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ФАУНА ЛЕГОЧНЫХ ГЕЛЬМИНТОВ В ОРГАНИЗМЕ ХОЗЯИНА, ЕЕ БИОЛОГИЧЕСКАЯ И ТАКСОНОМИЧЕСКАЯ КЛАССИФИКАЦИЯ

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Реферат

Цель исследования: Провести изучение различных групп легочных гельминтов; разработать биологическую и таксономическую классификацию данного вида гельминтов.

Материалы и методы: Проведены исследования 16 видов гельминтов семейств Cervidae, Bovidae, Leporidae, а также легочных гельминтов человека на территории России (Юг и центральные районы), Армении, Болгарии, Польши. Обнаруженные гельминты были изучены с использованием традиционных и новых методов гельминтологического исследования.

Результаты и обсуждение: В легких у исследованных млекопитающих, найдено 23 вида гельминтов, включая 1 Taeniidae (Echinococcus granulosus), 4 Dictyocaulidae и 18 Protostrongylidae. Мы разделили все эти легочные гельминты на три биологические группы.

В первую группу (геогельминты) вошли нематоды семейства Dictyocaulidae. Жизненный цикл данного вида гельминтов моноксенический, осуществляется прямым путём, без промежуточных хозяев

Вторая группа (биогельминты) включала в себя гельминты семейства Protostrongylidae. Характерным признаком является участие в их биологическом цикле промежуточных хозяев — наземных моллюсков.

К третьей группе были отнесены возбудители довольно опасного зооноза — *Echinococcus granulosis* larvae. Эти цестоды развиваются со сменой хозяев, но их промежуточными хозяевами являются позвоночные млекопитающие, имеющие окончательных хозяев — также позвоночных, в основном, плотоядных животных.

Нами также предложена таксономическая классификация семейства Protostrongylidae haelminths.

Ключевые слова: биологическое разнообразие, легочные гельминты, окончательные хозяева, промежуточные хозяева, географическое распределение, зоонозы.

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HOST-BASED FORMATION OF FAUNA OF LUNG HELMINTHS, ITS BIOLOGICAL AND TAXONOMIC CLASSIFICATION

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Abstract:

Object of study: Studies of lung helminths from various groups were performed. Elaboration of biological and taxonomic classification of these species has been proposed.

Materials and methods: 16 species from families Cervidae, Bovidae, Leporidae and humans were studied for lung helminths in Russia (South and central), Armenia, Bulgaria, Poland. The helminths found were studied using a scope of traditional and elaborated helminthological methods.

Results and discussion: In lungs of mammals studied 23 helminth species have been found including 1 of Taeniidae (*Echinococcus granulosus*), 4 of Dictyocaulidae and 18 of Protostrongylidae.

We have divided species composition of these lung helminths into three biological groups.

The first biological group included nematodes from Dictyocaulidae family. Life cycles of those helminths are monoxenous (they are geohelminths). The second group includes helminths from family Protostrongylidae. Their life cycles include intermediate hosts — land snails and so they are dixenous (biohelminths). The third group includes an agent of a quite dangerous zoonosis — *Echinococcus granulosis* larvae. These cestodes also develop per dixenous type, but their intermediate hosts are vertebrates with definitive hosts also vertebrate, mostly carnivores.

Taxonomic classification for family Protostrongylidae haelminths is also proposed.

Keywords: biological diversity, lung helminths, definitive hosts, intermediate hosts, geographical distributions, zoonoses.

Introduction

The results of our studies on biological diversity of animal (and human) lung helminths had been partially published in articles presenting some fragments on biological diversity of lung helminths and helminthoses. E.g., the article (Movsesyan et al., 2014) gives data on a character of sheep infections with Protostrongylidae in Armenia depending on natural landscape zones, results of these studies has also been presented at BIT's 5th Annual World Congress of Microbes — 2015 (Shanghai, China) and published as abstract in the Congress' Proceedings (Movsesyan, 2015).

It had been established that protostrongylosis, mulleriosis, cystocaulosis are widely distributed in Armenia and are registered at all natural landscape zones in animals of all ages. In 20-25% of cases protostrongyloidoses cause associated lung infections (Movsesyan et al., 2009).

Material on biological development cycles of Protostrongylidae had been presented in works (Movsesyan et al., 2010; Panayotova-Pencheva, Movsesyan, 2012) which show many land mollusk species serving as intermediate hosts for these nematodes.

Development cycles, distribution and epizootology of animal Protostrongylidae were given in the article by Panayotova-Pencheva et al. (2012). It shows part various vertebrate and invertebrate species play as definitive and intermediate hosts, respectively.

Here we publish the full results of our studies of biodiversity of lung helminths of animals and humans for the first time.

Material and methods

Helminthological material has been obtained from mammals of families Bovidae, Cervidae, Leporidae at Armenia, Bulgaria, Poland and southern regions of Russia (Fig. 1).

Methods

The helminthological material obtained was taken through cameral processing to establish species identity.

The methods used are given below in short and may be found in more detail in the monograph *Diagnosis of Parasitical diseases* (2004) edited by S.O. Movsesyan.

Intravital diagnostics of lung nematodes was performed using methods of Weid, Berman, Boyakhchyan, Kotelnikov, Korchagin, Khrenov. For postmortem diagnostics we used methods of partial dissection of organs in question per Skrjabin to obtain helminths from lungs, liver, kidneys and other organs.

Basics of these methods are given below:

Method of Weid — several fresh (no more than 6 hours) faecal pellets were placed into a Petri dish or clock glass, water was added, and after 5-10 minutes the pellets were taken from the dish while the liquid left placed under microscope to search for lung nematode larvae.

Method of Berman — used a cone with thin end up to 15 cm, on which rubber tube up to 20 cm was put. A thin test tube was placed into its free end. Fresh faeces (no more than 6-7 hr, 19-20 g) were put on wire sieve or gauze and placed into the cones with warm — up to 40 °C — water. After an hour long exposition the test tube was taken from the rubber tube, liquid poured out to the sediment's level, sediment was shaken then taken to a slide and studied under microscope for nematode larvae.

Method of Kotelnikov, Korchagin and Khrenov — animal faeces were placed into centrifugal tubes, filled with water at 25-26 °C and centrifuged at 1000-1500 rotations/minute for 2 min. After that faeces were taken from tubes using pincers, water poured out to sediment level and sediment shaken then taken to slides and studied under microscope.

Method of partial helminthological dissection per Skryabin — to obtain nematodes from lungs the latter were torn into small fragments and placed into a container with water. After 10-15 minutes lung fragments were rinsed and then discarded while water kept until sedimentation. The sediment was then studied under microscope for nematode larvae. The larvae found were placed into 3% formaldehyde solution for subsequent cameral processing.

Method of boiling abnormal lung tissue in lactic acid (Panayotova-Pencheva, 2011) — This method was used to find small, hardly visible worms located in the bronchioli and alveoli. The abnormal lung tissues were examined as follows: 1-2 cm^3 fragments from the lung lesions were taken and boiled in 40 percent lactic acid in a water bath at 100 °C for 1.5 hour. After that small (2-3 mm) pieces were compressed between slides and observed under a light microscope at magnification of 63, 160 and 400× to visualize sexual structures such as the spicules and gubernaculum.

Method of Boyakhchyan (Boyakhchyan, 2007) — faeces were taken from animals individually (3-4 balls), placed into small (20-30 cm^3) glass or plastic flagons, filled with water and closed. The flagons with probes were exposed so for 3 hours without shaking. During this time lung nematodes' larvae exited into water from faeces. To conserve the larvae liquid from the flagon was moved into a similar one containing 5-10 ml of 10% formaldehyde and faeces discarded. The flagons were tightly closed. In such manner they may be retained for a long time. So they were taken to a laboratory for microscopic studies.

Echinococcus larvae could be easily found during dissection of infected organs (lungs, liver, etc.) through presence of vesicles — cysts of *Echinococcus*.

To find out species composition of Protostrongylidae obtained, monograph of S.N. Boev (1975) was used. Larval forms of *Echinococcus* were established according to K.I. Abuladze (1964).

For mollusk species composition fundamental monographs (Akramovsky, 1976; Likharev, Rammelmeier, 1952; Damianov S.G., Likharev I.M., 1975; Sysoev, Schileiko, 2009) were used.

Table 1

A list of definitive host species of lung nematodes

Animal species	Russia	Armenia	Bulgaria	Poland	Nematode species
Order Artiodactyla Suborder Ruminantia Family Cervidae					
Dama dama	+	-	+	+	Varestrongylus sagittatus; D. filaria; D. viviparus; D eckerti
Cervus nippon	+	-	-	-	*E. cervi*; *V. sagittatus*; *D. filaria*; *D. viviparus*; *M. capillaris*
C. elaphus	+	-	+	+	*V. sagittatus; E. cervi*; *Dictyocaulus eckerti*; *D. filaria*; *D. viviparus*
C. elaphus sibiricus	+	-	-	-	Varestrongylus capreoli; V. sagittatus; E. cervi
Capreolus capreolus	+	-	-	+	Varestrongylus capreoli; Muellerius capillaris; Dictyocaulus capreolus; D. viviparus
Alces alces	+	-	-	+	*E. cervi; E. alcis,* *V. capreoli; Muellerius capillaris; D. capreolus; D. filaria; D. viviparus*
Fam. Bovidae					
Bison bonasus	-	-	-	+	Dictyocaulus viviparus
Bos taurus	+	+	-	+	Dictyocaulus viviparus
Rupicapra rupicapra	+	-	+	-	P. hobmaieri; P. rupicaprae; M. capillaris; M. tenuispiculatus; N. linearis
Capra aegagrus	+	+	-	-	P. muraschkinzewi; P. rufescens; M. capillaris; C. ocreatus
Ovis ammon	+	+	-	-	*P. davtiani; P. hobmaieri; P. raillieti; C. ocreatus*
Ovis musimon / Mouflon musimon	-	-	+	+	P. davtiani; P. hobmaieri; P. raillieti; P. rufescens; M. capillaris; V. capreoli
Ovis ophion armeniana	-	+	-	-	*P. davtiani; P. muraschkinzewi; C. ocreatus*
Ovis aries / Ovis amm on. dom.	+	+	+	+	M. capillaris; C. ocreatus; N. linearis; P. brevispiculum; P. rufescens; P. hobmaieri; D. filaria
Capra hircus	+	+	+	+	*M. capillaris; N. linearis; P. rufescens; P. hobmaieri;* *D. filaria*
Order Lagomorpha Family Leporidae					
Lepus europeus	+	-	+	-	
Total animal species 16	13	6	7	9	

Our analysis of character of lung helminths life cycles was based on concept proposed by Leickart at 1879 (cited through Petrochenko (1967)) that helminths may develop in more than one host. This concept provided basis for intensive studies of helminths' life cycles. As a result, the following concepts had been formulated for helminths' life cycles:

Monoxenous, dixenous and polyxenous types of development — terms were based on a Greek word *'xenos'* — i.e. host.

Later K.I. Skrjabin and R.S. Schultz (1940) proposed a new classification of character of life cycles of helminth development dividing them into categories of geohelminths development of which takes place without intermediate hosts and biohelminths where intermediate hosts do take part.

Results and Discussion

Species composition of Protostrongylidae-infected animals can be seen from Table 1 showing that totally 16 animal species were tested, with 13 in Russia, 7 in Bulgaria, 9 in Poland and 6 in Armenia. Ruminants from Bovidae and Cervidae families were mostly mixed infected (with several of the nematode species at the same time). This fact shows a broad receptivity of ruminants to Protostrongylidae. At the same time, regimen of maintenance and nutrition — grazing, watering, contacts with infection foci at natural conditions — also contribute to these animals infection. As for other studied mammals — from family Leporidae — they were found infected with only a single helminth species: *Protostrongylus tauricus*.

According to literature data, the following lung helminth species had been found in wild ungulates by Fertikov et al. (1999):

in *Alces alces* — *Dictyocaulus filaria*, *D. viviparus*, *Muellerius capillaris*, *Elaphostrongylus cervi*, *E. alcis*, *Varestrongylus capreoli*;

in *Cervus dama* — *D. filaria*, *D. viviparus*, *Varestrongylus saggittatus*;

in *Cervus nippon* — *D. filaria*, *D. viviparus*, *E. cervi*, *V. saggittatus*;

in *Capreolus capreolus* — *D. viviparus*, *Muellerius capillaris*, *Varestrongylus capreoli*;

in *Cervus elaphus* — *D. viviparus*, *E. cervi*, *V. capreoli*, *V. saggittatus*.

Samojlovaskaya (2010) had found the following species of lung nematodes in wild ungulates:

in *Alces alces* — *D. filaria*, *V. capreoli*;

in *Cervus nippon* — *D. filaria*, *M. capillaris*.

In addition to Protostrongylidae we had also found 4 nematode species from family Dictyocaulidae (*Dictyocaulus filaria*, *D. viviparus*, *D. eckerti*, *D. capreolus*) and one Taeniidae cestode species (*Echinococcus granulosus*).

According to their life cycles, helminth species found were divided into three biological groups (Movsesyan et al., 2014) (Fig. 2 (a, b, c)):

Geohelminths (monoxenous) — Dictyocaulidae;

Biohelminths (dixenous) with invertebrate intermediate hosts — Protostrongylidae;

Biohelminths (dixenous) with vertebrate intermediate hosts — Taeniidae.

I Biological group:

Monoxenous life cycles were characteristic of nematodes from family Dictyocaulidae я(Fig. 3), including *Dictyocaulus filaria* from lungs of small ruminants (sheep, goats, moufflon, Bezoar goat), *D. viviparus* from lungs of cattle and *D. eckerty* from Red deer and Fallow deer.

There were 4 *Dictyocaulus* species found in Poland: *D. viviparus* from cattle and European bison, *D. filaria* from sheep, *D. eckerty* from Red deer, and *D. capreolus* from elk and Roe deer (Demiaszkiewicz et al., 2009 a; Demiaszkiewicz et al., 2009 b; Pyziel et al., 2015).

In Bulgaria, *D. eckerti* was found in Red deer *Cervus elaphus* and Fallow deer *Dama dama* (Panayotova-Pencheva, 2012).

For sheep of Armenia, dictyocaulosis is distributed throughout all 5 ecological zones studied. Also, the highest infection rate (60%) with *D. filaria* has been found in lambs at subalpine meadows and the lowest — in lambs from dry Subtropics (Fig. 4).

II Biological group:

The second biological group of lung helminths are those development cycles of which pass through invertebrates, specifically land mollusks. Such are Protostrongylidae nematodes. The main diagnostic criteria of their morphology are shown at fig. 5 a, b.

In regions studied we have found 18 Protostrongylidae species, including 18 in Russia, 11 in Bulgaria, 10 in Poland and 7 in Armenia. The species common for all region was *Muellerius capillaris*. A list of species is given in Table 2.

Table 2

A list of Nematoda species studied

Species	Russia*	Armenia	Bulgaria	Poland
Dictyocaulidae				
Dictyocaulus filaria (Rudolphi, 1809)	+	+	+	-
D. viviparus (Bloch, 1782)	+	+	-	-
D. capreolus Gibbons, Höglund, 2002	+	-	-	+
D. eckerti Skrjabin	-	-	+	+
Total Dictyocaulidae 4 species	3	2	2	2
Protostrongylidae (Leiper, 1926) Boev et Schulz, 1950				
Cystocaulus nigrescens (Jerke, 1911) Gebauer, 1932	+	+	-	-
C. ocreatus (Railliet et Henry, 1907) Mikačič, 1939	+	-	+	+
Elaphostrongylus aleis Sten 1990	+	-	-	+
E. cervi Cameron, 1931	+	-	+	+
Muellerius capillaris (Mueller, 1889) Cameron, 1927	+	+	+	+
M. tenuispiculatus Gebauer, 1932	+	-	+	+
Neostrongylus linearis (Marotel, 1913) Gebauer, 1932	+	-	+	+
Protostrongylus brevispiculatum Mikačič, 1940	+	-	+	-
P. davtiani (Savina, 1940) Davtian, 1949	+	+	-	+
P. hobmaieri (Schulz, Orlow et Kutass, 1933) Cameron, 1934	+	+	+	+
P. kochi (Schulz, Orloff et Kutass, 1933)	+	+	-	-
P. muraschkinzewi (Davtian, 1940) Dougherty, 1951	+	+	-	-
P. raillieti (Schulz, Orlow et Kutass, 1933) Cameron, 1934	+	+	-	+
P. rufescens (Leuckart, 1865 Kamensky, 1905	+	-	+	+
P. rupicaprae Gebauer, 1932	+	-	+	+
P. tauricus Schulz et Kadenazii, 1949	+	-	+	-
Varestrongylus capreoli (Stroh et Schmid, 1938)	+	-	-	+
V. sagittatus (Mueller, 1890) Dougherty, 1945	+	-	+	+
Total Protostrongylidae 18 species	18	7	11	13

*Russia — here means south and central regions

Currently world fauna of Protostrongylidae includes about 60 species of 6 subfamilies and 12 genera. Their systematics are given at fig. 6.

According to Gadaev (2015) the following Protostrogylidae species were dominant in wild animals of Chechen Republic of Russian Federation:

in *Capreolus capreolus* — *P. davtiani*, *P. skrjabini*, *P. hobmaieri*, *M. capillaris*;
in *Capra cylindricornis* — *P. kochi*, *P. hobmaieri*, *M. capillaris*, *C. nigrescens*;
in *Capra aegagrus* — *M. capillaris*, *P. davtiani*;
in *Rupicapra rupicapra* — *M. capillaris*.

Taking into account all the regions, the Protostrongylidae species most widely distributed were: *Muellerius capillaris*, *Cystocaulus nigrescens*, *Protostrongylus muraschkinzewi*, *P. hobmaeri*, *P. kochi*, *P. davtiani*. Some pictures of widely distributed lung helminths are presented on fig. 7.

As for intermediate hosts of Protostrongylidae, 77 species were found. 50 of them were present in Russia, 39 in Armenia, 20 in Bulgaria, 12 in Poland. Studies in Armenia conditions have shown that there are 9 most commonly infected mollusk species (Fig. 8), with *Helicella derbentina*, *Napaeopsis hohenackeri* playing the greatest part.

These mollusks in conditions of Armenia high- and lowlands were infected with Protostrongylidae larvae (Fig. 9) at 3,0-13,0% at spring and 17,2-22,2% at summer-autumn period.

In Bulgaria natural infection of mollusks with protostrongylids was studied in Veliko Tarnovo region. It was found that 3 species were infected. These were *Helicella obvia*, *Monacha cartusiana* and *Bradybaena fruticum*. Season dynamics of the infection intensity and prevalence of protostrongylid larvae in the snails were investigated. The prevalence was highest during summer — between 30% and 35%, comparatively high at spring — 24% and lowest at autumn — 8.6%. Similar dynamics have been observed for parasite load but in this case a peak month was August after which it smoothly decreased (Panayotova-Pencheva, 2005).

There are 12 species of land mollusks in Poland which are Protostronhylidae intermediate hosts: *Arion subfuscus*, *Bradydaena fruticum*, *Cepaea nemoralis*, *C. vindobonensis*, *Helicella obvia*, *Helix pomatia*, *Helicigona arbustorum*, *Perforatella bidens*, *Succinea putris*, *Zonitoides nitidus*, *S. oblonga*, *Trocholus hispidus* (Movsesyan et al., 2010).

A scheme of Protostrongylidae life cycle is given at Fig. 10.

Dynamics of infection of sheep and goats from various age groups and ecological zones in Armenia with *Protostrongylus* are shown as graphs (Fig. 11 a, b) demonstrating the infection appearing in all climate zones but with highest occurrence at mountain meadow-steppes and mountain steppes.

Studies of three sheep age groups (lambs, young, adult) at four natural landscape zones (dry Subtropics, semi-deserts, mountain steppes and mountain meadow-steppes) have shown that the highest rate of infection with *Muellerius* and *Protostrongylus* (about 35%) can be seen in adults at mountain steppes and mountain meadow-steppes. At the same zones infection with *Cystocaulus* reached more than 45%.

III Biological group:

The third group of lung helminths, with development cycle using vertebrate intermediate hosts (also dixenous type) includes a causative agent of a dangerous zoonosis *Echinococcus granulosus* (Batsch, 1786) Rudolphi, 1801 (Fig. 12). Its definitive hosts are many vertebrate species, especially carnivores. A scheme of its life cycle is shown at fig. 13.

A wide distribution of larval echinococcosis in Armenia according to H. Gevorgian (2006) is given in Table 3.

Table 3

Distribution of larval echinococcosis in Armenia. Comparative data on infection level of animals at butcheries

Animals	Studied	Infected	Infection level, %
Cattle	1872	913	49±1,16 p<0,001
Sheep and goats	562	125	22±1,75 p<0,001
Pigs	726	107	15±1,32 p<0,001
Total	3160	1145	

So, degree of infection of cattle with this disease reaches almost 50% (Fig. 14 — affected animal organs) with 22% infection rate of sheep and goats and 15% of swine.

Studies of human population in Armenia have shown the infection in all age groups with the highest degree in people of 30-35 age. *Echinococcus* cysts were found in all organs (fig. 15), but lungs and liver were most commonly infected (42-43%; Fig. 16).

Conclusion.

Helminth material was collected from wild and domesticated mammals from Russia South and central regions, Armenia, Bulgaria, Poland. At all 16 animal species were studied, including domestic sheep and goats, and also 13 species of wild mammals from families Cervidae, Bovidae, Leporidae. Numbers of species studied from Russia — 15, from Armenia — 6, from Bulgaria — 7, from Poland — 9.

In these animal species, 23 lung helminth species were found, from families Dictyocaulidae, Protostrongylidae, Taeniidae.

Numbers of lung helminth species per region were as follows: South and central Russia — 18, Armenia — 7, Bulgaria — 14, Poland — 10. The following species were found to be common for all regions studied: *Echinococcus granulosus*, *Dictyocaulus filaria*, *D. viviparus*, *Muellerius capillaris*. Based on the analysis of life cycles, the biological classification of lung helminths into three types has been proposed:

1 — Monoxenous, or geohelminths — direct type of development. This biological type includes life cycle of fam. Dictyocaulidae nematodes.

2 — Dixenous, or biohelminths, development of which includes invertebrates as intermediate hosts — mainly land mollusks of 77 species. 50 mollusk species take part in life cycles of these helminths in Russia, 39 — in Armenia, 20 — in Bulgaria, 12 — in Poland. The species most commonly infected with nematode larvae were *Helicella derbentina*, *Napaeopsis hohenackeri*, *Monacha cartusiana*, *Bradybaena fruticum*. This type includes life cycle of fam. Protostrongylidae nematodes.

3 — Also dixenous, but using vertebrates as intermediate hosts. This includes life cycle of cestode *Echinococcus granulosus*.

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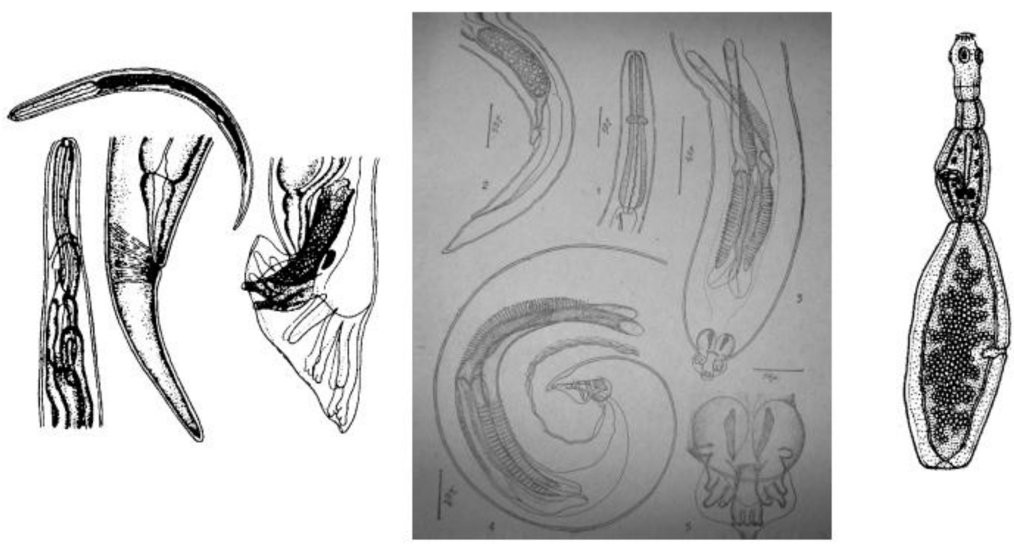
Fig. 1. Map of regions studied (Russia south, Armenia, Bulgaria, Poland).



a b c

Fig. 2. Helminths of different types of life cycles:
a — Dictyocaulidae — geohelminths, monoxenous type;
b — Protostrogylidae — biohelminths, or dixenous type with invertebrate intermediate hosts;
c — Taeniidae (*Echinococcus*) — dixenous type with vertebrate intermediate hosts.

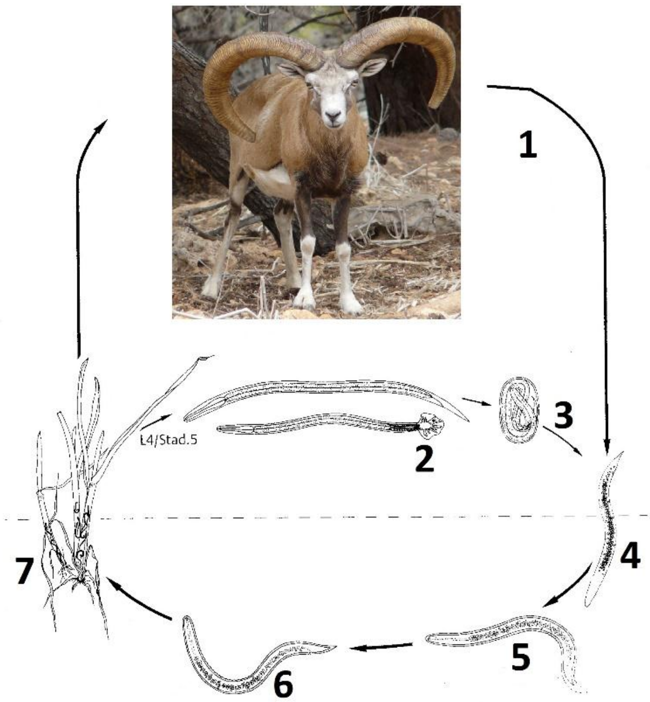


Fig. 3. A scheme of life cycle of Dictyocaulidae nematodes — geohelminths, i.e., no intermediate hosts by Eckert, 2001, modified by Movsesyan: 1 — host (moufflon); 2 — *Dictyocaulus* adult male and female; 3 — egg with larva; 4; 5; 6 — larvae of different stages; 7 — grass.

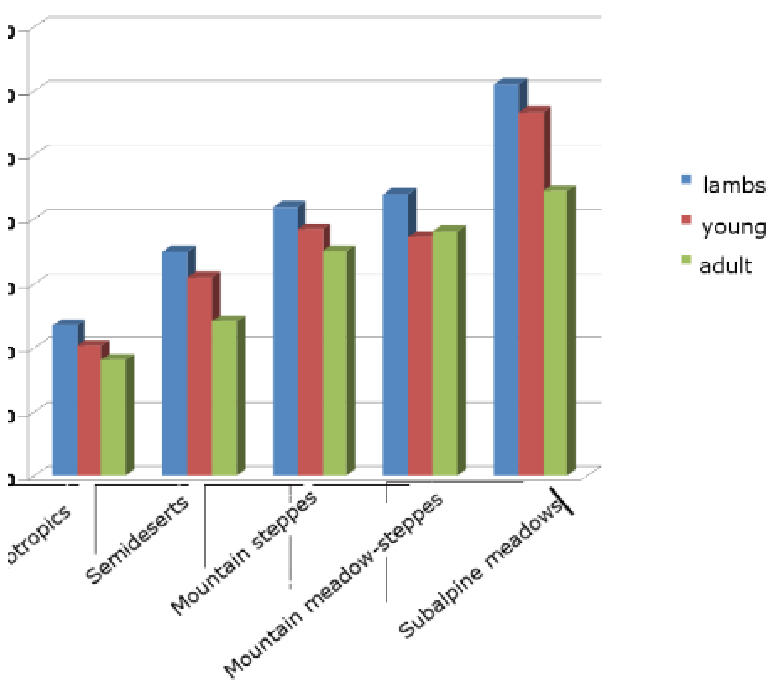


Fig. 4. Distribution of dictyocaulosis (caused by *D. filaria*) in various age groups of sheep in various landscape zones of Armenia.

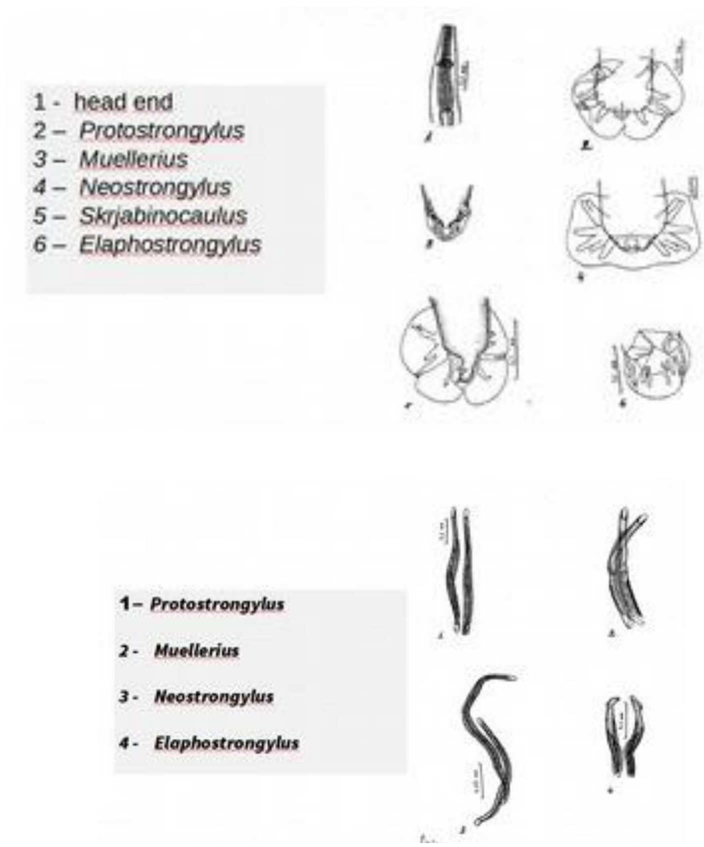


Fig. 5. Diagnostic criteria of morphology of various Protostrongylidae:
a — head end and bursae;
b — spiculae.

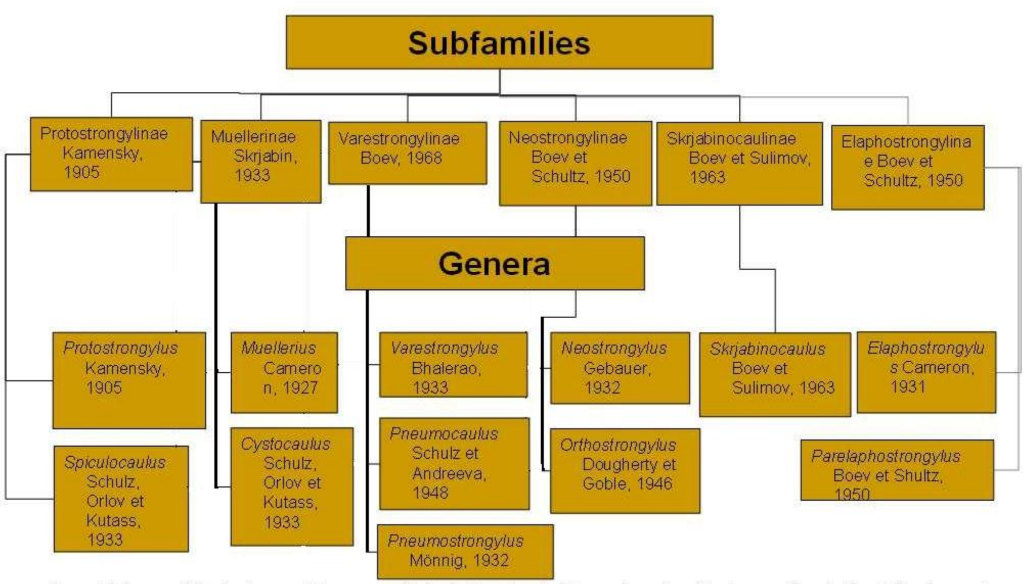
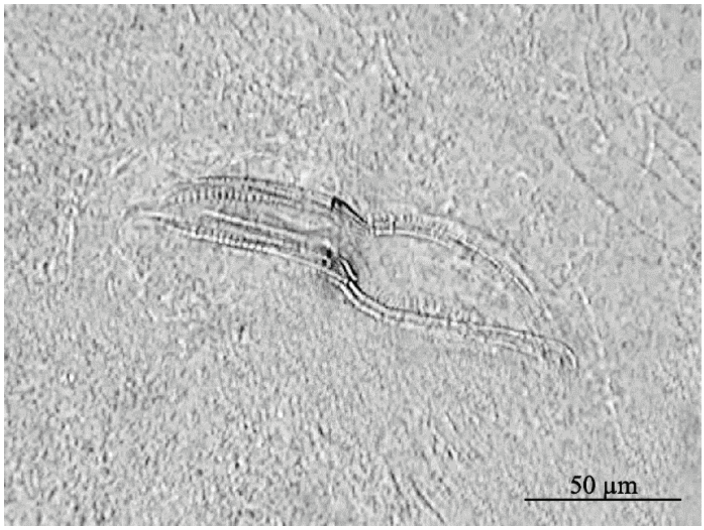


Fig. 6. Systematics of nematodes from fam. Protostrongylidae.

a



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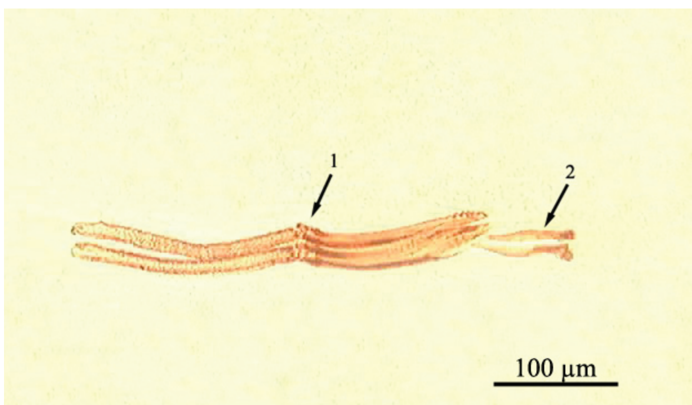

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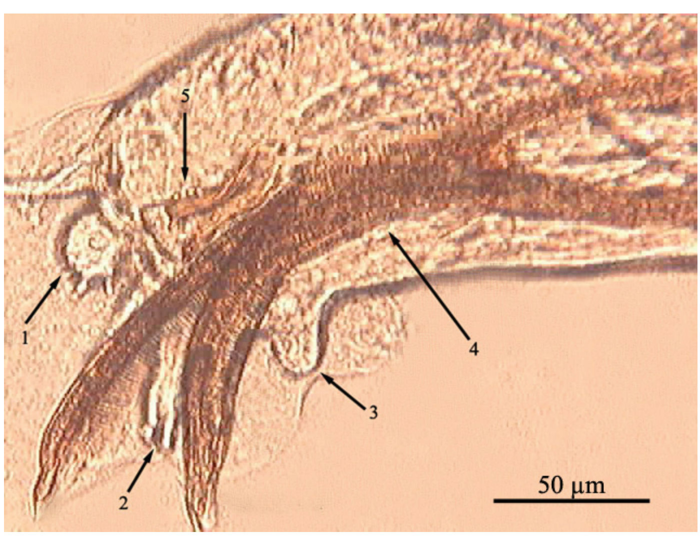
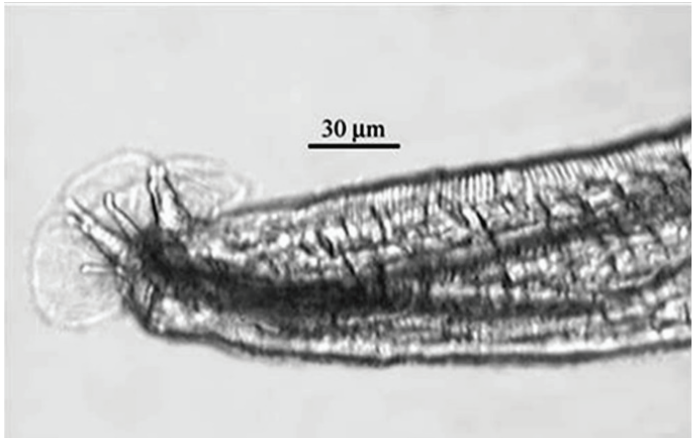
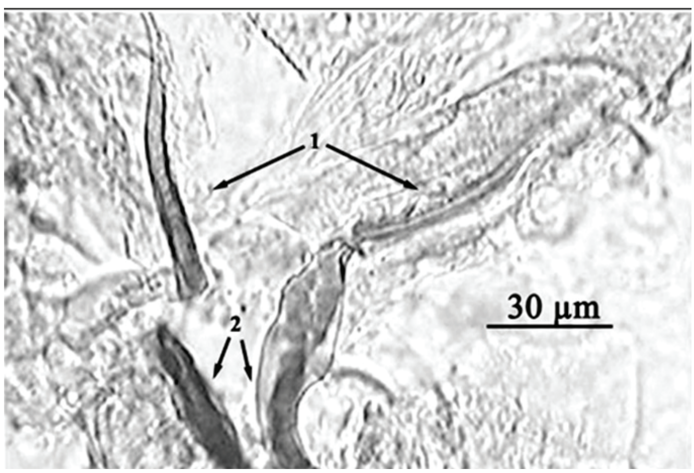


Fig. 7. Structures of some widely distributed lung helminths

d





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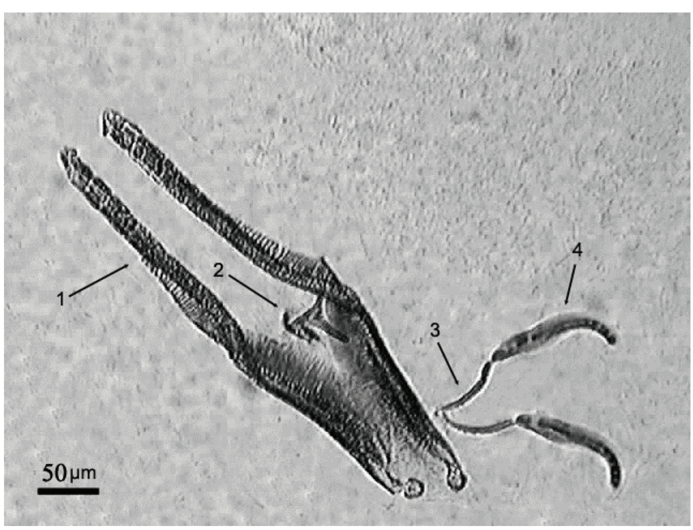
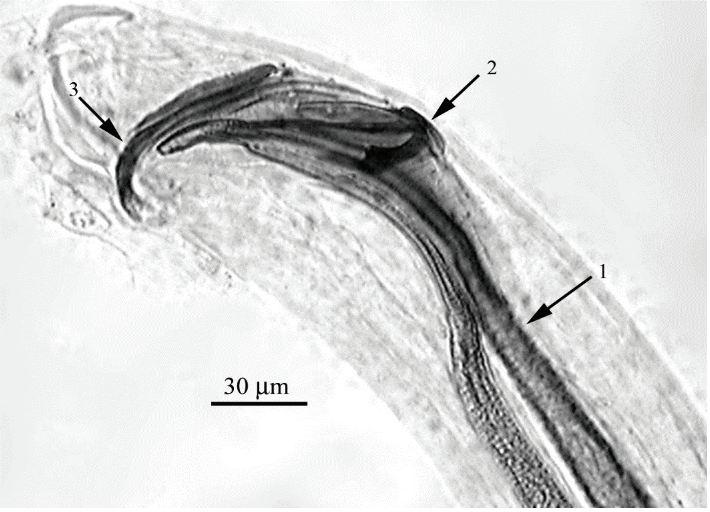


Fig. 7. Structures of some widely distributed lung helminths

f



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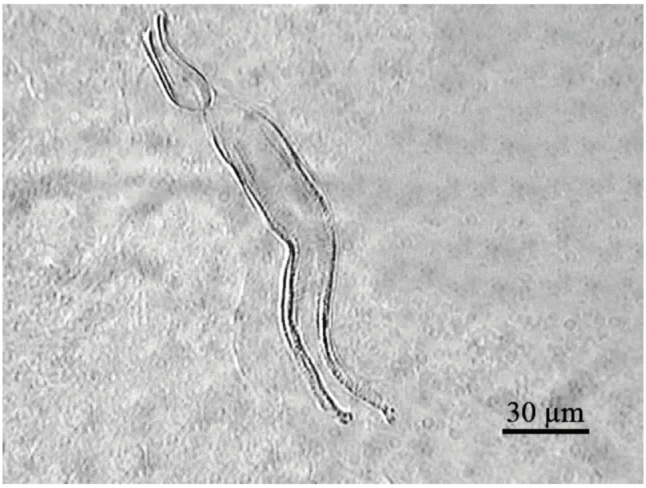

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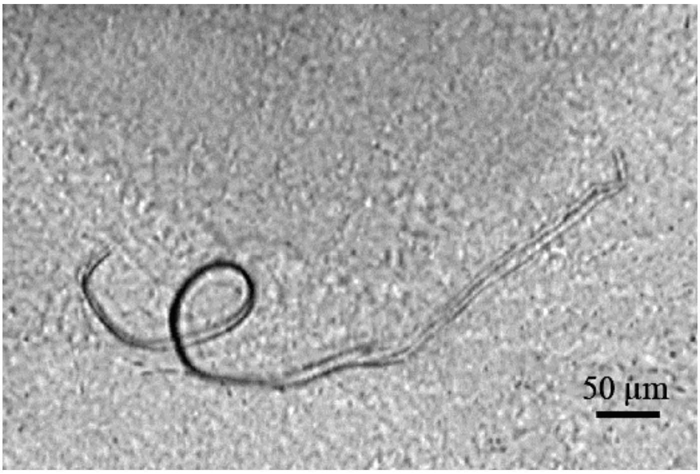
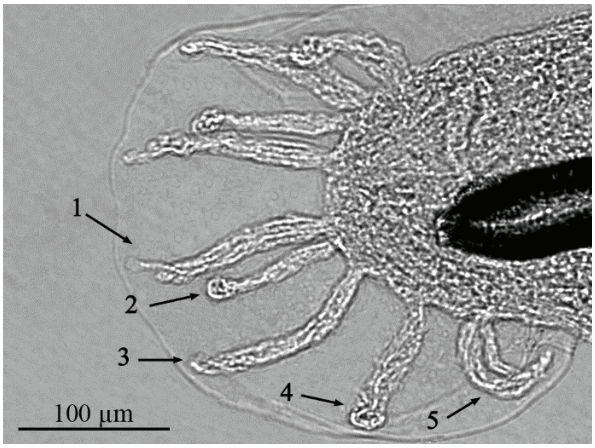


Fig. 7. Structures of some widely distributed lung helminths

i



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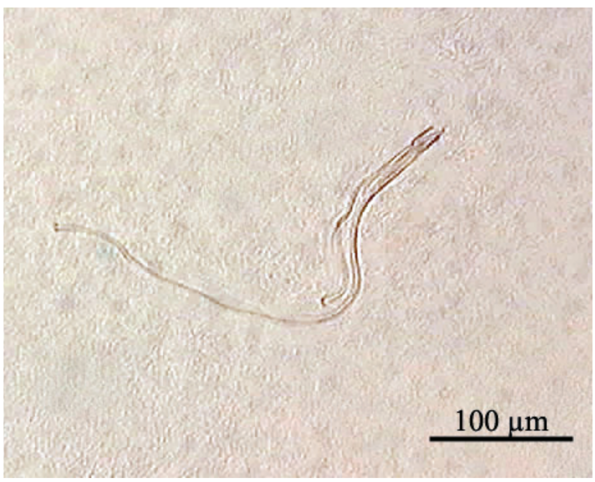

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Fig. 7. Structures of some widely distributed lung helminths (original pictures by Panayotova-Pencheva):
a — *Muellerius capillaris*, b — *Cystocaulus ocreatus*, c — *Protostrongylus rufescens,* d — *Protostrongylus rupicaprae*, e — *Protostrongylus tauricus*, f — *Protostrongylus hobmaieri*, g — *Protostrongylus brevispiculum*, h — *Muellerius tenuispiculatus*, i — *Dictyocaulus eckerti*, j — *Neostrongylus linearis*, k — *Varestrongylus sagittatus*.

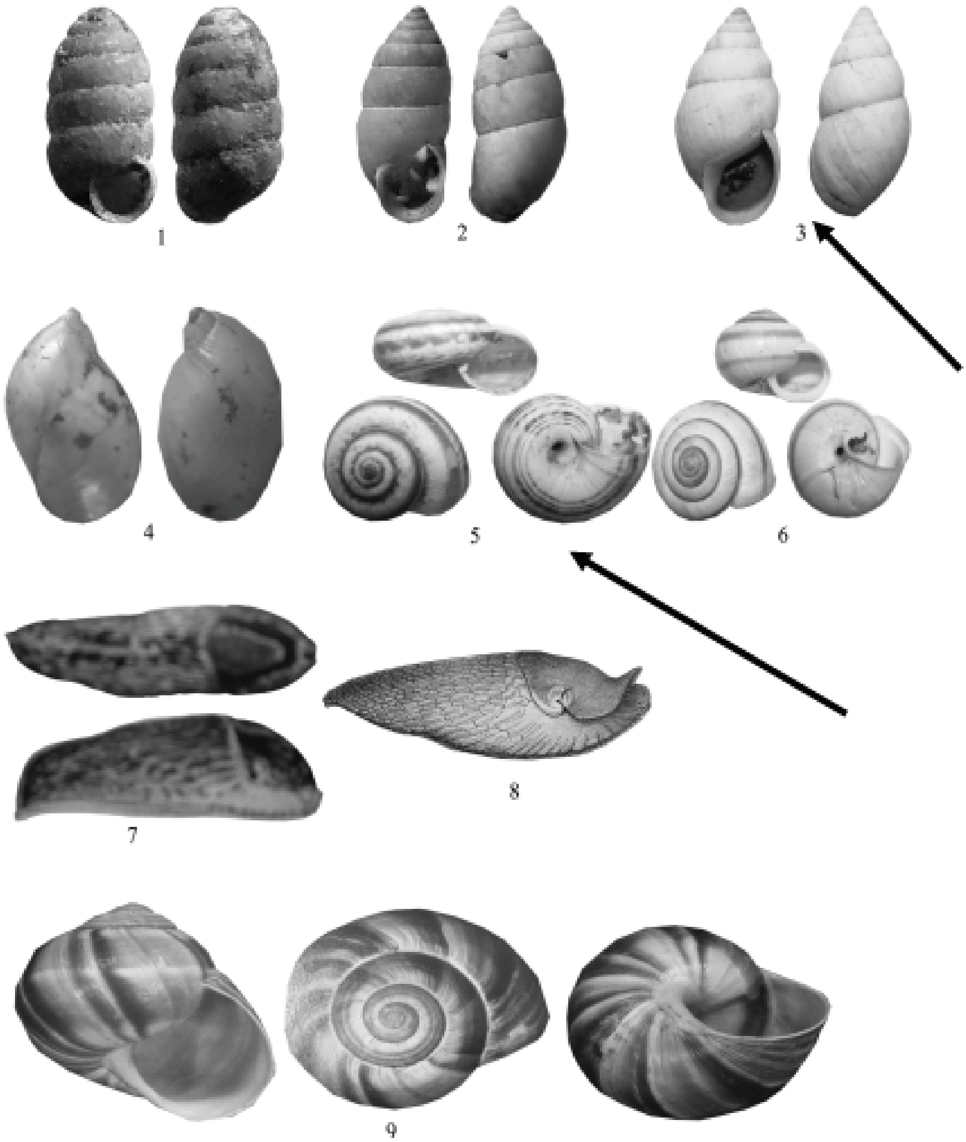


Fig. 8. Land snails of Armenia most commonly infected with Protostrongylidae.
1 — *Pupilla muscorum*;
2 — *Chondrula tridens*;
3 — *Napaeopsis hohenackeri*;
4 — *Succinea putris*;
5 — *Helicella derbentina*;
6 — *Hesseola solidior*;
7 — *Vitrinoides monticola*;
8 — *Deroceras caucasicum*;
9 — *Helix lucorum*.

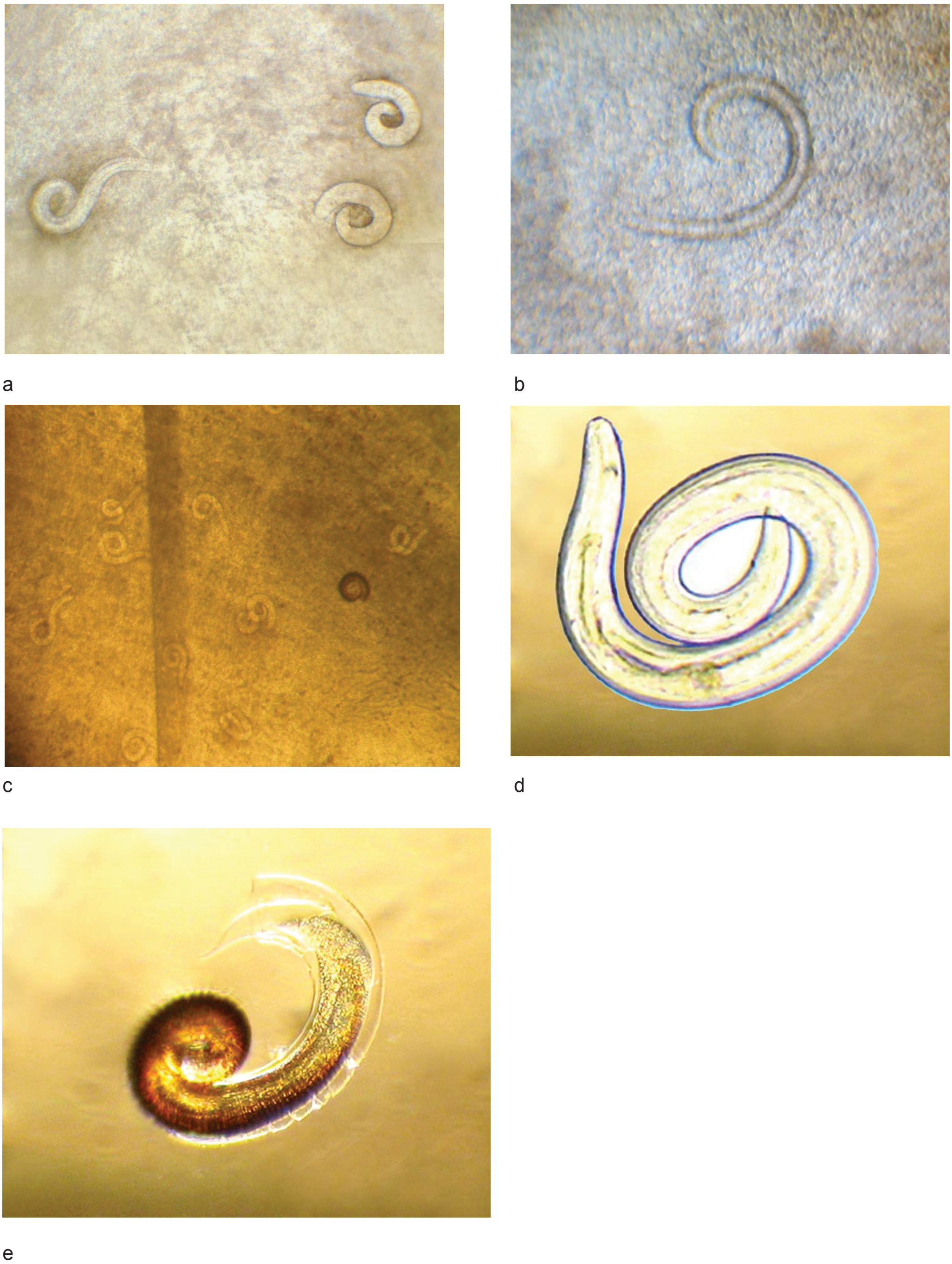


Fig. 9. Protostrongylidae larvae from mollusks of Armenia.
a. Protosrongylidae spp. from Helicella derbentina
b. Protosrongylidae sp. from Vitrinoides monticola
c. Protosrongylidae spp. in Napaeopsis hohenackeri
d. Cystocaulus nigrescens from Napaeopsis hohenackeri
e. Protostrongylus sp. from Helicella derbentina

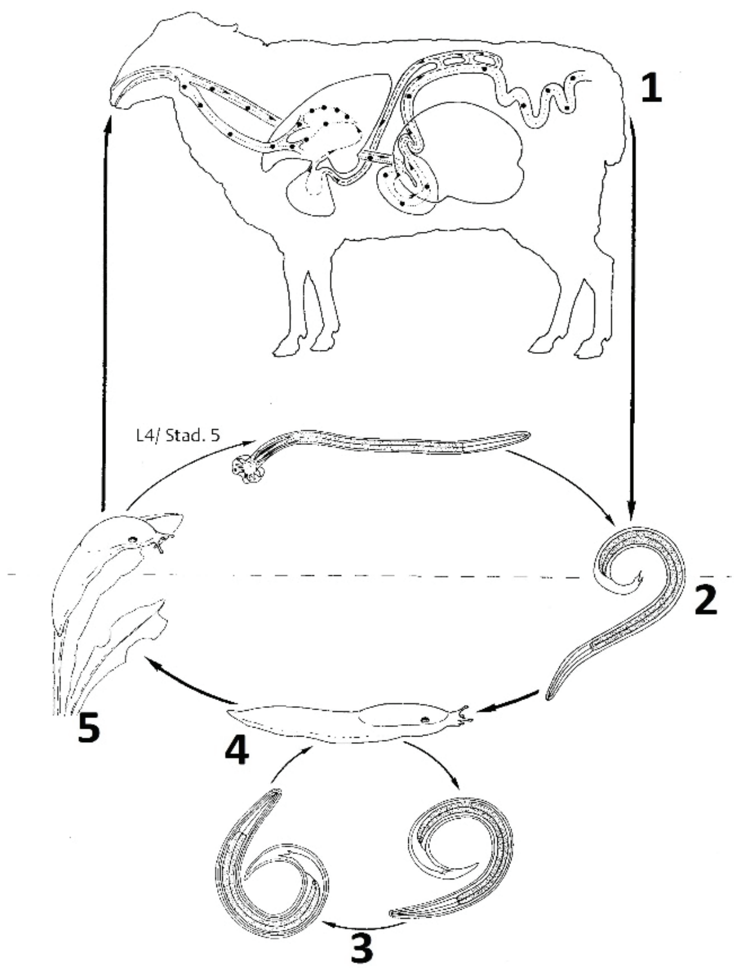
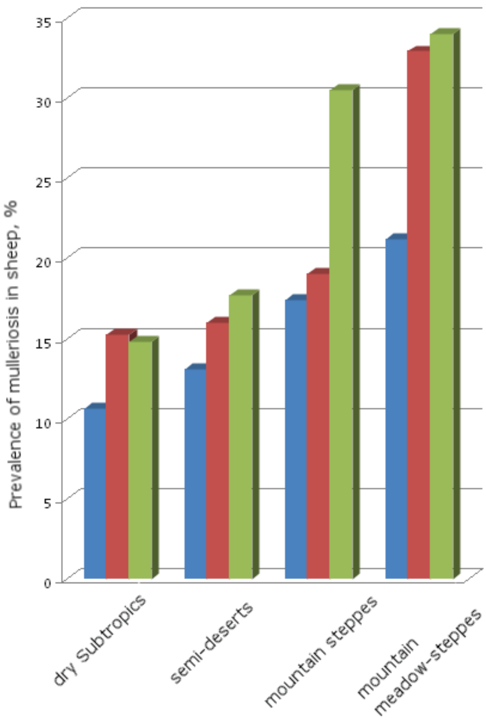
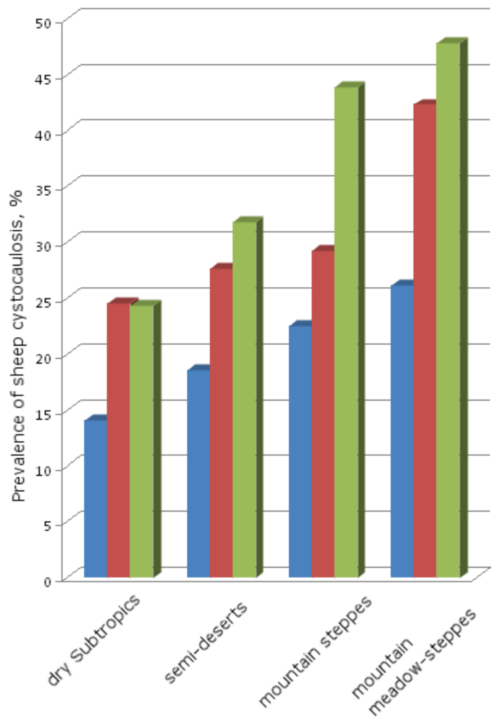


Fig. 10. Life cycle of Protostrongylidae (dixenous) by Eckert, 2001, modified by Movsesyan.
1 — definitive host; 2 — 1st stage larva; 3 — 2nd and 3rd stages larvae; 4;
5 — intermediate host (mollusk).





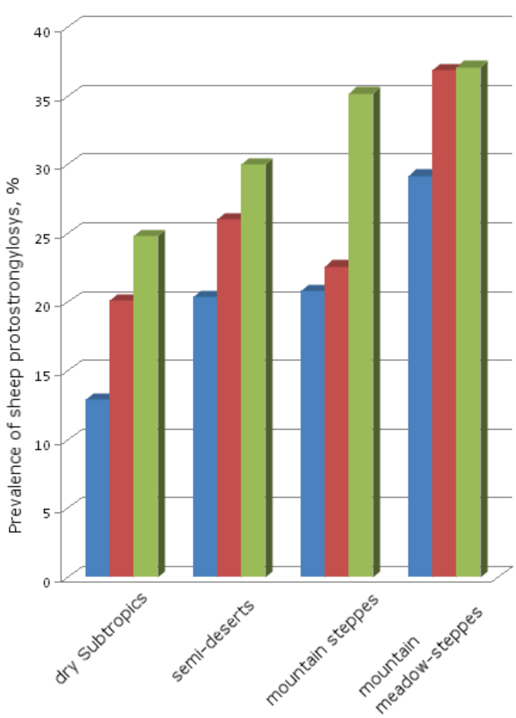
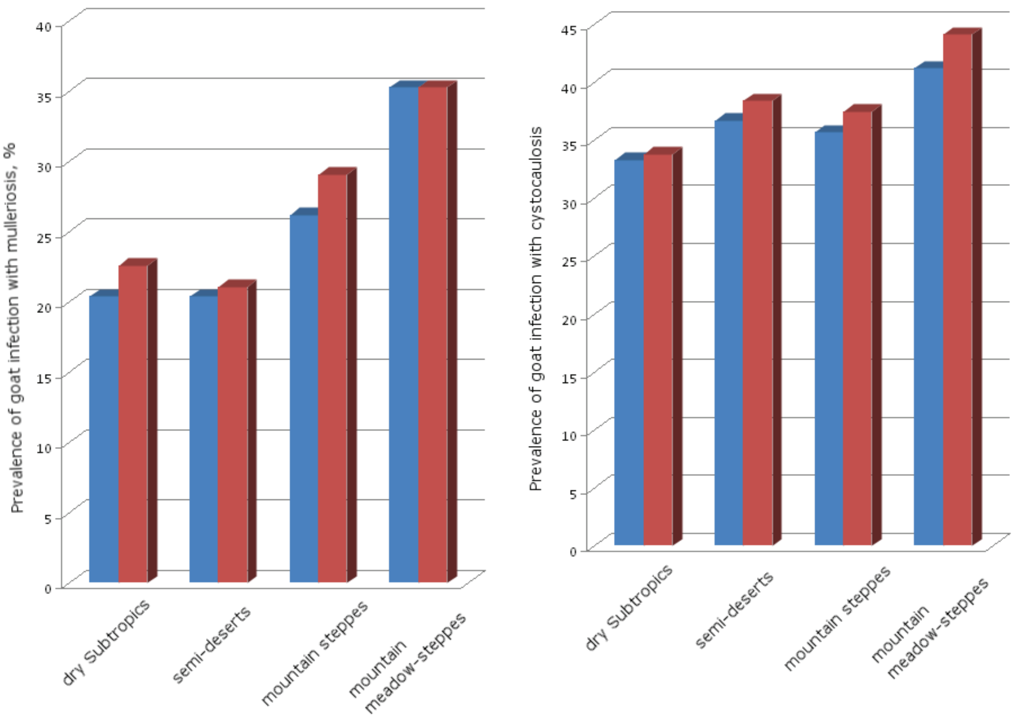
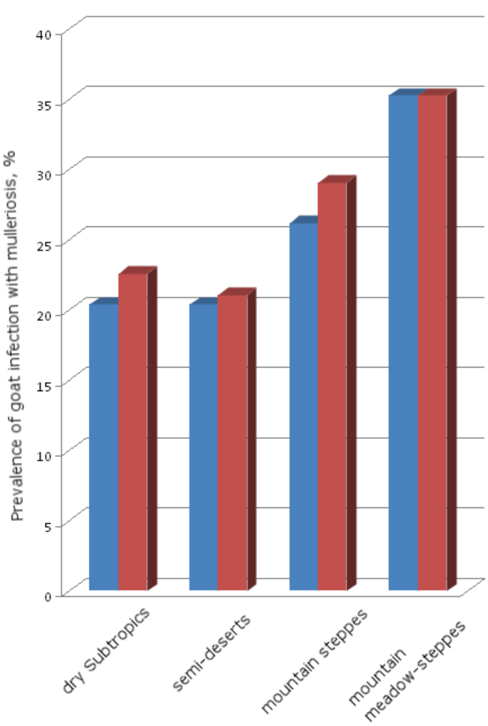


Fig. 11. Rate of infection of small ruminants of various age groups from different landscap zones of Armenia with Protostrongylidae.
a — sheep; b — goats.





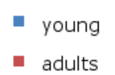


Fig. 12. Rate of infection of small ruminants of various age groups from different landscap zones of Armenia with Protostrongylidae.
a — sheep; b — goats.

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Fig. 12. Adult *Echinococcus granulosus*.

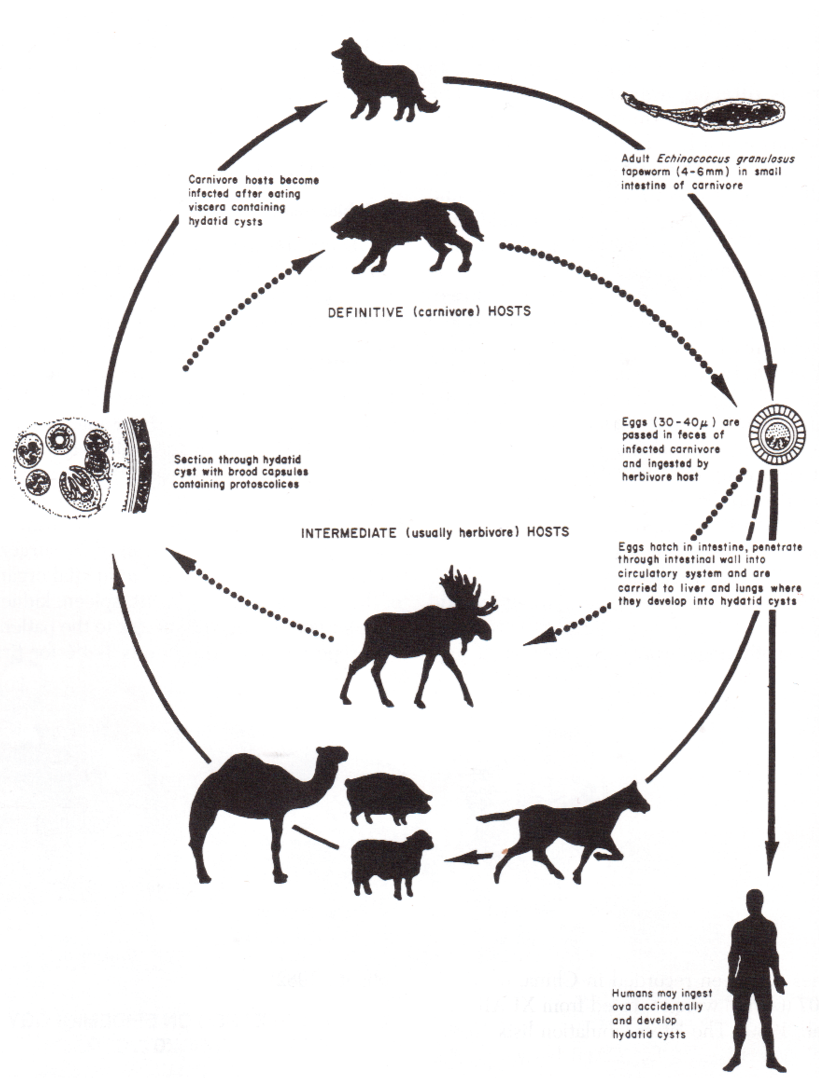

Fig. 13. Life cycle of *Echinococcus granulosus* by Eckert, 2001.

Fig. 14. Liver and lung affected by *E. granulosus* infection — Gevorgyan, 2011, Armenia.

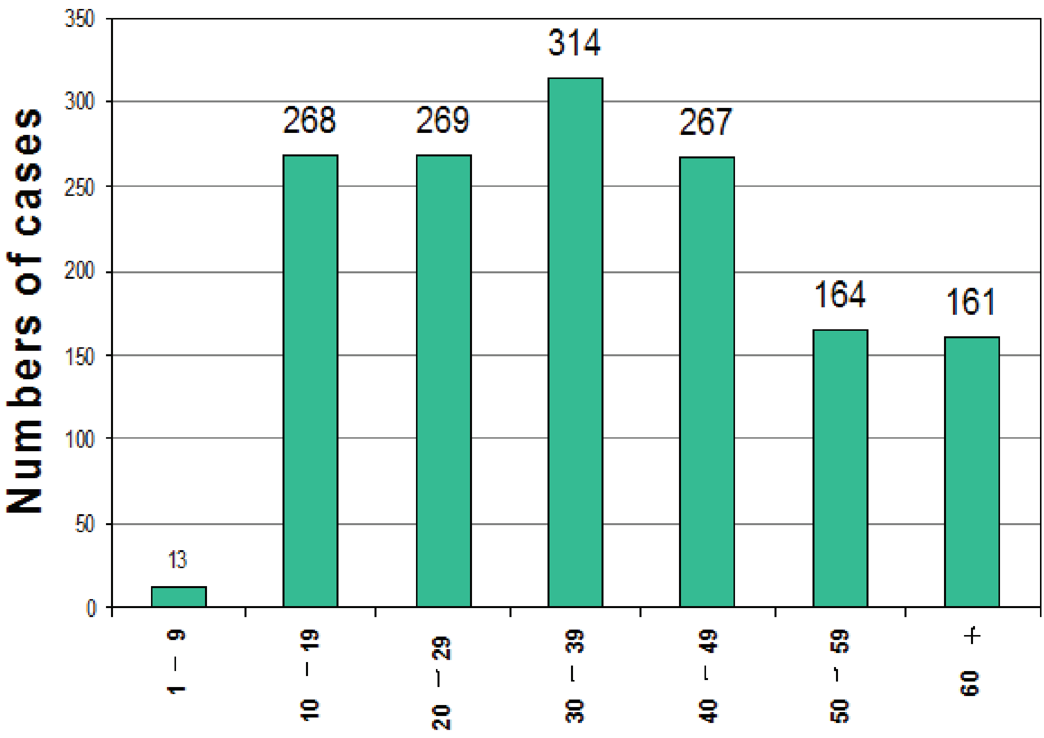

Fig. 15. Characteristics of human infection with *E. granulosus* distribution between age categories (Gevorgyan, 2011).

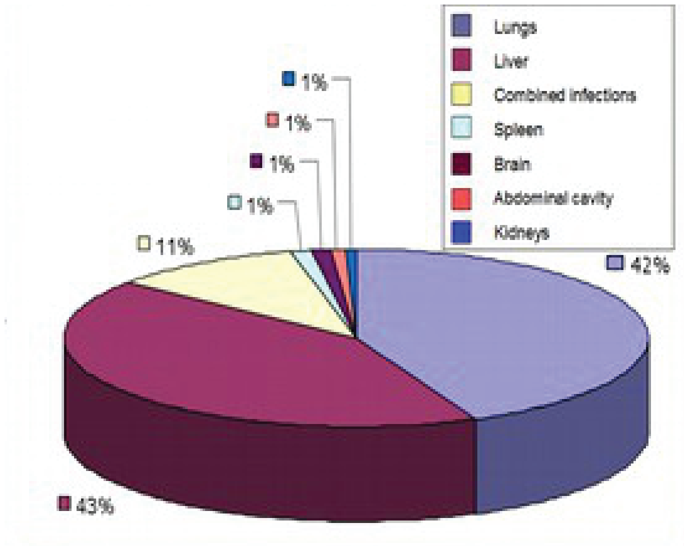

Fig. 16. Distribution of *E. granulosus* cycts between organs in humans in Armenia.