



Prevalence of *Echinococcus granulosus* in Azerbaijan and Study of its Prevention by The mathematical Modelling Method

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EACH of 4 main objects that ensures the prevalence of the *Echinococcus granulosus* between humans and ruminants has been defined by the prevention methods of the prevalence of *Echinococcus granulosus* evaluating by the mathematical model. It has been defined that the emergence of the butchers without the direct supervision of veterinarians affects the prevalence of the *Echinococcus granulosus*. As seen in the solution of the mathematical module, when the illegal meat cutting places were removed, the infection of the stray dogs with the *Echinococcus granulosus* is reduced. As a result, the infection of the *Echinococcus granulosus* to the people and ruminants through stray dogs was ended. To eliminate the infection of the *Echinococcus granulosus*, meat cutting places should be removed and preventing the stray dogs eating the infected innards which leads to infection with the *Echinococcus granulosus*. Life cycle of *E. granulosus* should be controlled to decrease the creation of uncontrolled meat cutting places and minimising its impact over human activity.

Keywords: Stray dog, Echinococcosis, Egg, Temperature, Mathematical model.

Introduction

Echinococcus granulosus (Batsch, 1786) is the reproductive of the *Echinococcosis* affects economically the cattle-breeding spreading among the ruminants around the republic. *E. granulosus* affects significantly the health of the people and animals in both larvae and adult stages.

In the larvae stage, echinococcosis causes decrease in the productivity (meat, milk, wool and fertility) of the ruminants over all the rates and to worsen the quality of their meat [1]. The disease also damages human's health locating in the visceral organs (mainly in liver, partially in lungs and rarely in other organs) during the adult stage. It is possible to save from Echinococcosis only with serious operation [2].

Although the disease causes serious damages

in cattle-breeding and in the human health, it is often noted that the *Echinococcus granulosus* species among the ruminants and humans remains a problem in our republic.

There is little information about the spread of the Echinococcosis in Azerbaijan [3, 4, 5, 6,7]; however this information is not satisfactory for defining the causes for the spread of echinococcosis, studying the effect of some risk factors and prevention of the disease.

Materials and Methods

During the study of the helminth fauna of the carnivores in Azerbaijan, 924 stray dogs were studied that has an effective role in the spread of this dangerous helminth echinococcosis.

Cestodes founded in the study were fixed in

70% alcohol. MBI-6 and 20 x 40 sized Olympus microscopes were used.

Results and Discussion

In the studies of some districts of Azerbaijan, it has been found that (during the period 2001-2017) *E.granulosus* spread among the stray dogs between 17,7% to 28,8%. Infection rate of the stray dogs in Shamakhi district was 29,8%, in Ismayilli was 17,7%, in Aghsu was 12,7%, in Baku and it's surroundings was 28,8%, in Sumgayit was 17,7%, in Mehdiabad was 23,2%, in Khizi was 19,4%, in Shabran was 26,3%, in Khachmaz was 17,7%, in Khudat was 17,7%, in Siyazan was 23,2%, in Nabran was 9,7%, in Yalama was 11,2%, in Bilasuvar was 24,2%, in Shaki was 27,8%, in Zagatala was 18,3%, in Oghuz was 23,7%, in Ganja was 13,2%, in Neftchala was 25,0%, in Balakan was 11,9%, in Lankaran was 27,8%, in Astara was 17,9%, in Jalilabad was 23,2% and in Yardimli was 12,7% (Diagram 1).

Diagram 1 shows the infection of the stray dogs with *E.granulosus* is different in various districts.

The main reason of their prevalence of the echinococcosis in the nature, among people and ruminants is the social factor. Thus, individual and agricultural farms were built as a result of the social-economical changes occurred in our country[8]. The visceral organs of the most cut-off animals were infected with echinococcosis and these organs were thrown to the environment

without defusing them. Then the stray dogs fed on these infected organs and they got infected with the larvae stage of echinococcosis. Those cases mostly happen during the meat-cutting in the individual farms without veterinary control.

Four main factors affect the prevalence of echinococcosis among people and ruminant in the environment: stray dogs (final host), ruminants (intermediate host), defused echinococcus eggs and uncontrolled meat-cutting places.

Making the dynamic mathematical model expressing the interdependence of these factors and the results of the decrease-increase of its variables could help to define the sequence of events in order to prevent the prevalence of echinococcus in the environment.

Some mathematical models were created and applied in the foreign countries expressing the prevalence dynamics of echinococcus among the wild animals [9, 10].

During this study, we got the following mathematical model regarding the effect of all significant factors that in the prevalence of echinococcus among people and domestic animals.

Mathematical model

The flowchart was described in Fig. 1. expressing the interrelation of the parameters and variables of the model.

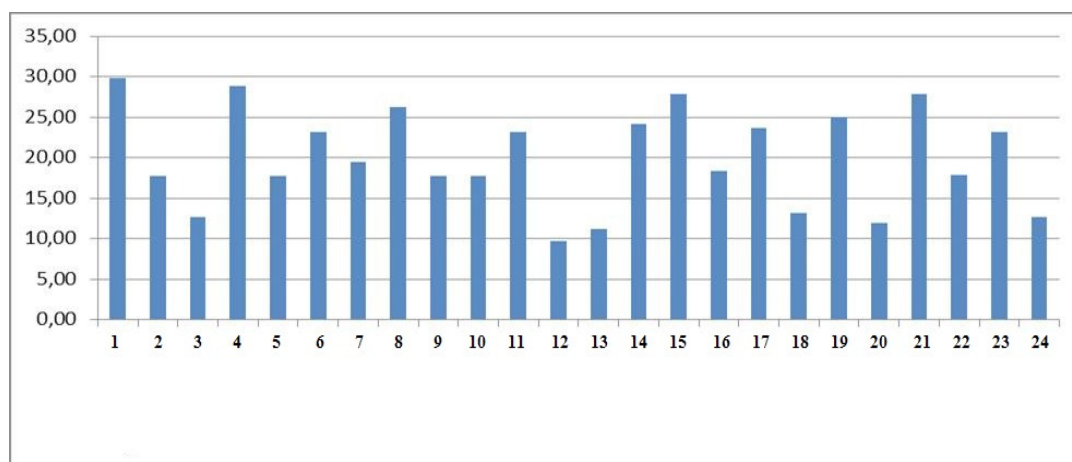


Diagram 1. The infection of the stray dogs with *E.granulosus* over the districts (%)

1- Shamaxi; 2- Ismailli; 3- Aghsu; 4- Baku and it's surroundings; 5- Sumgayit; 6- Mehdiabad; 7-Khizi; 8-Shabran; 9-Khachmaz; 10- Khudat; 11- Siyazan; 12-Nabran; 13-Yalama; 14- Bilasuvar; 15- Shaki; 16- Zagatala; 17-Oghuz; 18- Ganja; 19- Neftchala; 20- Balakan; 21- Lankaran; 22- Astara; 23- Jalilabad; 24- Yardimli.

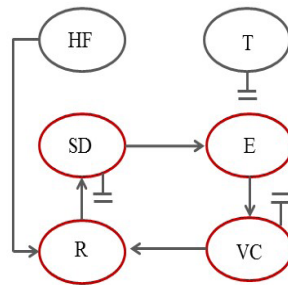


Fig. 1. *HF* –human factor and *T*- weather temperature are model parameters, *SD* - stray dogs, *E* -egg, *R* -ruminants , *VC* -veterinary control are variables.

General form of mathematical model is following:

$$\frac{dy_1}{dt} = F(y_1, y_4)$$

$$\frac{dy_2}{dt} = F(y_1, y_2, y_3, p_1)$$

$$\frac{dy_3}{dt} = F(y_2, y_3, p_2)$$

$$\frac{dy_4}{dt} = F(y_1, y_4, p_2)$$

Here y_i ($i=1\div 4$) –is the model variables: y_1 - number of the infected stray dogs, y_2 - numbers of eggs, y_3 - numbers of ruminants, veterinary control. $\frac{dy_i}{dt}$ ($i = 1 \div 4$) – speed of the relevant variables; p_i ($i=1\div 2$) –model parameters; p_1 – temperature factor, p_2 – human factor.

The comparison obtained from the studies of Ibrahimova has indicated that mathematical model is adequate with biological process for its quality [11].

In order to increase the effectiveness of the studies made according to the mathematical model and to ease the overview of the gained results, we composed the special program with help of DELPHI-7 redactor and realized the solution of the system of differential equations

with the method of 4th composition of Runge-Kutta. Model period is 1 day [12].

We realized some experiments on the model to investigate the prevalence dynamics of echinococcus:

The starting conditions of variables:

time ($T=0$);

number of final host ($Y1=100$);

number of intermediate host ($Y2=0$);

number of shed eggs ($Y3=0$);

number of veterinary control ($Y4=0$).

Without any intervention, so $P1=0$, $P2=0$.

Model solution (Fig. 2).

As shown in Fig. 2, when the infected visceral organs were thrown to the environment without veterinary control in the illegal meat cutting places, the infection of the stray dogs increase, as a result the contamination of the environment proliferates by the stray dogs with echinococcus eggs. As a result, the infection of the intermediate hosts (ruminants) with echinococcus eggs from the environment with grass or water.

In order to prevent the infection of echinococcus, each of these parameters were evaluated separately and the obtained results were studied by us:

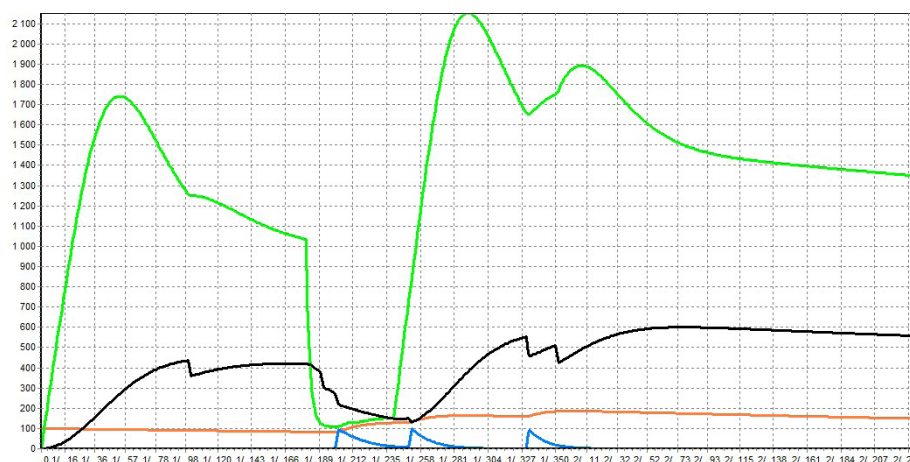


Fig. 2. — **Stray dogs;**
 — **Scattered eggs;**
 — **Ruminants;**
 — **Slaughter places;**

Stray dogs

Stray dogs take an essential role in the infection with echinococcus, circulation of echinococcosis in nature among people and ruminants. Infected dogs infect people and ruminants by excreting the echinococcus eggs to the environment. When the number of the stray dogs is minimized, thousands of the scattered echinococcus eggs that have infection ability in environment for long time cause to infect the ruminants with echinococcosis. Necessary results were not gained by this method.

Echinococcus eggs scattered to the environment

Echinococcus eggs scattered to the environment is one of the main factors that pave the way to the infection with echinococcus. Even if the temperature of the scattered eggs is 0C° degree in the external environment, they are able to infect the ruminants keeping their living ability to 110 days.

However, in summer the echinococcus eggs are destroyed in 40–45°C and under the hot sun beam. Therefore, the infection with echinococcosis doesn't happen in this season (July, August) or happen very rarely. In the following seasons, the ruminants infected with echinococcus eggs that are scattered to the environment by stray dogs. So, the impact of temperature does not take an important role in the prevention of the contamination.

Meat cutting places

However, reducing the meat cutting places without veterinary control to 0 gives a good result. In this case, the infection with echinococcus reduces to 0% totally in 1-2 years. As shown in Fig. 3, when the effect of human factor reduces to 0%, the number of the infected dogs and the number of eggs scattered to the environment by them decreased and as a result the contamination of ruminants with *E.granulosus* comes to 0%.

Desirable result was obtained. We saw the possibility of the prevention of the contamination of the stray dogs when the illegal meat cutting places were cancelled (Fig. 3).

Contamination of the stray dogs with *E.granulosus* when the meat cutting places were cancelled

The contamination of the stray dogs with echinococcus should not be allowed in any case. For this, the illegal meat cutting places without veterinary control should be cancelled, and the animals that were cut should be controlled for echinococcus [13].

The measures for the contamination with *E.granulosus* should be directed to decrease the creation of meat cutting places without veterinary control and to minimize the effect of the human activity.

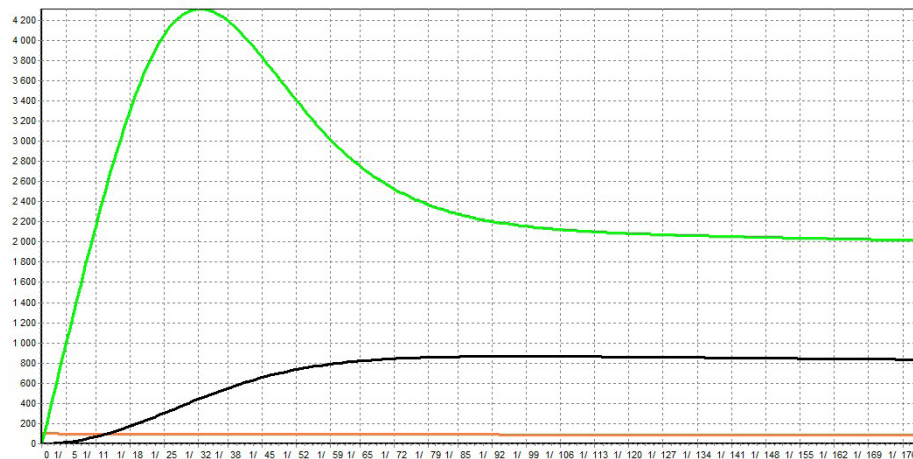


Fig. 3.
— **Stray dogs;**
— **Scattered eggs;**
— **Ruminants;**

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Conflict of interest

The authors have declared that no conflict of interest exists.

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