

1. Application of good production and hygiene practices during the slaughtering and processing of carcasses

The application of good production and hygiene practices aimed to determine pathological changes in the organs of pigs used for human consumption (liver above all) and then remove them harmlessly. The spectrum of these changes ranges from necrotic lesions, confluent changes and scar tissue to infectious cysts of zoonotic tapeworms *Ehinococus* sp. and *Taenia hydatigena.*

Special attention must therefore be paid to performing the correct procedure of evisceration of organs, in order to prevent potential contamination of the carcasses due to accidental damage to the liver or lungs where there are cysts of parasites, the wall of the intestine and the exit of intestinal contents that can also be contaminated with *B.coli* and *Cryptosporidium* spp.

2. Parasitological examination which is mandatory by law

This refers to regular trichinoscopy examinations and control for the presence of cocooned larvae of *T.solium*, which is provided by legal regulations on the safety of foods of animal origin. Inspection and evaluation of carcasses of slaughtered pigs for the presence of berries is regulated by the Rulebook on the method of veterinary-sanitary inspection and control of animals before slaughter and products of animal origin and trichinosis and the Instruction on the method and procedure for determining *Trichinella spiralis* larvae in pig, horse and game meat and meat products pigs, horses and wild game.

3. Harmless removal of contaminated organs and confiscations

During the bleeding procedure on the slaughter line in the slaughterhouse, the pigs' blood was deposited in special containers that had adequate lids for closing, while the digestive organs of the slaughtered animals were deposited in special containers. After that, heat treatment procedures were applied, which caused the blood and digestive organs to become harmless from the aspect of safety for human health. Their processing was carried out in rendering plants, so it was necessary for each slaughterhouse to have a signed contract with the rendering plant.

4. Implementation of educational programs at slaughterhouses

The education of veterinarians employed at slaughterhouses was carried out through one-day seminars as part of the contracted scientific and technical cooperation. Experiences have shown that workers at slaughterhouses very often, apart from practical knowledge in operational work, have little knowledge of the basic principles of preventive hygiene measures and ways of maintaining personal hygiene, which are necessary elements in the prevention of infection. For these reasons, the educational programs implemented, as well as the instructions on the application of hygiene measures, aimed to familiarize workers with basic biological hazards, with special reference to parasitic zoonoses.

RESULTS OF TAKEN MEASURES

This whole set of measures applied in farms and slaughterhouses were aimed at reducing the prevalence, incidence and damage caused by parasitic infections in pigs. In order to determine their effectiveness, control was needed after the implementation of these measures in practice.

In order to quantify the measures applied on farms and on individual holdings with a larger number of animals, the implementation of which began in the second half of 2016 and is carried out by the competent veterinary stations. Six months later, in order to establish the partisological situation of the pig population, samples of feces and scarification were collected from all categories of pigs. On each of the three farms, 80 samples of feces were sampled, 80 scarified samples, 20 from each production category - sows, suckling piglets (from 0 to 28 days of age), rearing piglets (from 28 to 75 days), fattening pigs (from 75 to 150 days of age) and breeding animals (gilts and boars).

Excrement samples were taken and scarifications from all categories of pigs were processed using standard parasitological examination methods. We performed coprological examinations using the methods of Patakij, Stoll and McMaster, as well as the modified method of Whitlook and Euzeby. Considering the high fecundity of females of certain species of helminths (Ascaris suum) to assess the infection, we used the subjective method

of descriptive description according to McMaster, taking the correction factor described by Kelly and Smith as well as the counting method according to Stoll with the correction factor (coefficient 2 for softened feces, 3 for diarrhea and 4 for completely liquid feces). Examination for ectoparasites was performed by scarification as well as the collection of adult parasites. All applied diagnostic methods were in accordance with WFP-EFP, WHO, FAO and OIE recommendations. All parasites are determined on the basis of morphological characteristics, according to the keys given by Euzeby and Soulsby.

We performed examinations for parasites both during necropsy and in pigs on the slaughter line. At the slaughterhouses, special attention was paid to the inspection of organs from fattening pigs originating from the examined farms. During the evisceration procedure, special attention was paid to the liver, lungs and intestines, the organs through which the larval migration of parasites takes place, where they can be found in adult form or as cystized larval forms (echinococcosis).

The first parasitological examinations were carried out before the implementation of control measures in order to establish the parasitological situation of the pig population. The next examinations were done six months after the implementation of the control program. The goal was to determine the effect of the application of the program on the reduction of parasitic infections in controlled herds of pigs.

At the beginning of the implementation of the program, the prevalence of parasitic infections on the investigated farms was as follows:

- Suckling piglets (from 0 to 28 days of age): *Eimeria sp* (6%), and *Isospora suis* (9%).

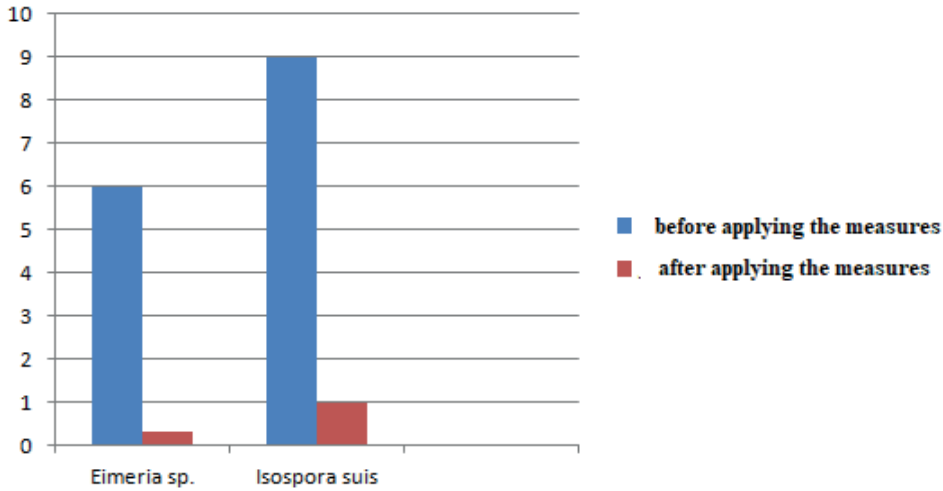
- Reared piglets (28 to 75 days old): *Cryptosporidium* sp (8%), *Ascaris suum* (10%). Scabies caused by *Sarcoptes scabiei var. suis* we found in 15% of pigs of this age.

- Fattening pigs (from 75 to 150 days of age) *Ascaris suum* (16%), *Hyostrongylus rubidum* (6%) and *Trichuris suis* (5%). On the slaughter line, ascariasis was found in 43% of pigs. Scabies caused by *Sarcoptes scabiei var. suis* we found in 29% of pigs of this age

- Breeding animals (gilts, sows and boars): *Eimeria* sp. (17%), *Isospora suis* (6%), *Cryptosporidum* sp. (8%), *Ascaris suum* (12%), *Hyostrongylus rubidum* (3%) and *Trichuris suis* (3%). Scabies caused by *Sarcoptes scabiei var. suis* we found in 9% of pigs of this age.

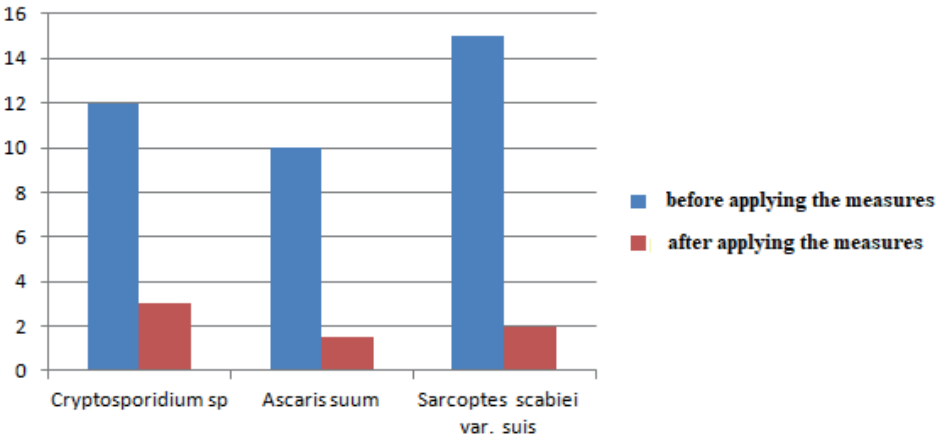
After six months from the beginning of the implementation of the aforementioned control measures for parasitic infections and other parasitological control, the following results were obtained:

- Suckling piglets (from 0 to 28 days of age): *Eimeria* sp (0.3%), and *Isospora suis* (1%).



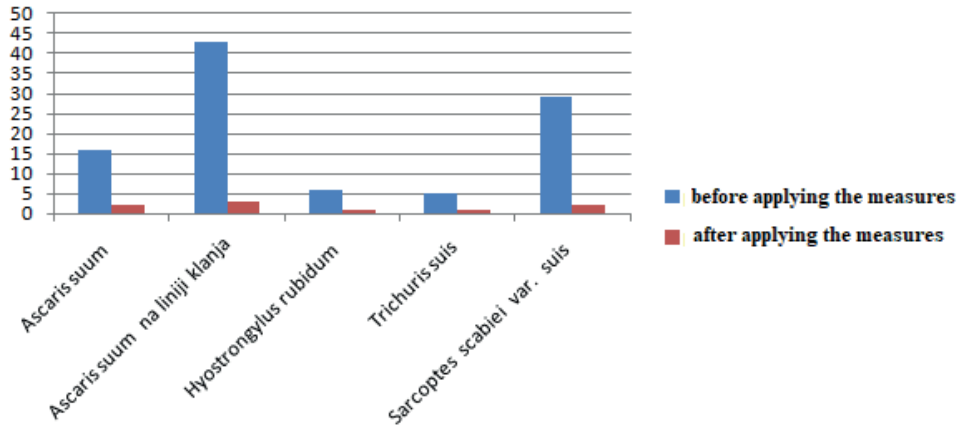
Picture 1 Results of the effect of the application of measures in piglets on teats (from 0 to 28 days of age)

- Reared piglets (28 to 75 days old): Cr*yptosporidium* sp (3%), *Ascaris suum* (1.5%). Scabies caused by *Sarcoptes scabiei var. suis* we found in 2% of pigs of this age.



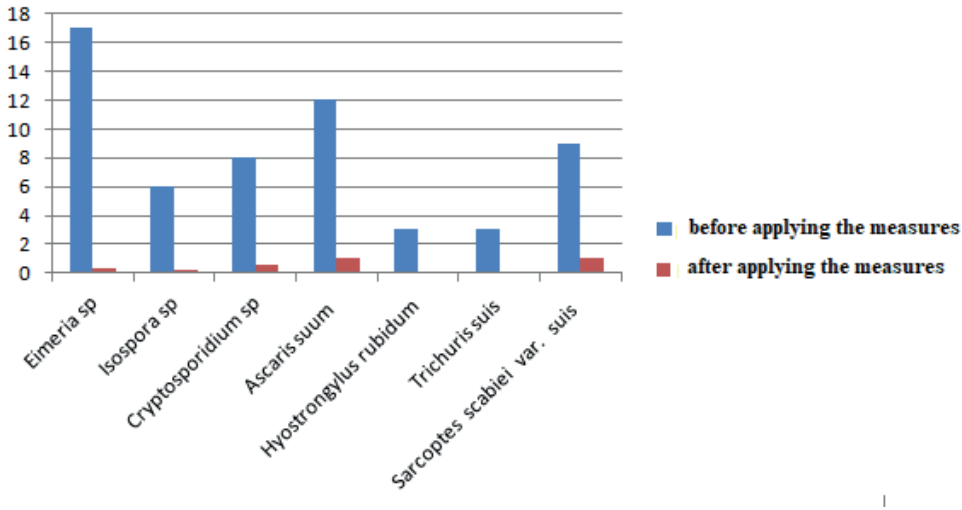
Picture 2 Results of the effect of the application of measures in reared piglets (28 to 75 days old)

- Fattening pigs (from 75 to 150 days of age) Ascaris suum (2%) Hyostrongylus rubidum (1%) and Trichuris suis (1%). On the slaughter line, ascariasis was found in 3%. Scabies caused by Sarcoptes scabiei var. suis we found in 2% of pigs of this age.



Picture 3 Results of the effect of the application of measures in fattening pigs (from 75 to 150 days of age)

- Breeding animals (gilts, sows and boars): *Eimeria* sp.(0.3%), *Isospora suis* (02%), *Cryptosporidum* sp. (0.6%), *Ascaris suum* (1%). Scabies caused by *Sarcoptes scabiei var. suis* we found in 1% of pigs of this age.



Picture 4 Results of the effect of the application of measures in breeding animals (gilts, sows and boars)

A visible decrease in the prevalence of parasitic infections is noticeable after the application of the implementation of the program.

Based on the conducted tests, we believe that by applying comprehensive measures starting from farms to slaughterhouses, in a relatively short time they made a significant contribution in controlling and reducing the prevalence of parasitic infections in pigs for slaughter.

This is supported by the established prevalence of parasite eggs found on the slaughter line, which showed a reduction of infection by more than 95% in all age and production categories. The obtained results give a justified recommendation for the application of these measures in other production facilities for pig breeding as well as in slaughterhouses.

Based on the obtained findings, the applied measures became part of the regular health care program for pigs on the investigated farms. A special contribution to the implementation of these measures was made by fellow veterinarians on pig farms, and the results achieved were a satisfaction both for them and for us, who conceived and implemented this complex program to control parasitic infections.

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