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## Biodiversity of filariae (Nematoda: Filariata), parasites of birds in Uzbekistan

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**Abstract:** In Uzbekistan, 53 species in 4 families of nematodes of the suborder Filariata Skrjabin, 1915 (Aproctidae [9], Splendidofilariidae [12], Diplotriaeidae [20], Oswaldofilariidae [12]) were found to infect 14 orders of birds. Passeriformes harbored 23, the greatest number of species. The rate of infection was significantly lower in birds confined to aquatic environments.

**Key words:** Nematoda, Filariata, birds, aquatic, terrestrial

### 1. Introduction

Filariata is an isolated group of highly specialized parasitic worms. Currently, opinions vary on taxonomic placement of various nematodes assigned to the Filariata and for that reason we have followed Sonin (1966, 1968, 1975) and placed our parasites into 4 families: Aproctidae, Diplotriaeidae, Oswaldofilariidae, and Splendidofilariidae. Despite a wide geographical distribution and the serious damage caused to hosts, many species have been poorly studied (Ryzhikov and Kozlov, 1959; Sultanov, 1963; Sonin, 1968, 1975; Azimov et al., 2009; Saparov et al., 2010). This study examines the biodiversity of Filariata in birds of Uzbekistan.

The present work is aimed at the study of the biodiversity of Filariata, parasites of the birds of Uzbekistan.

### 2. Material and methods

The avian fauna in Uzbekistan is notable for its high diversity. According to Shernazarov et al. (2006), 441 avian species have been recorded in Uzbekistan, some of which nest in Uzbekistan or have been recorded only during migrations.

The diversity of avian species composition in Uzbekistan is predetermined by a large number of their habitats, which significantly differ in their ecological peculiarities. As is known, Uzbekistan covers such landscape zones as deserts, semideserts, foothills, mountains, and river valleys. Each of these zones has its own typical avifauna.

Helminthological studies of birds have been conducted throughout all landscape zones in the territory of Uzbekistan (Figure).

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Nematodes of birds collected by us in the period from 2000 to 2010 have been used as the material for the present work. The study was carried out by using the method of complete helminthological dissections as described by Skrjabin (1928). This work incorporates the material collected during regular field trips organized by the Laboratory of General Parasitology of the Institute of Zoology of the Uzbek Academy of Sciences. We studied both domestic and wild birds from different landscapes during all seasons. We also studied birds kept in the Tashkent Zoological Park. The recorded nematodes were fixed in Barbagallo liquid. Equal volumes of lactic acid and glycerol were used during the treatment of Filariata species.

Morphometric studies were carried out by using the ocular micrometer of the microscope MBI-3; drawings were made using the drawing device RA-4. In the course of the work, we studied 3750 individuals of birds of 15 orders in the avifauna of Uzbekistan (Table 1). The identification of Filariata species was carried out using routine helminthological methods.

More than 25,000 insects (bloodsucking arthropods; phytophagous and saprophytophagous insects) were studied in the places of concentrations of wild and domestic birds in different zones in spring, summer, and autumn 2009/2010. For the collection of insects, we used routine entomological methods (Agrinsky, 1962). The dissection of insects and identification of larvae were done using the methods described by Nelson (1959, 1960) and Nelson and Pester (1962). The recorded nematode larvae

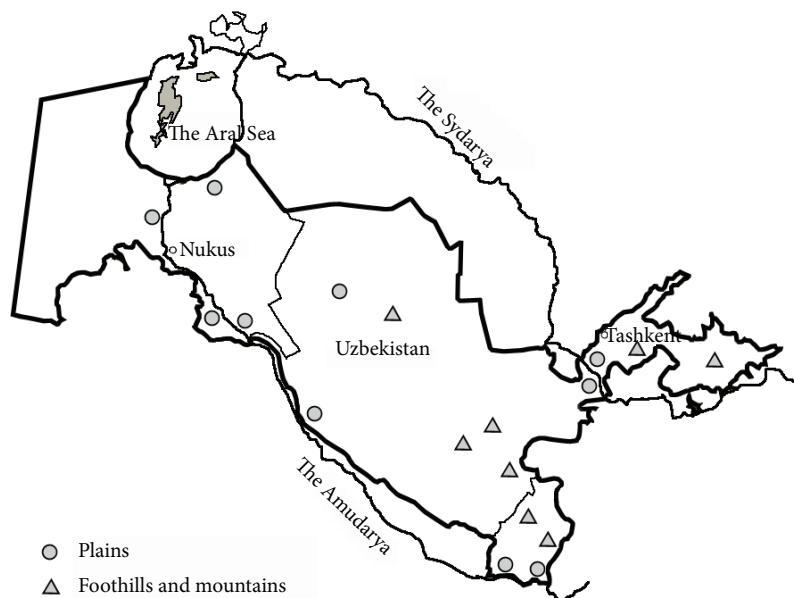


Figure. Map of Uzbekistan. Places of material collection.

Table 1. Infection of different avian species by Filariata in Uzbekistan.

No.	Birds	Studied		Infected	
		Species	Individuals	Number	%
1	Podicipediformes	5	25	-	-
2	Pelecaniformes	4	9	1	11.0
3	Ciconiformes	4	19	6	31.6
4	Anseriformes	10	805	15	10.8
5	Falconiformes	5	11	3	27.0
6	Galliformes	6	1150	285	24.8
7	Gruiformes	11	205	15	7.3
8	Charadriiformes	10	110	6	5.4
9	Columbiformes	8	210	10	4.7
10	Cuculiformes	3	27	1	4.0
11	Strigiformes	3	28	1	3.6
12	Caprimulgiformes	2	18	1	5.0
13	Apodiformes	3	21	1	4.7
14	Coraciiformes	3	98	2	2.0
15	Passeriformes	105	1021	173	16.9
Total		182	3750	520	13.8

were fixed in 1.5%–2% formalin. Most of the recorded insects were studied *in vivo*. The larvae were placed onto a slide in a drop of the physiological solution and rendered immobile by heating them on a spirit lamp. They were then covered with a cover slip and studied microscopically.

### 3. Results and discussion

The study of birds in Uzbekistan revealed representatives of all 4 families from the suborder Filariata. The family Aproctidae comprises 9 species of the genera *Aprocta*, *Aproctoides*, *Squamofilaria*, and *Pseudaprocta*. The 12 Splendidofilariidae species are united into 6 genera, namely *Splendidofilaria*, *Sarconema*, *Skrjabinocta*, *Ornithofilaria*, *Vagrifilaria*, and *Parornithofilaria*. The nematodes of the family Diplotriaeidae comprise 12 species of 6 genera: *Lemdana*, *Eulemdana*, *Cardiofilaria*, *Pseudlemdana*, *Pelecitus*, and *Paronchocerca*. A total of 53 Filariata species were reported from Uzbekistan. The species diversity of these nematodes is considered here based on orders of birds in terrestrial and aquatic cenoses.

**Filariata of Pelecaniformes:** The Pelecaniformes species (pelicans and cormorants) inhabit lakes, reservoirs, and the deltas of the Amudarya and Syrdarya rivers. They include 4 species from the families Pelicanidae and Phalacrocoracidae. The examination of 9 individuals (3 pelicans and 6 cormorants) revealed nematodes *Dicheilonema ciconiae* and *Lemdana behningi* in only 1 individual of the great cormorant, which were located in the lumen of the body of this bird. The total infection rate was 11%. The intensity of the infection reached 1 and 3 individuals, respectively.

**Filariata of Ciconiformes:** The Ciconiformes comprise 13 species of the families of Ardeidae, Threskornithidae, and Ciconiidae. These are water birds. They nest in marshlands, and on the banks and in the deltas of the rivers in the Amudarya and Syrdarya basins. Five Filariata species were reported from the Ciconiformes birds. Of the examined 19 individuals of 4 species, 6 were infected by the nematodes of the order under study, namely *Paronchocerca tonkinensis*, *P. bumpae*, *Pelecitus fulicaeatrae*, *Diplotriaeina tricuspis*, and *Dicheilonema ciconiae*. The total infection rate of Ciconiformes by Filariata was 31.6%.

**Filariata of Anseriformes:** The Anseriformes in the fauna of Uzbekistan are composed of birds of the family Anatidae, the ecology of which is closely connected with aquatic environments. They inhabit freshwater and brackish water bodies. They nest along the riverbanks, coasts of lakes, and in marshlands. Thirty-six Anseriformes species were reported from Uzbekistan. Of 805 individuals (10 species), 2 species, *Diplotriaeina microphallos* and *Sarconema eurycerca*, were recorded in 15 individuals. The total infection rate by the indicated species was 10.8%.

**Filariata of Falconiformes:** Falconiformes birds

include Pandionidae, Accipitridae, and Falconidae. The species diversity of these predatory birds comprises 40 species. The Filariata fauna includes 10 species: *Aproctoides striata*, *Ornithofilaria skrjabini*, *Diplotriaeina falconis*, *Serratospiculum guttatum*, *S. tendo*, *S. chungii*, *Skrjabinocta natali*, *Cardiofilaria pavlovskiyi*, *Pelecitus fulicaeatrae*, and *P. armenica*. It is noteworthy that of the recorded species only 6, namely *A. striata*, *O. skrjabini*, *D. falconis*, *S. tendo*, *S. chungii*, and *P. armenica*, are specific parasites of Falconiformes. Other species were also recorded in the birds of other ecological groups. The general infection rate of the considered birds by Filariata was 27%.

**Filariata of Galliformes:** Galliformes birds in Uzbekistan include Phasianidae, namely *Tetraoallus himalayensis*, *Alectoris chukar*, *Ammoperdix griseogularis*, *Perdix perdix*, *Perdix dauuricae*, *Coturnix coturnix*, *Phasianus colchicus*, and *Ph. colchicus* subsp. *zerafschanicus* (Shernazarov et al., 2006). Their habitats include plains and mountain meadows, rocks, and forests. In nature, Galliformes birds avoid marshlands. They make nests alone on the soil surface. Most Galliformes birds are settled; they broaden their movements depending on the presence of food resources.

Domestic Galliformes include domestic chicken, turkey, and guinea fowl. In general, Galliformes are widespread in Uzbekistan and are of high economic importance. Of 8 wild and 3 domestic Galliformes species, 6 species are known to be hosts of Filariata. The fauna of Filariata in Galliformes birds includes 4 species: *Ornithofilaria papilloerca*, *Parornithofilharzia lienalis*, *Dirafilarionema ulari*, and *Splendidofilaria gvozdevi*. Of 1150 studied individuals, 285 were infected by Filariata (24.8%).

**Filariata of Gruiformes:** The Gruiformes order comprises 13 species of the families Gruidae, Rallidae, and Otidae. These are mostly terrestrial waders inhabiting overgrown damp places, lakes, and meadows overgrown with vegetation (Gruidae and Rallidae). Among these is, for example, the coot, a real water and diving bird. Others, e.g., the Otidae, are terrestrial birds. They inhabit flatlands near mountains, deserts, and semideserts. They are sufficiently distributed in respective cenoses of Uzbekistan.

The fauna of Filariata of Gruiformes birds includes 3 species, namely *Aprocta crassa*, *Petrovifilaria mongolica*, and *Pelecitus fulicaeatrae*. The total infection rate of Gruiformes birds by Filariata was 7.0%.

**Filariata of Charadriiformes:** Charadriiformes birds comprise the families Burhinidae, Charadriidae, Recurvirostridae, Haematopodidae, Scolopacidae, Glareolidae, Stercorariidae, and Laridae. Seventy-two Charadriidae species are recorded in Uzbekistan. The habitats are preferably open landscapes: lake coasts,

plain-land rivers, and different types of marshes. Some representatives of Charadriiformes birds (*Scolopax rusicola*) inhabit forests and mountains (*Gallinago media*). They make nests on the ground not far from water bodies as a rule. In general, Charadriiformes birds are distributed in waterside areas of Uzbekistan.

The Filariata fauna of Charadriiformes birds consists of 4 species: *Diplotriaena isabellina*, *Cardiofilaria pavlovskyi*, *Pelecitus fulicaeatae*, and *Paronchocerca sonini*.

The total infection rate of Charadriiformes birds by Filariata was 5.4%.

**Filariata of Columbiformes:** The birds of the order Columbiformes include 12 species belonging to Pteroclididae and Columbidae. These are diurnal birds. Their habitats vary from forest plantations to rocks, precipices, and manmade constructions. Of 210 studied individuals (8 species), 10 were infected by nematodes, which is 4.7%. The species diversity of Filariata of Columbiformes consists of 3 species: *Skrjabinoceta petrovi*, *Splendidofilaria brevispiculum*, and *Eulemdana clava*. A widespread species, *Skrjabinoceta petrovi* is a specific parasite of Columbiformes birds, while the other parasites are common for other ecological groups of birds.

**Filariata of Cuculiformes:** Cuculiformes are diurnal birds living in trees, shrubs, or on the soil surface. In Uzbekistan, these birds are nesting and migrating. They are recorded in plain-land and mountain zones of Uzbekistan. Two species of cuckoos are known: *Cuculus canorus* and *Cuculus poliocephalus*.

Of Filariata, only 1 species, *Aprocta rotundata*, was recorded in cuckoos. This species was recorded in only 1 out of 27 individuals of Cuculiformes (4.0%).

**Filariata of Strigiformes:** The Strigiformes are generally nocturnal predatory birds. They inhabit forest plantations, deserts, and mountains. In Uzbekistan, 8 Strigiformes species are known. The Filariata fauna of these birds is composed of 2 species, *Diplotriaena henryi* and *Hamatospiculum quadridens*. The total infection rate of these birds by nematodes was 3.6%.

**Filariata of Caprimulgiformes:** The Caprimulgiformes include 2 species of the family Caprimulgidae. They are active at dusk and night. Their habitats are edges of forests, shrub thickets in deserts, and mountains. The total infection of Caprimulgiformes birds was 5%. Two species, *Aprocta caprimulgi* and *Aprocta obtusa*, were recorded in them.

**Filariata of Apodiformes:** In Uzbekistan, the Apodiformes birds comprise 5 species, which are representatives of the family Apodidae. These insectivorous birds are mainly diurnal. They are encountered in forests, foothills, plains, deserts, and settlements. Swifts prefer open landscapes. The total infection rate of these birds by Filariata was 4.7%. Only the species *Cardiofilaria*

*pavlovskyi*, which is encountered in other ecological groups of birds, was recorded.

**Filariata of Coraciiformes:** The order Coraciiformes is represented by kingfishers and bee-eaters. Four species were recorded. These birds occupy diverse habitats. They can be recorded in forests and plains, and along rivers and lakes covered with shrubs or trees. The total infection by Filariata was 2.0%. Three species were recorded: *Diplotriaena henryi*, *Splendidofilaria travossosi*, and *Squamofilaria coraciae*.

**Filariata of Passeriformes:** The order Passeriformes includes a large number of species. Of 441 avian species, more than 200 are birds included in Passeriformes. They comprise 23 families and occupy diverse habitats. Most Passeriformes species are confined to tree and shrub vegetation in forests, parks, and gardens. Among these, there are inhabitants of deserts, fields, and high mountains (some Corvidae); of Motacillidae, there are inhabitants of deserts, fields, and freshwater coastal zones. Passeriformes are widespread in the plains and mountainous zones of Uzbekistan. The Filariata fauna of Passeriformes is composed of 23 species. The most widespread parasites characterizing the fauna of Filariata in Passeriformes birds are Diplotriaenidae, found in most avian families.

The highest diversity of Filariata was recorded in Corvidae (12 species), Turdidae (9), and oriole (8), and to a lesser extent in Emberizidae (1). The total infection rate of Passeriformes by Filariata was 16.9%.

The considered families Aprocidae, Splendidofilariidae, and Oswaldofilariidae are represented by a small number of species (9, 12, and 12, respectively). The richest family is Diplotriaenidae, uniting 20 Filariata species of birds in the fauna of Uzbekistan.

A typical feature of localization of filariae in definitive hosts is that none of the Filariata species inhabit the digestive tract of birds in a mature state. Filariae are adapted to parasitizing organs and tissues of birds, which is a common localization for most nematodes of other suborders. Filariata are adapted to mainly parasitizing the following organs and tissues of birds: subcutaneous cellular tissue; orbital, nasal, and mouth cavities; air sacs; body cavity; and blood vessels (Table 2).

By the pattern of localization, the species of the Filariata suborder can be divided into the following groups: parasites of eye and nasal cavities (species of genera *Aprocta*, *Aproctooides*, and *Skrjabinoceta*); parasites of air sacs and body cavity (species of genera *Diplotriaena*, *Serratospiculum*, *Pseudaprocta*, *Parornithofilaria*, and *Dicheilonema*); parasites of subcutaneous cellular tissue (species of genera *Squamofilaria*, *Ornithofilaria*, *Hamatospiculum*, *Petrovifilaria*, and *Pseudlemdana*); parasites of muscle tissue (*Sarconema eurycerca*, localized in cardiac muscles); parasites of the circulatory system (species of genera *Splendidofilaria*, *Vargifilaria*,

Table 2. Localization of filariae in terrestrial birds.

Family and genera	Number of species	Localization	Definitive hosts (orders)
<b>Aproctidae</b>			
<i>Aprocta</i>	6	Ocular and nasal cavities	Passeriformes Caprimulgiformes Gruiformes Cuculiformes
<i>Aproctoides</i>	1	Ocular cavities	Falconiformes
<i>Squamofilaria</i>	1	Subcutaneous in the area of head and neck, pectoral muscle	Coraciiformes
<i>Pseudaprocta</i>	1	Body cavity	Passeriformes
<b>Splendidofilariidae</b>			
<i>Splendidofilaria</i>	4	Circulatory system	Passeriformes Coraciiformes Galliformes Columbriformes
<i>Skrjabinocta</i>	2	Ocular cavities	Falconiformes
<i>Ornithofilaria</i>	3	Subcutaneous cellular tissue and articulate bursa	Passeriformes Falconiformes Galliformes
<i>Vagrifilaria</i>	1	Circulatory system	Passeriformes
<i>Parornithofilaria</i>	1	Body cavity	Galliformes
<b>Diplotriaenidae</b>			
<i>Diplotriaena</i>	12	Aeriferous bags	Passeriformes Falconiformes Coraciiformes
<i>Hamatospiculum</i>	2	Subcutaneous cellular tissue	Passeriformes Strigiformes
<i>Petrovifilaria</i>	1	Subcutaneous cellular tissue	Gruiformes
<i>Serratospiculum</i>	3	Aeriferous bags	Passeriformes Falconiformes
<b>Oswaldofilariidae</b>			
<i>Eulemdana</i>	1	Subcutaneous cellular tissue	Columbriformes
<i>Cardiofilaria</i>	1	Circulatory system	Passeriformes Falconiformes Charadriiformes Apodiformes
<i>Pseudlemdana</i>	1	Subcutaneous cellular tissue	Passeriformes
<i>Pelecitus</i>	2	Articular bags	Falconiformes
<i>Paronchocerca</i>	2	Circulatory system	Passeriformes Ciconiformes
<i>Dirofilarionema</i>	1	Submucous of mouth cavity	Galliformes



*Paronchocerca*, and *Cardiofilaria*); and parasites of glenoid bags of limbs (*Pelecitus*).

**Intermediate hosts of Filariata:** All known Filariata species are heteroxenous forms. Their development takes place with the participation of intermediate hosts. Different groups of invertebrate animals, namely bloodsucking arthropods and herbivorous and saprophytophagous insects (Anderson, 1956, 1957, 1962; Dissanaïke and Fernando, 1965; Sonin, 1966, 1968, 1971, 1975; Kabilov, 1983), are intermediate hosts of Filariata.

When studying bloodsucking arthropods we recorded the larvae of nematodes in some representatives of midges *Simulium* (Simuliidae), black gnats *Culicoides* (Helicidae), and mosquitoes *Culex* and *Aedes* (Culicidae). By morphometric traits, we preliminarily assigned the recorded larvae in *Simulium* and *Culicoides* to the genus *Ornithofilaria* sp. Larvae of the nematodes *Culicoides*, *Aedes*, and *Culex* were assigned to the genus *Paronchocerca* sp. The infection level of bloodsucking insects by Filariata larvae reached 0.9%–1.6%.

When studying locusts, we also found the larvae of filariae *Diplotriana isabellina* and *Aprocta* sp. The infection level of locusts *Aiolopus oxianus*, *Calliptamus turanicus*, *Doclostaurus craussi*, and *Bryodema tuberculatum* reached 1.2%–4.0%. Thus, the development of Filariata is characterized by a single replacement of intermediate and definitive hosts as obligatory components of the life cycle. Different species of bloodsucking arthropods, herbivorous insects, and representatives of diverse ecological groups of birds are included into this cycle.

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## 4. Conclusions

1. The biodiversity of nematodes of the suborder Filariata parasitizing birds in Uzbekistan consists of 53 species of 4 families, namely Aproctidae (9), Splendidofilariidae (12), Diplotrianaidae (20), and Oswaldofilariidae (12).
2. Filariata were recorded in birds of 14 avian orders inhabiting terrestrial, waterside, and aquatic cenoses. They are important components of the biodiversity of respective ecosystems. The Filariata fauna of examined Passeriformes is significant (23 species) and constitutes 43.3%.
3. By the pattern of localization of the Filariata recorded by us, these can be divided into 2 groups. The first group are parasites of organs associated with the external environments, including Filariata parasitizing eye and nasal cavities and air sacs. The second group includes the nematodes parasitizing organs not associated with the external environment, which parasitize the abdominal and thorax cavities, subcutaneous cellular tissue, muscles, articular pouch, blood, and lymphatic systems.

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