study of the role of lymphoid clusters associated with FALC (fat-associated lymphoid clusters) in the processes of adhesion formation remains actual. The novelty of the work consists in the study of the characteristics of the distribution and number of lymphocytes in the mesentery of the small intestine in adhesion disease in comparison with the norm in rats. *The aim:* to study the features of the morphofunctional state of peritoneal tissues and lymphoid clusters associated with adipose tissue (FALC) in normal rats and with adhesion disease. *Materials and methods:* preparation, macroscopic, microscopic, histological (production of film preparations), staining with hematoxylin and eosin, mathematical (morphometric grid – the number of immunocompetent cells was counted on a standard area of 1000 μm2), planimetric (the mesenteric plane of the small intestine and the area that was changed by spike processes), statistical according to Student. *Conclusions.* Lymphoid clusters associated with FALC adipose tissue, represented by diffusely located lymphocytes of small, medium and large diameter and plasma cells, are observed in the mesentery of the small intestine. The experimental form of adhesion disease was characterized by gradual changes in the tissues of the mesentery of the small intestine and the formation of adhesions, which were noted on the 7th day of observation by a decrease in the mobility and gelatinization of the tissue; thickening and density of the connective tissue of the mesentery of the small intestine on the 14th day; the appearance of granular formations with hard conglomerates of heterogeneous structure in the tissue on the 21st day of observation. Adhesion formation was accompanied by dynamic changes in the structure of lymphoid tissue. There is an accumulation of lymphocytes in some areas of the mesentery on the 7th day of the study. The number of lymphocytes per standard unit of area also changes: on the 14th day, the indicator increases by 44%, on the 21st day by 47% compared to the 7th day of observation.

Key words: small intestine, rats, experiment, histological changes of peritoneum, immunity, morphology, microscopy, morphometry.

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RESULTS OF INSECTICIDE TESTING IN THE CONTROL OF IXODES TICKS

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TIn connection with the emergence of epidemiological threats caused by the expansion of the ranges of ixodid ticks, there is an urgent need to develop various measures related to the regulation of the number of these arthropods. Among these measures, the development of insecticidal drugs of chemical and natural origin occupies a prominent place. The first such drugs began to appear in the United States in the 50s and 80s of the twentieth century. Subsequently, similar drugs began to be developed in many countries where ixodid ticks began to pose a threat to public health.

Insecticides for controlling harmful arthropods, including ticks, are also produced and used in Ukraine. However, most of them are designed to control ectoparasites directly on the host body, and only a small number of them are intended to limit their number directly in biocenoses.

Some of the drugs of chemical and natural origin tested by us, which are based on active substances such as ivermectin, alphacipermethrin, piperonyl butoxide, as well as antibiotics of natural origin (macrolides, sterols, phospholipids and phytohormones), can be effectively used to limit the number of ixodid ticks directly in natural and artificial biotopes, without harming other members of these biotopes. The results of such testing showed that the lethal effect

of drugs based on ivermectin and alphacypermethrin and piperonyl butoxide at a concentration of 5% is observed in 100% of Ixodes ticks within 10-12 minutes. Preparations based on antibiotics of natural origin (macrolides, sterols, phospholipids and phytohormones) do not cause lethal effect in ticks even at concentrations above 10%.

Key words: *acaricides, ticks, infectious diseases, parks.*

Connection of the publication with planned research works.

The presented material is a fragment of scientific research within the framework of the initiative research work "Biology, epidemiological significance and measures to limit the number of ixodes ticks in urban and agrocenoses of the western region of Ukraine" (state registration number 0120U0104153) of the Department of Medical Biology of I. Horbachevsky Ternopil National Medical University, Ministry of Health of Ukraine.

Introduction.

Ticks are the carriers of pathogens of dangerous infectious diseases, and their bites can threaten humans with about 150 diseases. Among them, the most epidemiologically important are tick-borne viral encephalitis, Lyme disease, granulocytic anaplasmosis, monocytic ehrlichiosis, Crimean-Congo hemorrhagic fever, hemorrhagic fever with renal syndrome, tularemia, etc.

The task of non-specific prophylaxis is to protect people from bites of blood-sucking arthropods. This task is solved in two ways: by exterminating ticks in natural foci of infections and by individual protection of people from their bites. The fight against various ectoparasites, including ixodes ticks, is the subject of a relatively small number of publications, most of which are published in Europe and North America. In 50-80 years, the main tactic for controlling ixodes infestations was the use of conventional synthetic acaricides [1, 2].

Most modern acaricides include pyrethroid and carbamate compounds as active ingredients and are effective in reducing tick populations.

However, many synthetic drugs were toxic to other animals and human and polluted the environment when used in tick control. Therefore, subsequently, they began to use drugs with active ingredients of plant or animal origin.

Currently, new drugs based on natural antibiotics (macrolides, sterols, phospholipids and phytohormones), avermectins and alphacypermethrin and piperonyl butoxide have appeared on the Ukrainian market of acaricidal drugs. However, the acaricidal effect of these drugs on limiting the number of Ixodes ticks in natural and urbanized habitats remains unclear.

The aim of the study.

To determine the effectiveness of insect-acaricidal drugs on Ixodes ticks and to test them in the park.

Object and methods of research.

We used 80 Ixodes ticks collected from the environment with the help of a "flag", a cloth with a rough surface, white, 1x1 m in size, which was fixed transversely with slats (or a frame made of wire with a diameter of 5-6 mm). The whole structure was attached to a 1.5-meter long longitudinal rod. Holding the pole from the side, they pulled the cloth across the grass. After walking a distance of 50-100 meters, they checked the "flag" on both sides and removed ticks from it with tweezers. The captured ticks were placed in hermetically sealed boxes and subsequently examined for identification and detection of disease agents. For long-term storage, ticks were placed in 70% alcohol or frozen. Ticks were manually removed from humans and animals using tweezers. The SEO-IMAGLAB optoelectronic system was used to identify ticks. Acaricides against ticks of the species *Ixodes ricinus* and *Dermacentor reticulatus* were used as № 1, № 2 and № 3 based on antibiotics of natural origin, ivermectin and alphacipermethrin with piperonyl butoxide, respectively, at a working concentration of 1.0% to 5.0%.

The study was conducted in two stages.

The first stage was doing in the laboratory for the study of ticks and tick-borne infections of the Ternopil National Medical University. At this stage, the acaricidal effect of the Drug № 1, the active ingredient of which is a complex of natural avermectins A1, A2, B1 and B2 (0.01%) isolated from the soil streptomycete *Streptomyces avermitilis*, Drug №2 – 1 ml of which contains the active ingredient ivermectin – 10 mg, filler – up to 1 ml and Drug № 3 – 1 ml of which contains alphacipermethrin – 90 mg and piperonyl butoxide – 118 mg. For this purpose, 4 groups of ticks were formed (3 experimental and 1 control, n=10 each). Ticks were placed on Petri dishes. Ticks of experimental groups 1, 2, and 3 were disinfested with 5.0 % aqueous solutions of drugs №1, №2, and №3, respectively. Ticks of the control group were sprayed with water.

At the second stage, the optimal working concentration of the drug that showed the best acaricidal effect was determined. To accomplish this task, five groups of ticks were formed (4 experimental and 1 control from the first stage, n=10 in each). Each group of ticks was placed on a white cloth with a size of 50-50 cm^2. Ticks were disinfested with an aqueous solution of Preparation №3 in the following concentrations: experimental 1 – 2.0%; experimental 2 – 3.0%; experimental 3 – 4.0%; experimental 4 – 5.0%. Ticks of the control group were sprayed with water. The air temperature outside was 18-19.0^{0}C. The temperature of the working solution was 17.0^{0}C.

Water and acaricidal agents were applied using a spray bottle.

To determine the effectiveness of the drugs, the time during which changes in tick behavior occurred was noted. Observations were stopped when the experimental ticks stopped moving. After that, the ticks were placed under a stereomicroscope, where they were tested for mobility by irritation with dissecting needles.

Each drug used in the study has a registration certificate. Drug №1 – registration certificate № B 039554 dated 31.12.2014, drug №2 – registration certificate № – AV-09506-01-21 dated 08.10.2021, drug №3 – registration certificate № AV-00005-03-14 dated 15.07.2019.

Research results and their discussion.

In the practice of controlling Ixodes ticks, drugs of chemical and biological origin are used in the form of concentrated sprays, essential oils or liquids for oral use by the hosts on which the ticks feed.

Fluazuron, registered in Switzerland (Acatak, Novartis, Basel, Switzerland), with LD 50 and LD 95 of 19.5

Table 1 – Acaricidal effect of drugs of natural and chemical origin on ticks in laboratory conditions, n=10

№	Group	Drug concentration, %	Exposure time, min	Ticks died, pcs.	Ticks death, %
1	Experimental 1	5	15	0	0
2	Experimental 2	5	12	2	20
3	Experimental 3	5	10	10	100
4	Control (Water)	water	10	0	0

mg/kg and 100 mg/kg, was first used as a drug to control Ixodes ticks [3].

The best known and most widely used drug of natural origin is the chamomile extract pyrethrin, which acts on the sodium channels of nerve cell membranes, leading to paralysis and death of ticks [4].

Essential oils of some plants also have an acaricidal effect. For example, lemongrass essential oil (*Cymbopogon citratus Stapf*), which may contain several biologically active compounds, such as citral α, citral β, netol geraniol, citronellal, terpinolene, geranyl acetate, myrcene, and terpinol methylheptenone, is highly effective. Lemongrass essential oil leads to 96 % to 100 % death of certain species of Ixodes ticks [5].

Oral drugs administered to animals per os are quite effective. For example, Fluralaner has a high effect against ectoparasites and is widely used to control ixodids on dogs and cats. Isoxalolin blocks and inhibits arthropod gamma-aminobenzoic acid and chloride channels, and is also toxic to arthropod neurons. The drug's half-life in animals is 116 days [6].

One of the most important ways to prevent infectious diseases transmitted by Ixodes ticks is to vaccinate the population that is or may temporarily be at risk. Such vaccines have already been developed and tested. For example, the LYMERix® vaccine has been registered and developed in the United States to prevent Lyme borreliosis [7, 8, 9].

One of the works that deals with the issues of controlling Ixodes ticks in Ukraine is the work of Levytska V. A [10]. As part of her research, experiments were conducted to determine the effect of four drugs: Cyfluthrin, Permethrin, Imidacloprid and Fipronil on ticks of two species I. ricinus and D. reticulatus. According to the results of the study, the first two drugs showed the best effect, namely 100% mortality of ticks within 24 hours: Cyfluthrin and Permethrin. The other two drugs caused the death of only 10-40% of ticks during 24 hours of exposure.

Treatment with acaricides should be carried out before the onset of tick activity, in the spring as soon as the snow melts. Acaricide preparations should be used in strict accordance with the instructions. Particular attention should be paid to areas along paths, dense grass, and the perimeter of recreation areas.

In the specific prevention of tick-borne infections, significant progress has been made in overcoming viral tick-borne encephalitis. In Ukraine, according to the Order of the Ministry of Health of Ukraine № 595 of September 16, 2011, vaccinations against this disease are carried out on epidemic indications. Non-immune contingents and persons who will be in the epidemic center of this infection are subject to vaccination [11].

In our research, we tested three drugs, one of which was of biological origin the other two were synthetic.

Drug № 1 is a biological product that contains antibiotics of natural origin – macrolides, sterols, phospholipids and phytohormones. It can be used as a bioinsecticide, bioacaricide and bionematicide.

Drug № 2 is a chemical product with ivermectin as its main active ingredient. Its main purpose is to combat internal parasites of pets, in particular helminths. The substance enhances the release of gamma-aminobutyric acid in presynaptic neurons.

Drug № 3 is a combined insecticidal acaricide with alphacypermethrin and piperonyl butoxide as active ingredients. This drug has a moderate toxic effect on vertebrates and invertebrates, and therefore is classified as a Class III toxicity drug. The results of acaricidal action of the drugs are presented in **table 1**.

After application of a 5.0% solution of preparation №1 at an exposure time of 15 minutes, ticks remained viable, although in some individuals their activity decreased. In our opinion, the active substances of drug № 1 did not enter the ticks' body through the ticks' covers.

Thus, antibiotics of natural origin – macrolides, sterols, phospholipids, phytohormones and a complex of natural avermectins of groups A1, A2, B1 and B2 at a concentration of 0.01% and the waste products of the soil bacterium Streptomyces avermitilis, which are components of preparation № 1 at 5.0% concentration, do not lead to the death of ticks.

After applying a 5.0% solution of preparation № 2, three *I. ricinus* ticks died within 12 minutes. The three dead ticks were placed under a stereomicroscope, and the arthropods showed mobility and responded to irritation with a dissecting needle. Thus, to achieve 100.0% tick mortality, it is necessary to increase the working concentration of the drug, which leads to an increase in the cost of working solutions.

The use of a 5.0% solution of drug № 3 on *I. ricinus* ticks in the laboratory showed that after spraying them, the lethal effect of the drug was manifested within 5 minutes. This is confirmed by the fact that the ticks placed under a stereomicroscope did not show mobility and did not respond to irritation with a dissecting needle. In laboratory conditions, a 5.0% solution of drug № 3 led to the death of all ticks within 10 minutes. Thus, the active substances alphacipermethrin and piperonyl butoxide of at 5.0% concentration are effective in killing ticks.

At the second stage, the optimal working concentration of drug № 3 was determined, at which it would have a lethal effect on ticks

Table 2 – Effect of Drug №3 in different concentrations on ticks in vivo n=10

№	Group	Drug concentration, %	Exposure time, min	Ticks died, pcs.	Ticks death, %
1	Experimental 1 (drug No. 3)	2,0	10	1	10
2	Experimental 2 (drug No. 3)	3,0	10	3	30
3	Experimental 3 (drug No. 3)	4,0	10	6	60
4	Experimental 4 (drug No. 3)	5,0	10	10	100
5	Control (Water)	water	10	0	0

in the park. The results of the study are presented in **table 2**.

From the data in **table 2**, it can be seen that under the action of a 2.0% solution of drug №3, one tick died within 10 minutes, and under the action of 3.0% and 4.0% solutions of preparation № 3, the number of dead ticks increased to three and six, respectively. Drug №3 at 5.0% concentration for 10 minutes of exposure resulted in 100.0% death of ticks in the park.

Conclusions.

1. Drug № 1 is ineffective in the control of Ixodes ticks.

2. Drug № 2 oral in a concentration of 5.0% can be used to limit the number of Ixodes ticks in parks. The time of action is 10-12.0 minutes.

3. Grug № 3 in a concentration of 5.0% can be used to limit the number of Ixodes ticks in city squares, parks, as well as in areas adjacent to livestock farms and poultry houses. The drug has a duration of action of 10.0 minutes.

4. There is a need to conduct additional research on the safety of drugs on the fauna of biocenoses, in particular on invertebrates: insects, mollusks, and arachnids.

Prospects for further research.

To test a combination of acaricidal drugs and their safe use in parks of cities and towns.

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РЕЗУЛЬТАТИ АПРОБАЦІЇ ДІЇ ІНСЕКТИЦИДІВ У БОРОТЬБІ З ІКСОДОВИМИ КЛІЩАМИ

Подобівський С. С., Ліпська В. В., Стравський С. Я., Федонюк Л. Я.

Резюме. Кліщі є носіями збудників небезпечних інфекційних захворювань, а їхні укуси можуть загрожувати людині близько 150 недугами. Боротьбі з різноманітними ектопаразитами, в тому числі і з іксодовими кліщами приурочено відносно невелика кількість публікацій\, більшість з яких опубліковані в країнах Європи і Північної Америки.

Нині на ринку акарацидних препаратів в Україні появляються нові препарати, до складу якого входять антибіотики природного походження – макроліди, стероли, фосфоліпіди та фітогормони, хімічний препарат, основною діючою речовиною якого є івермектин та комбінований інсектоакарицид, діючими речовинами якого є альфациперметрин і піперонілу бутоксид.. Однак акарицидна дія цих препаратів щодо обмеження чисельності кліщів у природних та урбанізованих біотопах залишається нез'ясованою.

Мета: визначити ефективність дії окремих інсектоакарицидів на іксодових кліщів і провести апробацію цих препаратів в умовах парку.

Досліджувані препарати випробовували на іксодових кліщах двох видів: *Ixodes ricinus* та *Dermacentor reticulatus*. Апробація препаратів здійснювалася в лабораторії та в природних умовах. Препарати, які проходили апробацію, є сертифікованими і застосовуються в боротьбі з іншими ектопаразитами та фітофагами.

Препарат на основі антибіотиків природного походження у 5,0% концентрації призводив до незначного зниження активності кліщів. Через покриви членостоногих діючі речовини цього препарату не потрапляли всередину його організму. На нашу думку цей препарат повинен потрапити спочатку в рослину, а вже потім разом із її соками до кліща.

Хімічний препарат з основною діючою речовиною івермектин у концентрації 5,0% спричинив загибель трьох самок *I. ricinus* протягом 12 хв.

Діючі речовини альфациперметрин і піперонілу бутоксид третбого препарату у 5,0% концентрації призводять до 100,0% загибелі кліщів в умовах парку протягом 10 хв.

За результатами досліджень препарат на основі антибіотиків природного походження не спричиняє летальної дії на іксодових кліщів, він неефективний у боротьбі з іксодовими кліщами. Препарати на основі івер-

мектину та альфациперметрину і піперонілу бутоксиду у концентрації 5,0% можна використовувати для обмеження чисельності іксодових кліщів у рекреаційних зонах в міських скверах, парках, сільськогосподарських угіддях, а також на територіях, прилеглих до приміщень тваринницьких ферм і пташників. Час дії препаратів близько 10,0 хвилин.

Ключові слова: акарициди, кліщі, інфекційні хвороби, парки.

RESULTS OF TESTING THE EFFECT INSECTICIDES IN THE CONTROL OF IXODID TICKS

Podobivskyi S. S., Lipska V. V., Stravskyi Y. S., Fedoniuk L. Ya.

Abstract. Ticks are carriers of dangerous infectious diseases, and their bites can threaten humans with about 150 diseases. A relatively small number of publications have been devoted to the control of various ectoparasites, including ixodes ticks, most of which have been published in Europe and North America.

Currently, new drugs are appearing on the Ukrainian market of acaricidal drugs, which include antibiotics of natural origin – macrolides, sterols, phospholipids and phytohormones, a chemical drug with ivermectin as the main active ingredient and a combined insecticidal drug with alphacipermethrin and piperonyl butoxide as active ingredients. However, the acaricidal effect of these drugs on limiting the number of ticks in natural and urbanized habitats remains unclear.

Objective: to determine the effectiveness of certain insecticidal acaricides on ixodes ticks and to test these drugs in the park.

The investigated drugs were tested on two species of ixodid ticks: *Ixodes ricinus* and *Dermacentor reticulatus*. The drugs were tested in the laboratory and in the wild. The drugs that were tested are certified and are used in the fight against other ectoparasites and phytophages.

The drugs based on antibiotics of natural origin at 5.0% concentration led to a slight decrease in tick activity. The active substances of this preparation did not get inside the arthropod's body through the arthropod's covers. In our opinion, this drug should first get into the plant, and only then, together with its juices, to the tick.

A chemical preparation with the main active ingredient ivermectin at a concentration of 5.0% caused the death of three female *I. ricinus* within 12 minutes.

The active substances alphacipermethrin and piperonyl butoxide of the third preparation at a concentration of 5.0% resulted in 100.0% death of ticks in the park within 10 minutes.

According to the results of the research, the preparation based on antibiotics of natural origin does not have a lethal effect on Ixodes ticks, it is ineffective in the control of Ixodes ticks. Preparations based on ivermectin and alphacipermethrin and piperonyl butoxide at a concentration of 5.0% can be used to limit the number of Ixodes ticks in recreational areas in city squares, parks, agricultural land, as well as in areas adjacent to livestock farms and poultry houses. The time of action is about 10.0 minutes.

Key words: acaricides, ticks, infectious diseases, parks.

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