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Arthropods – Intermediate Hosts of Filariat of The Fauna of Warm-Blooded Animals of Uzbekistan

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Abstract
This article involves original data on experimental studies of the life cycles of representatives of oviparous and viviparous filariats at various stages of ontogenesis, the composition of their intermediate and final hosts of the fauna of warm-blooded animals in Uzbekistan. The ecological connections in the system "definitive host – intermediate host – filaria", as well as the ways of their circulation in various conditions of Uzbekistan were clarified. As intermediate hosts of filariae parasitizing in warm-blooded animals of Uzbekistan, we registered representatives of arthropods belonging mainly to the families: flies – Muscidae, mosquitoes – Culicidae, midges – Simulidae and wood lice – Ceratopogonidae.

Analysis of the results of our own research and literature allows us to consider the general trend in the evolution of the life cycles of modern filariat.
Keywords: Fauna, helminth, intermediate hosts, circulation, biocenosis, ecosystem, filariat, birds, mammals, warm-blooded animals.

Introduction. The development of effective measures for the prophylaxes of helminthiasis, including filariasis of warm-blooded animals and humans, largely depends on the completeness of our knowledge on the fauna and life cycles of the causative agents of these diseases.

Helminths, including filariats, as articulations of biocenoses, develop and circulate in individual ecosystems in accordance with the environmental conditions prevailing for them, the number of intermediate hosts, and the potential for their infection. All these factors, obviously, determine the state of the pathogen population itself and these should be taken into account when developing measures to prevent invasions and justifying ways to combat them.

It is becoming increasingly clear that only based on accurate knowledge of the life cycles of helminths, including filariats. It becomes possible to find rational measures of active intervention in the epizootic process, as well as to find ways to disrupt individual links of the epizootic chain in order to quickly and dramatically suppress the parasite population and elimination of the focus of the disease.

It can be stated that each type of parasite has its own ecological niche and life cycle scheme, on the implementation of which the dynamism of the parasite and host system depends.

In the process of evolution, the considered parasites have mastered almost all systems and organs of productive animals in which they live and reproduce. For the implementation of life cycles, they have developed a complex of such adaptations as a change of owners and alternation of

generations. As intermediate and additional hosts, they have mastered a number of species from various classes of invertebrate fauna.

Based on this, the study of the circulation of pathogens of helminthiasis, including filariasis of productive animals, in various conditions of Uzbekistan is of great theoretical and practical importance.

Aim of the research. The purpose of this research is to analyze the results of our long-term studies and literature data on the study of arthropods (***Arthropoda***) – intermediate hosts of filariat of the fauna of warm-blooded animals in various biocenoses of Uzbekistan.

Material and methods of study

For many years (2000-2018), we have studied the role of some representatives of arthropods in the transmission and distribution of filariat of warm-blooded animals in various biocenoses of Uzbekistan.

In order to identify the circle of intermediate hosts of the dominant filariat species participating in the functioning of the parasite-host system, in various biocenoses of Uzbekistan, we collected and studied about 49 thousand specimens of argasid and ixodid ticks, as well as locust, dipteran and coleopteran insects. At the same time, the degree of infection of ticks and insects with invasive larvae of filariat of warm-blooded animals was established.

Results and discussion

Filariats parasitize mainly in birds of various ecological groups (more than 275 species) and in mammals (about 235 species), to an insignificant extent in reptiles (46 species) and in very small numbers in amphibians (20 species).

Recognizing the dependence of the formation of the life cycles of filariates on the nature of their localization in the body of the final host, we note that, with rare exceptions, the filariates of warm-blooded animals have adapted to parasitism in closed organs and systems of animals. The females of these groups are viviparous. Intermediate hosts-blood-sucking diptera, swallow microfilariae and parasite eggs together with animal blood.

It should be noted that the effectiveness of the participation of blood-sucking arthropods in the transmission of invasion is provided by their trophic connections and developed in the process of evolution parasite-host relationsю

Viviparous filariates have another unique feature - the birth of microfilariae of cavity parasites that have the ability to actively introduce into the lymphatic and blood vessels of the host. Nevertheless, the evolution of life cycles is clearly visible in the nematodes under consideration, which is expressed both in their simplification and in the replacement of an intermediate host. The replacement of the intermediate host of viviparous filariates contributed to ensuring their isolation from the direct impact of environmental factors in all phases of their development. In the course of evolution, due to the peculiarities of the biological cycle, a peculiar larval phase - microfilariae - was developed in the system “filariates - blood-sucking arthropods [intermediate hosts] - warm-blooded animals [final hosts]”, which is fundamentally different from the larvae of other stages both morphologically and ecologically.

The life cycles and biology of the filariat proceed with the obligatory participation of an intermediate host. Numerous arthropods, widespread in terrestrial ecosystems were established as intermediate hosts.

Consequently, among all groups of invertebrates, the arthropod type – *Arthropoda* is distinguished by the greatest variety of adaptations to the most varied living conditions, a colossal richness of forms and a huge number of species. The number of arthropod species is approaching three million. Particularly abundant in species are insects, the proportion of which is more than 90% of the known species of arthropods [1,2]. From the general variety of arthropods, according to the specifics of the carried out work, we are interested in representatives of the class of insects (*Insecta*)

and arachnids (*Arachnida*). Some groups of these arthropods participate in the life cycles of a number of helminths species as their intermediate hosts.

Among the roundworms (*Nematoda*), a large group of species of the suborder *Filariata (*order *Spirurida*, subclass *Secernentea*) is associated with insects and arachnids. All known representatives of the suborder filariat are heteroxenous forms that their development takes place with the participation of intermediate hosts. Life cycles have been deciphered in a relatively small number of species of this group of nematodes and, mainly, in mammalian parasites. Little information is known about the developmental cycles of bird filaria. The known data on the biological cycles of the filariat of the world fauna were summarized by Anderson [3], according to which, the intermediate hosts of oviparous forms are arthropods, which swallow parasite eggs with food, and viviparous filariat is blood-sucking arthropods.

Based on the foregoing, when studying the intermediate hosts of filariat in birds and mammals, researchers focused their attention on representatives of two classes of arthropods – insects and arachnids (Table 1).

Table 1

Arthropods of Uzbekistan – intermediate hosts of filariat

Genus filariat	The hosts	
	Definitive	Intermediate
Aprocta	Bird	Acrididae: *Melanoplus, Calliptamus, Dociostaurus*
Diplotriaena	Bird	Acrididae: *Bryodema, Aiolopus, Angaracris Locusta, Oedaleus*
Ornithofilaria	Bird	Simuliidae: *Simulium* Ceratopogonidae: *Culicoides*
Paronchocerca	Bird	Culicidae: *Culex, Aedes*
Dipetalonema	Mammals	Argasidae: *Ornithodoros* Ixodidae: *Rhipicephalus* Culicidae: *Aedes*
Dirofilaria	Mammals	Culicidae: *Culex, Aedes*
Onchocerca	Mammals	Ceratopogonidae: *Culicoides* Simuliidae: *Simulium, Odagmia, Friesia*
Parafilaria	Mammals	Muscidae: *Haematobia*
Setaria	Mammals	Culicidae: *Culex, Aedes* Muscidae: *Stomoxys, Haematobia*
Stephanofilaria	Mammals	Muscidae: *Stomoxys, Liperosia, Haematobia*

Some groups of the indicated classes turned out to be intermediate hosts of filariae of birds and mammals of Uzbekistan. Below we will consider representatives of each of the two classes participating in the biological cycles of filariat.

Class - arachnids (*Arachnida*). Of the whole class of arachnids, blood-sucking parasites of birds and mammals of Uzbekistan were found among representatives of two orders - acariform ticks (*Acariformes*) and parasite form ticks (Parasitiformes).

Representatives of the orders under consideration are quite widespread in the terrestrial ecosystems of the republic. Their total number is about 250 species [4].

Representatives of the genus *Ornithodoros* (*Argasidae*) and *Rhipicephalus* (*Ixodidae*) were registered as intermediate hosts for mammalian filariae. Thus, *Ornithodoros tartakovskyi* and *Rhipicephalus turanicus* turned out to be intermediate hosts of the nematode *Dipetalonema vitae*, a parasite of gerbils. Infection of mites with microfilariae *D. vitae* was 1.5% in *Ornithodoros tartakovskyi* and 2.6% in *Rhipicephalus turanicus*. We observed these ticks as intermediate hosts of *D. vitae* in Uzbekistan for the first time. Earlier, microfilariae of this nematode were found in ticks *Ornithodoros tartakovskyi, O. erraticus*, and *Rhipicephalus sp*. [5]. The microfilariae morphology of the parasites we found was identical to that of *D. vitae* microfilariae.

Class Insects (***Insecta***). The fauna of this class is most often recorded as intermediate hosts of filariat. Representatives of insects in Uzbekistan are extremely rich and diverse. They are represented by more than 12000 species, united in 29 orders [6].

The participation of individual groups of insects in the life cycles of filariat depends on the characteristics of biology, ecology, and morphology. Therefore, the intermediate hosts of primitive oviparous filariat can be only representatives of those groups of insects that feed on the feces of definitive hosts or eat food contaminated with feces – most likely, some coleopteran, orthoptera, and cockroaches. This assumption was proven by a number of authors [7,8,9].

They found that the intermediate hosts of a number of nematode species (*Diplotriaena agelaius, D. isabellina, Serratospiculum tendo, Aprocta cylindrica*, and *Haematospiculum cylindricum*) are *Orthoptera* or *Coleoptera*. The circle of intermediate hosts of filariat is limited to herbivorous and saprophytic insects. Infection of birds occurs when they eat intermediate hosts infested by larvae (Table 2).

Table 2.

Orthoptera – intermediate hosts filariae of birds of Uzbekistan

Species of filariae	Intermediate hosts		
	Acrididae	Investigated, copies	Infected, %
Aprocta cylindrica Linston, 1883	*Calliptamus turanicus*	1050	2.2
	Dociostaurus kraussi	1610	4.0
	Locusta migratoria	725	3.9
Diplotriaena isabellina Koroliowa, 1929	*Bryodema tuberculatum*	2600	3.1
	Aiolopus oxianus	1701	1.2
	Melanoplus frigidis	1005	4.2
Diplotriaena tricuspis (Fedtchenko, 1874)	*Aiolopus thalassinus*	535	2.1
	Oedaleus decorus	610	1.5
	Angaracris barabensis	550	2.3

The locust family (*Acrididae*) is the largest of the insects of the *Orthoptera* order. They inhabit many natural landscapes – deserts, steppes, foothills and mountains. The species diversity of locusts in Uzbekistan, with their huge numbers, includes about 250 species [10, 11].

From studied of 13 species, only nine species were found to have larvae of oviparous filariat of the families *Aproctidae* and *Diplotriaenidae*. The invasion of individual insect species by the larvae

of *Aprocta cylindrica* was 2.2 – 4.0%, *Diplotriaena isabellina* – 1.2 – 4.2%, *Diplotriaena tricuspis* – 1.5 – 2.3%. Most often as intermediate hosts of oviparous filariae of genera *Aprocta, Diplotriaena, Haematospiculum and Serratospiculum* are recorded to *Orthoptera of the family Acrididae* and some coleoptera.

At present time, it has been established that the intermediate hosts of viviparous (larvae of viviparous) filariat are blood-sucking dipterans of the order *Diptera*. By the number of species, the Diptera order is considered one of the largest among insect orders. According to incomplete literature data, more than 1900 of their species are known. It is assumed that more than 6-7 thousand species live in Uzbekistan.

Diptera are important components of biogeocenoses. They mastered various landscapes in Uzbekistan as well. There are many among dipterans and blood-sucking parasites of vertebrates – birds and mammals. The role of representatives of different taxonomic groups in the transfer of larvae (microfilariae) of filaria is not the same. In this context, we are interested in blood-sucking dipterans of the following families: flies – *Muscidae*, mosquitoes – *Culicidae*, midges – *Simuliidae*, wood lice – *Ceratopogonidae*, mosquitoes – *Phlebotomidae*, some of which turned out to be intermediate hosts of the filariat of the fauna of Uzbekistan.

Kabilov noted blood-sucking dipterans in Uzbekistan as intermediate hosts of filariat of the genera of Onchocerca, *Parafilaria, Setaria, and Stephanofilaria* [12].

For certain species of filariat of birds and mammals of the republic and adjacent territories, blood-sucking dipterans are registered as intermediate hosts of mammals [13, 14, 15, 16].

Under studying of blood-sucking dipterans of Uzbekistan, we found larvae of filariae, whose mature nematodes parasitize in various organs and systems of birds and mammals [17, 18, 19].

Flies of the *Muscidae* family and mosquitoes – *Culicidae* are registered as the most frequent carriers of filariats (Table 3).

In the blood-sucking *Muscidae*, larvae of filariae of four species belonging to different genera and families and parasitizing in the mature phase only in mammals of the orders of artiodactyls and equids were noted.

Table - 3.

Diptera – intermediate hosts of filaria birds and mammals of Uzbekistan

Species of filariae	Intermediate hosts		
	Systematic position	Investigated, copies	Infected, %
	Muscidae:		
Stephanofilaria stilesi Chitwood, 1934 *S. assamensis* Pande, 1936	*Lyperosia irritans,* *L. titillans,* *Stomoxys calcitrans,* *Haematobia atripalpis*	5639 1010 989 168	2.6 2.7 0.7 0.5
Setaria labiatopapilloga (Alessandrini, 1848)	*S. calcitrans*	989	0.9
Parafilaria multhipa-pillosa (Gondamine et Dzouilly, 1878)	*H. atripalpis*	168	0.5
	Culicidae:		
Setaria sp.	*Culex pipiens*	867	0.3
Dirofilaria sp.	*C. pipiens*	968	0.3
Paronchocerca bumpae Anderson et Prestwood, 1964	*C. modestus*	751	0.9

Setaria labiatopapillosa	*Aedes caspius*	2336	0.3
Dirofilaria immitis (Leidy,1865)	*A. caspius*	2030	0.7
Dipetalonema evansi (Lewis, 1882)	*A. caspius*	1720	0.7
Dirofilaria repens Railliet et Henry, 1911	*Anopheles superpictus*	194	1.0
Setaria equina (Abildgaard, 1789)	*A. maculipennis*	595	1.2
	Simuliidae:		
Ornithofilaria papillocerca (Lubimov, 1946)	*Simulium vulgare*	3156	1.2
Ornithofilaria sp.	*S. multistriatum*	1143	1.0
Onchocerca lienalis (Stiles, 1892)	*S. flavidum*	109	0.9
O. lienalis	*Odagmia ornata*	7940	4.8
O. lienalis	*Friesia alajensis*	5824	4.0
	Ceratopogonidae:		
Onchocerca cervicalis Railliet et Henry, 1910	*Culicoides puncticollis*	920	0.2
Ornithofilaria fallisensis Anderson, 1954	*C. desertorum*	702	1.3

Culicidae are registered as intermediate hosts for 8 species of filariat in birds and mammals. Among them, only *Paronchocerca bumpae* is a parasite of birds, the larvae of which are found in *Culex modestus* (0.9%). We found mature forms of this nematode in the heart of the marabou – *Leptoptilos crumeniferus* in Tashkent Zoo Park. In the study of the captured mosquitoes of the genera *Aedes* and *Culex* from the aviary, where one individual of the marabou was kept (2012 - 2013), larvae (microfilariae) were found in the *Culex modestus* mosquito at various stages of development.

The morphological features of microfilariae corresponded to the main features of the microfilariae of the nematode *P. bumpae*, described from the blood of tinamu [20]. Based on these data, it is possible to assume that the larvae of filaria found from the mosquito of *C. modestus*, belong to the species *P. bumpae*.

The overwhelming majority of species of filariat larvae are nematodes, the mature forms of which are parasites of mammalian orders – carnivorous, cloven-hoofed, and equid-hoofed and calluses.

Midges of the genera *Simulium, Odagmia*, and *Friesia* were registered as intermediate hosts for vertebrate filariat: birds (*Ornithofilaria papillocerca, Ornithofilaria sp*.) In addition, mammals (*Onchocerca lienalis*). As our studies have shown, representatives of the genus *Simulium* can participate as intermediate hosts for filariat in both birds and mammals.

We also noted woodlice (Ceratopogonidae) as intermediate hosts for filariae of mammals and birds. The participation of wood lice in the life cycles of filariat is represented by species of the genus *Culicoides*. Larvae of *Onchocerca cervicalis* was found in *Culicoides puncticollis* and *Ornithofilaria fallisensis* in *C. desertorum.*

Thus, the carried out researches have shown that the larvae of filariat of birds and mammals was found in representatives of various classes of the arthropod type. Our research made it possible to somewhat expand the range of intermediate hosts of filariat in the considered vertebrates. To date, larvae of filariat of warm-blooded animals of Uzbekistan were found in representatives of the order *Parasitiformes* of the class of arachnids. In ticks *Ornithodoros (Argasidae)* and *Rhipicephalus (Ixodidae)*, only larvae of *D. vitae*, a parasite of gerbils, were recorded. This circumstance allows us to

point out the insignificant role of ticks in the circulation of filarial invasion in the natural conditions of our country.

Representatives of the orders *Orthoptera* and *Diptera* were the main intermediate hosts of the filariat of the studied animals. At the same time, locust species was noted for oviparous filariat of birds, and sucking dipterans for viviparous filariat of birds and mammals. Species of the families *Muscidae* and *Culicidae* occupy a special place among them.

Only arthropods of the terrestrial way of life turned out to be intermediate hosts of filariat, and their connection with these invertebrates is very conservative. Filariat has no connection with invertebrates of aquatic cenoses.

The ecological relationship between intermediate and definitive hosts is realized based on trophic relationships of the three components of the parasitic system (filariats - intermediate - definitive hosts).

Consequently, the prevention of the most dangerous filaratosis of warm-blooded animals is based on the breaking of biocenotic links between the corresponding helminths and their owners.

The presented materials are of great scientific and practical importance for the development of rational measures for the prevention of filaratosis in warm-blooded animals, the pathogens of which develop with the participation of various arthropods.

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