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Haemoproteids (Haemosporida: Haemoproteidae) of Wild Birds in Bulgaria

Peter SHURULINKOV and Vassil GOLEMANSKY

Institute of Zoology, Bulgarian Academy of Sciences, Sofia, Bulgaria

Summary. 21 species of parasites of the genus *Haemoproteus* were found during the period 1999-2001 in the blood of 773 wild birds of 77 species (mostly passerines). Data on the morphology, size, their hosts, and the prevalence and intensity of invasion of each of these parasite species were gathered. The most commonly found parasite species were: *H. belopolskyi, H. lanii, H. balmorali, and H. payevskyi.* Two parasite species encountered very rarely in the Palearctic Zone: *H. velans* and *H. caprimulgi*, were also found. The prevalence of the invasion was especially high (up to 66.7%, n=30) in the case of *H. lanii* in the host genus *Lanius* (Laniidae). The total prevalence of the invasion of the birds studied was 18.5%. The highest prevalence found in the shrike family (Laniidae): 66.7% (n=30). A high rate was also found in the flycatcher family (Muscicapidae): 27.3% (n=33); the warbler family (Sylviidae): 22.8% (n=351); and the thrush family (Turdidae): 15.0% (n=81). The lowest rate was established in the sparrow family (Ploceidae): 3.45% (n=58). The highest rate of prevalence was found during spring, with a maximum in May (an average of 37.8%). Locally nesting migratory birds were more commonly invaded (a prevalence of 25.3%) than locally resident birds (5.8%). Spring migrants were also more frequently invaded (31.4%) than fall migrants (13.3%). Most invasions were of low intensity (between 1 and 10 parasites per 100 microscope fields at magnification 2000x). In only a few instances intensive invasions were observed; for example, in the host genus *Lanius* (Laniidae), between 200 and 330 parasites per 100 microscope fields were noted.

Key words: Haemosporidians, *Haemoproteus*, morphometry, prevalence, wild birds.

INTRODUCTION

Haemoproteids (family Haemoproteidae Doflein 1916) in wild birds are relatively well investigated, mainly in Western and Northern Europe, North America and South Asia. They are very poorly investigated in South-eastern Europe and neighbouring regions of Asia Minor (Bennet *et al.* 1982, Bishop and Bennet 1992,Valkiunas 1997). From the Balkans, data on these parasites have been published for Macedonia (Wülker 1919), for Greece (Wenyon 1926, Pasiotou *et al*. 1992, Theodoridis *et al*. 1998) and for Bulgaria (Valkiunas *et al*. 1999). In these publications, blood parasites found were identified only to genus level, and rarely to species, and the number of bird species studied was small. For the Balkan region, only three species of bird haemoproteids were identified: *H. columbae* (Pasiotou *et al*. 1992), *H. belopolskyi* (Valkiunas *et al*. 1999), and *H. payevskyi* (Valkiunas *et al*. 1999). This is a very small number of species, since on the Balkan Peninsula there are more than 450 species of birds and there are surely much more parasite species to be found. The purpose of this article is to enlarge the knowledge of the diversity of the blood parasites of wild birds in Bulgaria, of their hosts, and of seasonal variation trends in the prevalence.

Address for correspondence: Vassil Golemansky, P. Shurulinkov, Institute of Zoology, 1 Tzar Osvoboditel Blvd., 1000 Sofia, Bulgaria; Fax: (3592) 988-28-97; E-mail: protolab@ppc.datacom.bg

MATERIALS AND METHODS

Blood smears of 773 wild birds of 77 species (31 families and 12 orders) were studied. The birds were caught during the whole year from 1997 to 2001, mainly in three places in Bulgaria: the village Nova Cherna, Silistra District (567 birds caught); and the village Chelopechene (91) and Vrana Campsites (62), Sofia District.

Only 53 birds were caught in other regions of Bulgaria (Rupite, Blagoevgrad District, Sofia, Nissovo, Russe District, Atanassovsko Lake, Burgas District). The birds were caught in vertical mist nets, and blood was taken by cutting the longest claw of each specimen. The families and species of birds studied are shown in Table 1.

From each bird caught, three (rarely 2) blood smears were prepared and then fixed in methanol for 5 min and stained with Giemsa. The smears were studied through a Zeiss microscope (200x, 400x and 2000x). During the work with oil immersion lens (2000x), 600 microscope fields were used. Identification of the haemoproteids found was made through the use of Valkiunas (1997). Bird classification published by Voous (1977) was used. To calculate the intensity of invasion all parasites per 100 microscope fields at magnification 2000x were count.

Measurements (in micrometers) are given only for parasites with more than 20 gametocytes measured. To verify the degree of reliability of the data, Fisher's Criterion is used (Plochinsky 1970). In these comparisons, the degree of probability (p) is stated in the text.

RESULTS

A total of 21 species of *Haemoproteus* were found in the blood of the birds studied (n=773). The species composition and data on their morphology, their hosts and their distribution across Bulgaria are given below. Data on the prevalence are shown in the text for each host species of bird.

Haemoproteus belopolskyi Valkiunas, 1989

Morphology. Gametocyte is usually ameboid. A fully-grown gametocyte can encircle the nucleus of an affected erythrocyte. The nucleus of the parasite is situated closer to one of the poles of the gametocyte, and it is usually attached to the cell membrane of the affected erythrocyte. The granules are medium in size and they are dispersed in the cytoplasm. Their number varies between 4 and 17, rarely rising to 20. The measurements of the parasites and the host erythrocytes are shown in Table 2. Three cases of invasion of 1 erythrocyte by 2 gametocytes were found in the blood of Garden Warbler (*Sylvia borin*).

Hosts in Bulgaria: *Acrocephalus schoenobaenus* (16.1%, n=112), *A. palustris* (32.3%, n=31), *A. scirpaceus* (41.2%, n=17), *A. arundinaceus* (5.3%, n=75), *Sylvia nisoria* (4 cases of 4 examined), *S. borin* (2 cases of 7 examined), *S. atricapilla* (33.3%, n=42), *S. curruca* (6.3%, n=16), *S. communis* (5 cases of 7 examined), *Hippolais icterina* (2 cases of 4 examined), *Phylloscopus trochilus* (1 case of 5 examined), *Ph. sibilatrix* (27.3%, n=11).

Intensity of invasion

Intensity	Number of cases	%
below 1	11	18.0
1-10	36	59.0
10-100	13	21.3
over 100	1	1.6

Maximal intensity registered in blood of Garden Warbler (*Sylvia borin*) was 182 parasites per 100 microscope fields (16.09.2000, Nova Cherna).

Localities: Nova Cherna, Rupite, Vrana and Chelopechene (61 cases). Found in both local breeding birds and spring and fall migrants.

Notes. Widely distributed in the Palaearctic, Ethiopic and Indomalayan zoogeographical zones. In the list of hosts, the species *Acrocephalus scirpaceus* has not been previously included (Valkiunas 1997).

Haemoproteus payevskyi Valkiunas, Iezhova et Chernetsov, 1994

Morphology. Gametocytes are of uniform type, with rounded ends. The nucleus is large and clear, and located in the centre of the gametocyte. The gametocyte does not fill the poles of the affected erythrocyte. The granules are medium in size, rarely large, and they number between 5 and 21. The measurements of the parasites and the affected erythrocytes are shown in Table 2.

Hosts in Bulgaria: *Acrocephalus arundinaceus* (9.3%, n=75) and *A. palustris* (3.2%, n=31).

Intensity of invasion

Intensity	Number of cases
below 1	0
1-10	4
10-100	3
over 100	1

Localities: Nova Cherna (8 cases) and Chelopechene. Found in both spring migrants (6 cases) and local breeding birds (2 cases).

Notes. Marsh Warbler (*A. palustris*) is a new host of this parasite (Bishop and Bennet 1992, Valkiunas 1997).

Haemoproteus coraciae Mello et Afonso, 1935

Morphology. A fully-grown gametocyte does not encircle the nucleus of the affected erythrocyte. The margins of the gametocyte are most often entire, rarely ameboid. Gametocyte usually does not fill the poles of the erythrocyte, but sometimes a fully-grown gametocyte can fill them. The nucleus of the parasite is clear cut and located centrally. The granules are small, rounded, most often between 5 and 10 in number.

Host in Bulgaria: *Coracias garrulus* (2 cases of 2 examined)

Intensity of invasion. Found twice with intensities of 9 and 17 parasites per 100 fields.

Locality: Nova Cherna, in May.

Notes. The species is found in the Indomalayan and Ethiopic zoogeographical zones, and also in the South and Central Palaearctic (Valkiunas 1997).

Haemoproteus fringillae Labbe, 1894

Morphology. A fully-grown gametocyte does not encircle the nucleus of the affected erythrocyte. The gametocyte usually does not adhere to the host cell membrane in the central area. The fully-grown gametocyte fills the poles of the erythrocyte and usually displaces its nucleus. The parasite nucleus is often triangular and displaced slightly towards one of the polar zones. The pigment granules are small, rarely medium-sized, 8-15 in number.

Hosts in Bulgaria: *Fringilla coelebs* (1 case of 3 examined), *Coccothraustes coccothraustes* (2 cases of 2 examined).

Intensity of invasion. Below 1 in 2 cases and 5 in the third case.

Localities: Nova Cherna (1 case) and Vrana (1 case) in the blood of resident birds in breeding season and in autumn.

Notes. Widely distributed species, found in all zoogeographical zones except the Australian. Host species are of 2 families: Fringillidae and Emberizidae (Valkiunas 1997).

Haemoproteus velans Coatney et Roudabush, 1937

Morphometry. A fully-grown macrogametocyte is often circumnuclear. Circumnuclear microgametocytes were not seen. The gametocyte displaces the host cell nucleus and often does not adhere to its membrane. Invaded erythrocytes are longer than the others. The macrogametocyte nucleus has clear margins but the nucleus of the microgametocyte is diffuse. Pigment granules vary in size and are dispersed in all parts of the cytoplasm. Their number is usually between 15 and 26. Volutine granules were not seen. The measurements of the parasites and the host erythrocytes are shown in Table 3.

Host in Bulgaria: *Dendrocopus syriacus* (1 case of 1 examined)

Intensity of invasion. The only invasion found was 81 parasites per 100 fields.

Locality: Rupite, Blagoevgrad district, in a resident breeding bird.

Notes. It is reported for Palaearctic Wrynecks (*Jynx torquilla*) wintering in India (Valkiunas 1997). Our finding proves its distribution in the Palaearctic. The parasites observed by us lack volutine granules and so differ from the description in Valkiunas (1997).

Haemoproteus attenuatus Valkiunas, 1989

Morphology. A large space between the gametocyte and the host cell membrane is usually seen only in the central zone. So the gametocyte is thin in the central zone and broad at the ends. The cytoplasm is divided in areas differing slightly in colour. The parasite nucleus is closer to one of the poles. The pigment granules a re medium or small in size, usually more than 20 in number. If the granules are small, their number is higher.

Hosts in Bulgaria: *Luscinia luscinia* (2 cases of 7 examined), *Erithacus rubecula* (6.3%, n=16).

Intensity of invasion. Three invasions found with 2, 4 and 17 parasites per 100 fields respectively. It is interesting that the highest intensity was found in the blood of a Robin (*Erithacus rubecula*) caught on 10.03.2001 at Chelopechene in winter.

Localities: Nova Cherna and Chelopechene. Found in the blood of spring (2 cases) and fall migrants (1 case) only.

Notes. Reported from Curonian Spit in Baltic Sea up to now; 1 host species Robin (*Erithacus rubecula*) (Valkiunas 1997). Thrush Nightingale (*Luscinia luscinia*) is a new host for the species.

Haemoproteus lanii Mello, 1936

Morphology. Circumnuclear gametocytes may persist, but usually they are very rare. A fully-grown gametocyte has entire margins. The parasite nucleus is centrally located and adheres to the erythrocyte nucleus. Rarely the parasite nucleus is located in one of the poles. The pigment granules are medium sized or large, 5-16 in number. The measurements of the parasites and

Table 1. Number of the examined birds (% shown only in cases with more than 10 examined individuals) and the prevalence of the invasions with different species of haemoproteids. Abbreviations of the haemoproteid names: Hant - *H. anthi,* Hate - *H. attenuatus,* Hbal - *H. balmorali,* Hbel - *H. belopolskyi,* Hcap - *H. caprimulgi,* Hcor - *H. coraciae,* Hdol - *H. dolniki,* Hfri - *H. fringillae,* Hher - *H. herodiadis,* Hhir - *H. hirundinis,* Hlan- *H. lanii,* Hmin - *H. minutus,* Hmot - *H. motacillae,* Hnoc - *H. noctuae,* Hori - *H. orioli,* Hpal - *H. pallidus,* Hpas - *H. passeris,* Hpay - *H. payevskyi,* Hpic - *H. picae,* Hvel - *H. velans,* Hwen - *H. wenyoni*

Families/species	Number of examined birds	Number of infected birds	%	Species of haemoproteids
Pelecanidae	14	0	0	
Pelecanus onocrotalus (Bruch)	14	0	0	
Ardeidae	7	3		Hher
Ixobrychus minutus (L.)*	7	3		Hher
Anatidae	1	0		
Anas platyrhynchos (L.)	1	0		
Accipitridae	1	0		
Accipiter nisus (L.)	1	0		
Scolopacidae	1	0		
Tringa nebularia (Gunn.)	1	0		
Columbidae	1	1		H. sp.
Streptopelia turtur (L.)*	1	1		H. sp.
Cuculidae	3	0		
Cuculus canorus	3	0		
Strigidae	3	1		Hnoc
Asio otus (L.)*	1	1		Hnoc
Otus scops (L.)	1	0		
Athene noctua (Scop.)	1	0		
Caprimulgidae	2	1		Hcap
Caprimulgus europaeus (L.)*	2	1		Hcap
Alcedinidae	21	1	4.8	H. sp.
Alcedo atthis (L.)*	21	1	4.8	H. sp.
Coraciidae	2	2		Hcor
Coracias garrulus (L.)*	2	2		Hcor
Picidae	12	1	8.3	Hvel
Dendrocopus major (L.)	3	0		
D. syriacus (Hemp. et Eher.)*	3	1		Hvel
D. medius (L.)	2	0		
Picus canus (Gm.)	2	0		
P. viridis (L.)	1	0		
Jynx torquilla (L.)	1	0		
Hirundinidae	21	1	4.8	Hhir
Hirundo rustica (L.)	16	0		
Riparia riparia (L.)	4	0		
Delichon urbica (L.)*	1	1		Hhir
Motacillidae	25	2	8.0	Hmot, Hant
Anthus trivialis (L.)*	21	2	9.5	Hmot, H. ant
Motacilla flava (L.)	4	0		
Prunellidae	5	0		
Prunella modularis (L.)	5	0		
Turdidae	81	12	14.8	Hmin, Hbal, Hate
Turdus merula (L.)*	14	3	21.4	Hmin, H. sp.
T. philomelos (Brehm)	6	0		
T. iliacus (L.)	1	0		
Phoenicurus phoenicurus (L.)*	14	1	7.1	Hbal
Erithacus rubecula (L.)*	16	3	18.8	Hbal, Hate
Saxicola rubetra (L.)*	3	1		Hbal
Luscinia luscinia (L.)*	7	4		Hbal, Hate
L. megarhynchos (Brehm)	20	0		

Table 1 (contd.)	Number of examined birds	Number of infected birds	%	Species of haemoproteids
Sylvidae	351	80	22.8	Hbel, Hpay, Hwen
Sylvia nisoria (Bech.)*	4	4		Hbel
S. borin (Bodd.)*	7	2		Hbel
S. atricapilla (L.)*	42	15	35.7	Hbel, Hwen
S. communis (Latham)*	7	5		Hbel
S. curruca (L.)*	16	1	6.3	Hbel
Acrocephalus arundinaceus (L).	75	11	14.7	Hpay, Hbel
A. palustris (Bech.)*	31	11	35.5	Hpay, Hbel
A. scirpaceus (Herm.)*	17	7	41.2	Hbel
A. schoenobaenus (L.)*	112	18	16.1	Hbel
Hippolais icterina (Vieil.)*	4	2		Hbel
Phylloscopus trochilus (L.)*	5	1		Hbel
Ph. sibilatrix (Bech.)*	11	3	27.3	Hbel
Ph. collybita (Vieil.)	4	0		
Locustella fluviatilis (Wolf)	7	0		
L. luscinioides (Savi)	9	0		
Muscicapidae	33	9	27.3	Hbal, Hpal
Ficedula parva (Bech.)	6	0		
F .semitorquata (Hom.)	1	0		
F. albicollis (Temm.)	3	0		
F. hypoleuca (Pall.)	5	0		
M. striata (Pall.)*	18	9	50.0	Hbal, Hpal
Aegithalidae	2	0		
Aegithalos caudatus (L.)	2	0		
Remizidae	4	0		
Remiz pendulinus (L.)	4	0		
Paridae	46	0		
Parus major (L.)	34	0		
P. caeruleus (L.)	11	0		
P. palustris (L.)	2	0		
Sittidae	5	0		
Sitta europaea (L.)	5	0		
Certhiidae	3	0		
Certhia brachydactyla (Brehm)	1	0		
C. familiaris (L.)	2	0		
Troglodytidae	8	0		
T*roglodytes troglodytes*	8	0		
Laniidae	30	20	66.7	Hlan
Lanius collurio (L.)*	27	19	70.4	Hlan
L. minor (Gm.)*	3	1		Hlan
Corvidae	3	1		Hpic
Pica pica (L.)	2	0		
Garrulus glandarius (L.)*	1	1		Hpic
Oriolidae	3	2		Hori
Oroilus oriolus (L.)*	3	2		Hori
Sturnidae	1	0		
Sturnus vulgaris (L.)	1	0		
Ploceidae	58	2	3.5	Hpas
Passer domesticus (L.)	28	0		
P. hispaniolensis (Temm.)*	14	2	14.3	Hpas
P. montanus (L.)	17	0		
Fringillidae	26	3	11.5	Hfri, Hdol
*Fringilla coelebs (L.)**	3	1		Hfri, Hdol
Carduelis chloris (L.)	12	0		
C. carduelis (L.)	9	0		
Emberizidae	3	0		
Emberiza citrinella (L.)	1	0		
E. calandra (L.)	2	0		
TOTAL	773	143	18.5	

Table 2. Measurements of *Haemoproteus belopolskyi* and *H. payevskyi.* Abbreviations: A - average measurement, GR - number of granules, L - length, lim - range, LNE - length of the nucleus of the erythrocyte, LNG - length of the nucleus of the gametocyte, NDR - nucleus displacement ratio, SD - standard deviation, W - width, WNE - width of the nucleus of the erythrocyte, WNG - width of the nucleus of the gametocyte

	H. belopolskyi (n=30)			*H. payevskyi* (n=20)		
Measurement	lim	A	SD	lim	A	SD
Uninfected erythrocytes						
L	9.2-11.3	10.68	0.74	12-14.5	13.25	0.86
W	6.0-7.2	6.56	0.44	6.0-8.0	7	0.75
LNE	4.8-7.0	5.51	0.56	6.0-7.0	6.44	0.5
WNE	2.0-3.0	2.41	0.27	2.0-3.0	2.52	0.34
Erythrocytes infected by macrogametocytes						
L	10.2-13.0	11.58	0.65	13-15.5	14.53	0.69
W	5.8-7.2	6.72	0.42	6.0-7.0	6.7	0.42
LNE	4.8-6.0	5.48	0.44	5.5-7.0	6.47	0.53
WNE	2.0-2.8	2.39	0.26	1.5-2.0	2.27	0.32
Erythrocytes infected by microgametocytes						
L	11.0-12.3	11.67	0.5	14-15	14.7	0.48
W	6.0-8.0	7.02	0.53	6.5-8.0	7.23	0.44
LNE	5.0-6.0	5.4	0.44	6.0-7.0	6.23	0.31
WNE	2.0-2.7	2.32	0.26	2.0-2.5	2.16	0.21
Macrogametocytes						
L	11.0-21.0	14.05	1.71	11.0-15.0	13.6	1.05
W	5.8-7.2	6.72	0.42	2.8-3.0	2.98	0.06
LNG	2.0-3.5	2.6	0.43	2.0-3.0	2.21	0.33
WNG	1.3-2.2	1.75	0.29	1.5-2.0	1.9	0.21
NDR	0.6-1.0	0.88	0.12	0.5-0.85	0.66	0.12
GR	4-15	9.13	3.13	13-20	15	2.45
Microgametocytes						
L	12.5-16	14.2	1.18	11-15	13.2	1.11
W	2.3-3.0	2.81	0.27	3.0 -4.0	3.15	0.34
LNG	4.0-6.0	5.45	0.83	1.8-2.1	1.97	0.09
WNG	1.5-3.0	2.3	0.59	1.2-1.7	1.4	0.17
NDR	0.75-1.0	0.84	0.07	0.67-0.75	0.72	0.04
GR	6-14	8.9	2.47	10-16	13.6	1.84

the host erythrocytes are shown in Table 3. The invasion of 1 erythrocyte by 2 gametocytes was registered on a few occasions.

Hosts in Bulgaria: *Lanius collurio* (70.4%, n=27), *Lanius minor* (1 case of 3 examined)

Intensity of invasion

Intensity	Number of cases	%
below 1	2	10.5
1-10	7	36.8
10-100	8	42.1
over 100	2	10.5

Maximal intensity: 335 parasites per 100 fields in the blood of a Lesser Grey Shrike (*Lanius minor*).

Localities: Nova Cherna, Atanassovsko Ezero (Burgas district), Chelopechene, Nisovo (Russe district) (20 cases). Found in both breeding birds and migrants.

Notes. Distributed in Palaearctic, Ethiopic and Indomalayan zoogeographical zones (Valkiunas 1997).

Haemoproteus orioli Mello, 1935

Morphology. A fully-grown gametocyte fills the poles of the infected erythrocyte, but does not encircle its nucleus. The parasite nucleus is often situated at one of the ends. The parasite displaces the host cell nucleus and the NDR is between 0.5 and 1. The pigment granules vary in size and number between 4 and 18.

Host in Bulgaria: *Oriolus oriolus* (2 cases of 3 examined)

Intensity of invasion. Registered only once with intensity of 4 parasites per 100 fields.

Locality: Nova Cherna. Found in blood of a breeding bird.

Table 3. Measurements of *Haemoproteus velans* and *H. lanii.* Abbreviations: A - average measurement, GR - number of granules, L - length, lim - range, LNE - length of the nucleus of the erythrocyte, LNG - length of the nucleus of the gametocyte, NDR - nucleus displacement ratio, SD - standard deviation, W - width, WNE - width of the nucleus of the erythrocyte, WNG - width of the nucleus of the gametocyte

	H. velans (n=30)			*H. lanii* (n=20)		
Measurement	lim	A	SD	lim	A	SD
Uninfected erythrocytes						
L	11-13	12.3	0.53	10-13	11.61	0.72
W	6.0-8.0	6.84	0.58	6.0-8.0	6.84	0.5
LNE	5.0-7.0	6.14	0.48	5.0-6.5	5.8	0.45
WNE	2.0-3.0	2.39	0.36	2.0-2.7	2.19	0.22
Erythrocytes infected by macrogametocytes						
L	12-15	14.06	0.78	11.2-13.5	12.14	0.59
W	6.0-8.0	7.11	0.48	6.0-9.0	7.1	0.64
LNE	5.0-6.5	5.8	0.37	5.0-6.5	5.68	0.55
WNE	2.0-3.0	2.27	0.35	2.0-3.0	2.24	0.24
Erythrocytes infected by microgametocytes						
L	12.5-15.5	13.88	0.8	12-14	12.65	0.61
W	6.0-8.0	7.00	0.63	6.0-8.0	7.04	0.57
LNE	5.0-7.0	5.79	0.51	4.5-6.5	5.68	0.48
WNE	2.0-3.0	2.31	0.34	2.0-2.5	2.19	0.22
Macrogametocytes						
L	14-26	20.0	3.43	12.5-20.0	16.15	2.0
W	2.5-4.5	3.25	0.45	2.0-3.5	2.77	0.44
LNG	2.0-5.0	3.26	0.61	1.5-3.0	2.18	0.4
WNG	2.0-3.0	2.32	0.38	1.0-2.0	1.32	0.39
NDR	0-1	0.53	0.29	0.57-0.9	1	0.79
0.08						
GR	15-35	23.86	4.91	8-14	10.5	1.93
Microgametocytes						
L	13.5-20.0	16.37	1.61	13-21	14.8	2.07
W	2.5-4.5	3.44	0.5	2.0-3.5	2.74	0.46
LNG	5.0-5.5	3.0-6.0	4.49	0.85		
WNG	3.0	1.0-3.5	2.29	0.62		
NDR	0-0.8	0.4	0.18	0.5-1.0	0.83	0.12
GR	13-28	20.6	3.8	8-15	11.2	2.0

Notes. Distributed in Palaearctic, Ethiopic and Indomalayan zoogeographical zones (Valkiunas 1997).

Haemoproteus herodiadis Mello, 1935

Morphology. A fully-grown gametocyte does not fill the poles of the infected erythrocyte and often has no contact with either its cell membrane or its nucleus. The gametocyte has entire margins. The young gametocyte never adheres to the host cell nucleus. The parasite nucleus is in the central zone and varies in size. The pigment granules are small, 8-16 in number. The measurements of the parasites and the host erythrocytes are shown in Table 4.

Host in Bulgaria: *Ixobrychus minutus* (3 cases of 7 examined).

Intensity of invasion. A very low rate of invasion was registered in 2 cases - below 1. In the third case the intensity was 5 parasites per 100 fields.

Locality: Nova Cherna. Found only in May.

Notes. Reported for Holarctic and Indomalayan zoogeographical zones (Valkiunas 1997).

Haemoproteus balmorali Pierce, 1984

Morphology. A fully-grown gametocyte usually doesn't fill the poles of the infected erythrocyte and doesn't encircle its nucleus. The erythrocyte nucleus is displaced by the parasite. The gametocyte adheres to the host cell membrane at the polar zones, but usually does not do so in the central zone. The parasite nucleus is clear, oval to ellipsoid, situated most often close to the

Table 4. Measurements of *Haemoproteus herodiadis* and *H. balmorali.* Abbreviations: A - average measurement, GR - number of granules, L - length, lim - range, LNE - length of the nucleus of the erythrocyte, LNG - length of the nucleus of the gametocyte, NDR - nucleus displacement ratio, SD - standard deviation, W - width, WNE - width of the nucleus of the erythrocyte, WNG - width of the nucleus of the gametocyte

	H. herodiadis (n=10)			*H. balmorali* (n=20)		
Measurement	lim	A	SD	lim	A	SD
Uninfected erythrocytes						
L	14-16	14.68	0.8	12-13.5	12.44	0.54
W	7.0-8.0	7.13	0.32	6.2-7.5	6.92	0.42
LNE	6.0-8.0	7.16	0.6	5.2-7.0	5.94	0.54
WNE	2.6-3.0	2.85	0.17	2.5-3.0	2.65	0.2
Erythrocytes infected by macrogametocytes						
L	12-18	15.25	1.74	13-14.3	13.38	0.47
W	6.0-8.0	7.33	0.76	6.5-8.0	7.17	0.41
LNE	5.5-8.0	6.7	0.71	6.0-6.5	6.1	0.21
WNE	2.0-3.0	2.5	0.34	2.2-3.0	2.67	0.3
Erythrocytes infected by microgametocytes						
L	14.5-17	15.75	0.95	13-14	13.53	0.5
W	6.5-8.0	7.22	0.6	6.5-8.0	7.05	0.37
LNE	5.8-8.0	6.83	0.65	5.8-6.5	6.1	0.2
WNE	2.0-3.0	2.22	0.32	2.2-3.0	2.7	0.31
Macrogametocytes						
L	11-13.5	12.45	0.76	16-19	17.55	1.04
W	2.0-3.0	2.76	0.39	2.0-3.0	2.17	0.33
LNG	2.0-4.5	3.32	0.71	2.0-3.0	2.77	0.39
WNG	1.0-3.0	1.95	0.54	1.2-2.0	1.82	0.3
NDR	0.67-0.8	0.72	0.04	0.85-1.25	0.98	0.11
GR	9-15	11.9	2.88	?	?	?
Microgametocytes						
L	11-14.5	13.45	1.23	15-19.5	17.25	1.38
W	2.5-3.0	2.9	0.21	1.5-3.2	2.3	0.48
LNG (n=3)	4.2-5.0	7.5-9.0	8.25	0.49		
WNG (n=3)	1.5-2.0	1.5-3.2	2.3	0.48		
NDR	0.44-0.8	0.72	0.12	0.64-1	0.9	0.11
GR	11-20	13.5	2.76	?	?	?

poles and adhering to the host cell membrane. Volutine granules are present, so counting the pigment granules is difficult. The microgametocyte cytoplasm is darker coloured at the ends and all the granules are gathered there. The measurements of the parasites and the host erythrocytes are shown in Table 4.

Hosts in Bulgaria: *Muscicapa striata* (50 %, n=18), *Luscinia luscinia* (2 cases of 7 examined), *Saxicola rubetra* (1 case of 3 examined), *Erithacus rubecula* (12.5 %, n=16), *Phoenicurus phoenicurus* (7.1 %, n=14).

Intensity of invasion

	Number of cases	%
below 1	2	13.3
1-10	6	40.0
10-100	6	40.0
over 100	1	6.6

Maximal intensity registered: 290 parasites per 100 fields in blood of a Robin (*Erithacus rubecula*), Nova Cherna, 14.09.2001.

Localities: Nova Cherna and Chelopechene. Found on 15 occasions in the blood of migrants.

Notes. Reported for a great number of hosts of the families Turdidae and Muscicapidae. Found in the Palaearctic, Ethiopic and Indomalayan zoogeographical zones (Valkiunas 1997).

Haemoproteus passeris Kruse, 1890

Morphology. A young gametocyte adheres to only the cell membrane of the infected erythrocyte. The fully grown gametocyte occasionally can fill the poles of the infected erythrocyte and does not encircle its nucleus. The gametocyte has entire or ameboid margins. The parasite nucleus is clear cut, situated closer to one of the ends. The pigment granules are medium-sized, rarely

Table 5. Measurements of *Haemoproteus passeris* and *H. pallidus.* Abbreviations: A - average measurement, GR - number of granules, L - length, lim - range, LNE - length of the nucleus of the erythrocyte, LNG - length of the nucleus of the gametocyte, NDR - nucleus displacement ratio, SD - standard deviation, W - width, WNE - width of the nucleus of the erythrocyte, WNG - width of the nucleus of the gametocyte

	H. passeris (n=10)			*H. pallidus* (n=10)		
Measurement	lim	A	SD	lim	A	SD
uninfected erythrocytes						
L	11-12	11.48	0.48	11.5-13.5	12.45	0.63
W	6.0-7.0	6.25	0.42	6.0-7.0	6.4	0.46
LNE	5.0-6.0	5.62	0.39	5.6-6.5	6.06	0.24
WNE	2.0-3.0	2.51	0.35	2.0-2.5	2.25	0.2
Erythrocytes infected by macrogametocytes						
L	12-13	12.47	0.42	12-15	13.17	0.82
W	6.0-7.0	6.38	0.49	6.0-7.0	6.2	0.35
LNE	5.2-6.0	5.77	0.39	5.7-7.0	6.06	0.35
WNE	2.0-3.0	2.53	0.25	2.0-2.2	2.02	0.06
Erythrocytes infected by microgametocytes						
L	11.5-13	12.3	0.67	13-14.8	13.28	0.62
W	6.0-7.0	6.33	0.38	6.0-7.0	6.25	0.33
LNE	5.0-6.2	5.73	0.37	5.5-6.4	6.04	0.24
WNE	2.0-3.0	2.47	0.3	2.0	2.0	0
Macrogametocytes						
L	11-16	13.55	1.57	13-15.5	13.85	0.78
W	2.0-2.4	2.04	0.13	2.0-2.5	2.07	0.16
LNG	2.0-3.5	2.39	0.51	1.5-2.0	1.9	0.22
WNG	2.0-2.5	2.05	0.16	0.7-1.5	1.08	0.29
NDR	0.71-1	0.92	0.1	0.75-1.1	0.96	0.1
GR	8-18	11.9	3.31	10-15	12.8	1.75
Microgametocytes						
L	12.5-19.5	15.3	1.89	13.5-16	14.65	1.13
W	2.0-3.0	2.22	0.36	2.0-3.0	2.27	0.34
LNG	?					
WNG	?					
NDR	0.5-1	0.81	0.15	0.8-1.0	0.95	0.07
GR	9-15	12	2	10-15	12.5	1.7

small, oval to ellipsoid, 8-15 in number. In the microgametocyte the granules are gathered in the poles. The measurements of the parasites and the host erythrocytes are shown in Table 5.

Hosts in Bulgaria: *Passer hispaniolensis* (14.3%, n=14)

Intensity of invasion. Found twice with intensities of 12 and 16 parasites per 100 fields, respectively.

Locality: Nova Cherna. Found in local resident birds in breeding season.

Notes. Found in all zoogeographical zones (Valkiunas 1997)

Haemoproteus pallidus Valkiunas et Iezhova, 1991

Morphology. In comparison with other haemoproteids the gametocyte of *H. pallidus* is obviously paler. The fully-grown gametocyte does not fill the poles of the infected erythrocyte. The gametocyte usually adheres to the host cell nucleus but does not adhere to its cell membrane. The parasite nucleus is situated closer to one of the ends. The microgametocyte nucleus is diffuse and very difficult to measure. The pigment granules are small to medium, most often between 10 and 15 in number. Erythrocytes infected by 2 gametocytes are not rare. Measurements of the parasites and the host erythrocytes are shown in Table 5.

Host in Bulgaria: *Muscicapa striata* (11.1%, n=18)

Intensity of invasion. Found twice in mixed invasions with *H. balmorali*. Intensities registered were 12 and16 parasites per 100 fields respectively.

Localities: found at Nova Cherna in a fall migrant and at Chelopechene in a spring migrant.

Notes. Known for the Palaearctic and Ethiopic zoogeographical zones (Valkiunas 1997).

Table 6. Measurements of *Haemoproteus noctuae.* Abbreviations: A - average measurement, GR - number of granules, L - length, lim - range, LNE - length of the nucleus of the erythrocyte, LNG - length of the nucleus of the gametocyte, NDR - nucleus displacement ratio, SD - standard deviation, W - width, WNE - width of the nucleus of the erythrocyte, WNG - width of the nucleus of the gametocyte

Measurement (n=10)	lim	A	SD
Uninfected erythrocytes			
L	14-16	14.82	0.68
W	7.0-8.0	7.65	0.53
LNE	5.8-8.0	6.68	0.7
WNE	2.5-3.5	2.9	0.29
Erythrocytes infected by macrogametocytes			
L	14-16.5	15.32	0.81
W	7.5-9.0	8.25	0.54
LNE	5.0-7.0	6.19	0.69
WNE	2.0-3.0	2.62	0.42
Erythrocytes infected by microgametocytes			
L	13.5-16.0	15.25	0.75
W	7.5-9.2	8.27	0.52
LNE	6.0-7.3	6.51	0.46
WNE	2.3-3.0	2.69	0.26
Macrogametocytes			
L	18.5-26.5	22.6	2.67
W	2.0-3.0	2.8	0.35
LNG	2.5-4.0	3.35	0.58
WNG	1.5-3.0	2.12	0.30
NDR	0.8-1.0	0.91	0.09
GR	17-25	20.7	2.58
Microgametocytes			
L	20-24	21.6	1.15
W	2.0-3.0	2.43	0.5
LNG (n=3)	8.0-8.5		
WNG (n=3)	2.0		
NDR	0.8-1.0	0.92	0.08
GR	14-22	17.7	2.16

Table 7. Total prevalence of invasions with haemoproteids of wild birds in different parts of Eurasia

Place (country)	Total prevalence %	Source
England	3.8-8.6	Pierce and Mead (1976, 1977, 1978)
Poland	6.4-15.6	Dymowska and Żukowski (1965), Ramisz (1965), Dymowska and Żukowski (1968)
Chechoslovakia (former)	11.8	Kučera (1981)
Kazakchstan	13.7	Jakunin (1972)
Greece	19.6	Theodoridis *et al*. (1998)
Curonian Spit in the Baltic Sea (Kursiu peninsula)	34.8	Valkiunas (1985)
Bulgaria	18.5	present study

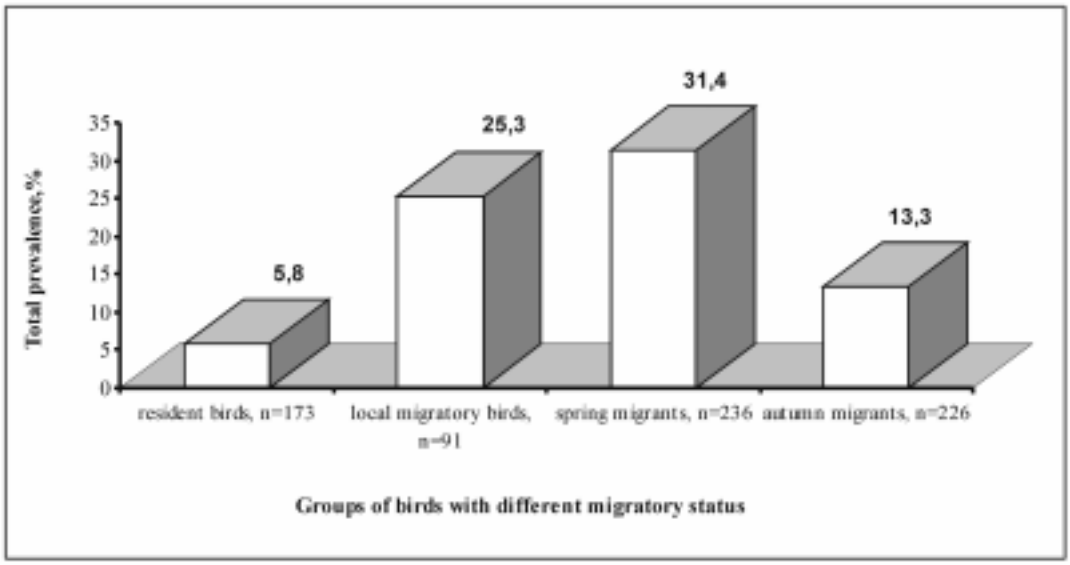

Fig. 1. Total prevalence of haemoproteid invasions of birds with different migratory status in Bulgaria

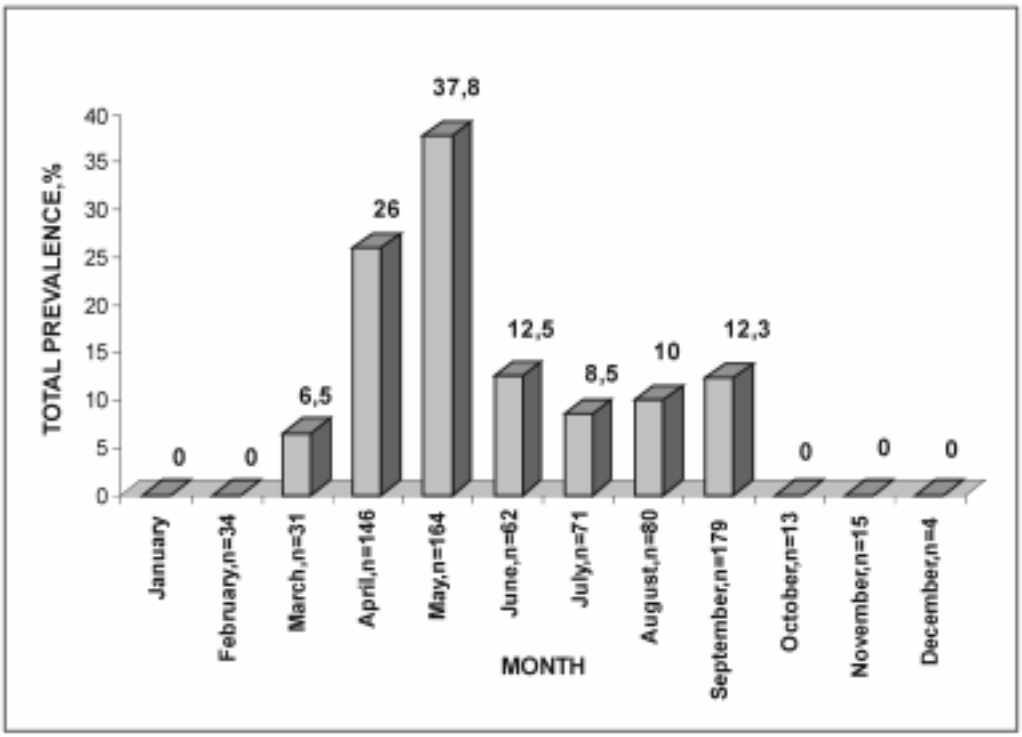

Fig. 2. Total prevalence of haemoproteid invasions by months

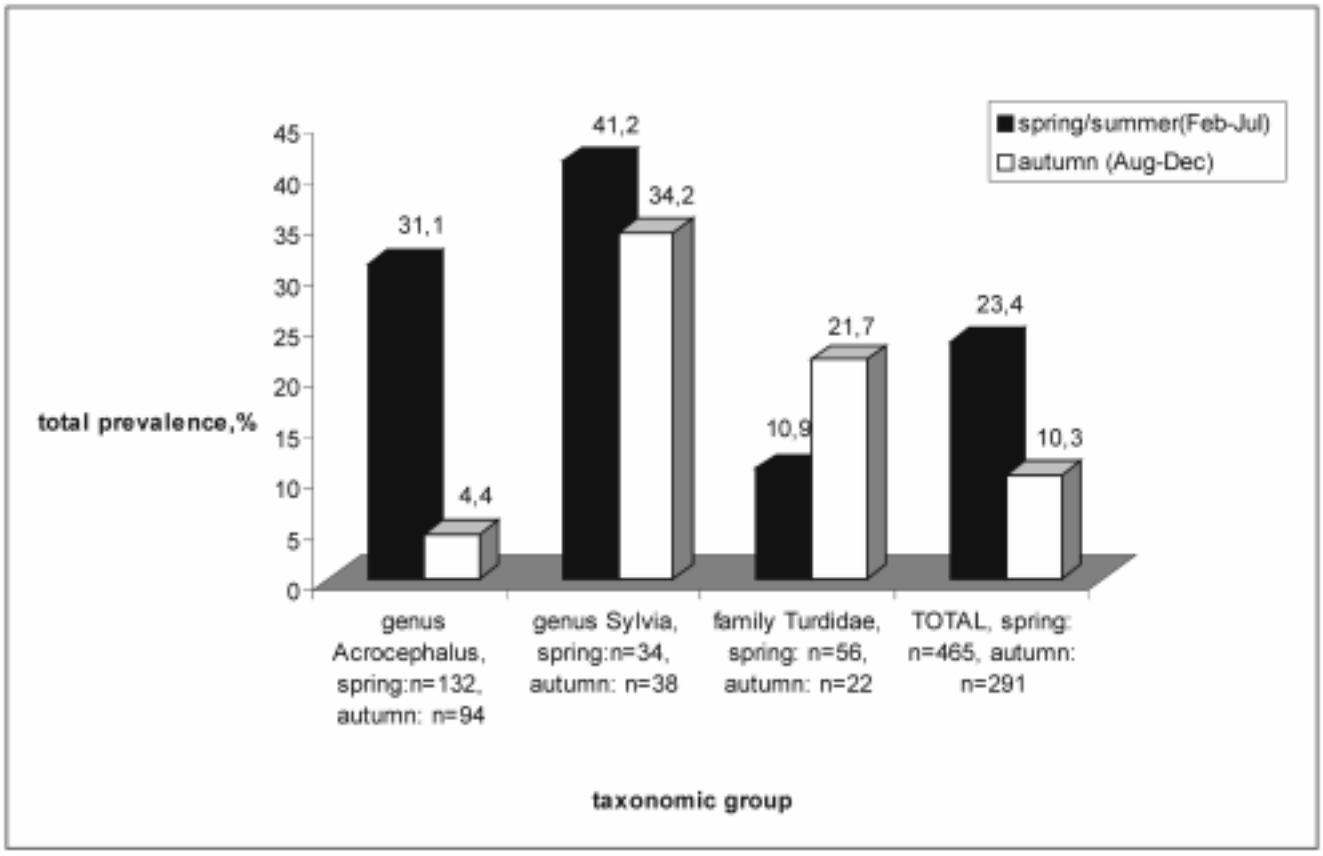

Fig. 3. Seasonal differences in the total prevalence of the haemoproteid invasions: a comparison among different taxonomic groups of birds

***Haemoproteus picae* Coatney et Roudabush, 1937**

Morphology. A fully-grown gametocyte fills the poles of the infected erythrocyte and has a tendency to encircle its nucleus. Nevertheless a case with a fully encircled erythrocyte nucleus was not observed. The gametocyte has entire margins. The parasite nucleus is ellipsoid, situated closer to one of the ends and to the host cell membrane. The pigment granules are medium-sized to large, 10-18 in number. The largest granules are ellipsoid.

Host in Bulgaria: *Garrulus glandarius* (1 case of 1 examined)

Intensity of invasion. Found only once with a very low rate of infection (below 1).

Locality: Rupite, Blagoevgrad district. Found in the blood of a local breeding bird.

Notes. Distributed in Holarctic (Valkiunas 1997).

***Haemoproteus anthi* Mello, 1935**

Morphology. A fully-grown gametocyte fills the poles of the infected erythrocyte and strongly displaces its nucleus. The gametocyte has a tendency to encircle the erythrocyte nucleus, but a case with fully encircled erythrocyte nucleus was not observed. The parasite nucleus is situated closer to one of the ends. The pigment granules medium in size, 8-14 in number.

Host in Bulgaria: *Anthus trivialis* (4.8 %, n=21)

Intensity of invasion. Found only once with an infection rate of 2.

Locality: Nova Cherna. Found in the blood of a fall migrant.

Notes. Distributed in the Palaearctic, Ethiopic and Indomalayan zoogeographical zones (Valkiunas 1997).

***Haemoproteus motacillae* Bennet et Pierce, 1990**

Morphology. A gametocyte adheres to the host cell membrane in the polar zones, but often does not do so in the central zone. The gametocyte has entire or ameboid margins. The fully-grown gametocyte fills the poles of the infected erythrocyte and does not encircle its nucleus. The parasite nucleus is ellipsoid, situated close to the cell membrane of the infected

erythrocyte. The pigment granules are ellipsoid, large in size, number between 5 and 14.

Host in Bulgaria: *Anthus trivialis* (4.8%, n=21)

Intensity of invasion. Found only once with an infection rate of 9.

Locality: Nova Cherna. Found in the blood of a fall migrant.

Notes. Distributed in the Palaearctic, Ethiopic and Indomalayan zoogeographical zones (Valkiunas 1997).

Haemoproteus noctuae Celli et Sanfelice, 1891

Morphology. Circumnuclear parasite**.** A fully-grown gametocyte does not adhere to the host cell nucleus. The gametocyte has entire or ameboid margins. The parasite nucleus is large, centrally located, rarely displaced towards one of the ends. The pigment granules are small to large, between 15 and 29 in number. In the microgametocyte granules are often gathered at the poles. The measurements of the parasites and the host erythrocytes are shown in Table 6.

Host in Bulgaria: *Asio otus* (1 case of 1 examined)

Intensity of invasion. Found only once with an infection rate of 18.

Locality: Nova Cherna. Found in the blood of a breeding bird.

Notes. Distributed in all zoogeographical zones (Valkiunas 1997).

Haemoproteus hirundinis Sergent et Sergent, 1905

Morphology. A fully-grown gametocyte fills the poles of the infected erythrocyte. The gametocyte has entire margins. The pigment granules vary from small to large, around 10 in number.

Host in Bulgaria: *Delichon urbica* (1 case of 1 examined)

Intensity of invasion. Found only once with a very low rate of infection (below 1).

Locality: Vrana. Found in spring.

Notes. Distributed in the Holarctic, Ethiopic and Indomalayan zoogeographical zones (Valkiunas 1997).

Haemoproteus minutus Valkiunas et Iezhova, 1992

Morphology. Ever a fully-grown gametocyte is rarely longer than the host cell nucleus and never fills its poles. The gametocyte has entire margins. The parasite nucleus is situated closer to one of the poles, sometimes has a terminal position. The pigment granules are small, 4-10 in number.

Host in Bulgaria: *Turdus merula* (7.1%, n=14)

Intensity of invasion. Found only once with an infection rate of 10.

Locality: Nova Cherna. Found in a resident breeding bird.

Notes. Distributed in the Palaearctic. Described from Curonian Spit in the Baltic Sea in the blood of a Blackbird (*Turdus merula*). Other hosts are not known (Valkiunas 1997).

Haemoproteus caprimulgi Williams, Bennet et Mahrt, 1975

Morphology. A circumnuclear parasite**.** The young gametocytes and some of the grown gametocytes have no contact with either the host cell membrane or the host cell nucleus. The parasite nucleus has a variable location. The parasite margins are entire or ameboid. The pigment granules are 16-29 in number.

Host in Bulgaria: *Caprimulgus europaeus* (1 case of 2 examined)

Intensity of invasion. Found only once with an infection rate of 1.

Locality: Nova Cherna. Found in a spring migrant.

Notes. Distributed in the Holarctic (mainly Nearctic) and Indomalayan zoogeographical zones, rarely in the Palaearctic (Valkiunas 1997). In the description of the species (Valkiunas 1997) 2 types of growth are reported: the first with a strong displacement of the host cell nucleus, and the second (more rare) with circumnuclear gametocytes. In our samples, only circumnuclear parasites were observed (second type of growth).

Haemoproteus wenyoni Mello, Sa, Sousa, Dias et Noronha, 1916

Morphology. A gametocyte fills the poles of the infected erythrocyte, but never encircles its nucleus. The parasite margins are entire or ameboid. The gametocyte adheres to the host cell membrane at the polar zones, but often does not do so in the central zone. The parasite nucleus is clear cut, ellipsoid and situated closer to one of the poles. The pigment granules are small, usually between 18 and 20 in number.

Host in Bulgaria: *Sylvia atricapilla* (2.4%, n=42)

Intensity of invasion. Found only once with an infection rate of 9.

Locality: Rupite, Blagoevgrad district. Found in a local breeding bird on 30.04.2001.

Notes. Widely distributed species, found in all zoogeographical zones except the Australian. Rare in the Palaearctic. In the original description of the species (Valkiunas 1997) ameboid gametocytes were not observed, but volutine granules were found. So there is a difference between the original and our description.

***Haemoproteus dolniki* Valkiunas et Iezhova, 1992**

Morphology. A gametocyte fills the poles of the infected erythrocyte, but never encircles its nucleus. The parasite margins are entire. The gametocyte adheres to the host cell membrane at the polar zones, but often does not do so in the central zone. The erythrocyte nucleus is not displaced by the gametocyte. The pigment granules are medium in size, most often between 12 and 15 in number.

Host in Bulgaria: *Fringilla coelebs* (1 case of 3 examined)

Intensity of invasion. Found only once with an infection rate of 12.

Locality: Vrana. Found in a local breeding bird.

Notes. Distributed in the Palaearctic zoogeographical zone. The only known host species is Chaffinch (*Fringilla coelebs*) (Valkiunas 1997).

Prevalence and intensity of the invasion

The total prevalence of invasion of the birds studied is 18.5%. The prevalence of invasion varies considerably among different families of birds (Table 1). The highest prevalence is found in Laniidae: 66.7% (n=30). A high rate was also found in Muscicapidae: 27.3% (n=33); Sylviidae: 22.8% (n=351); and Turdidae: 15.0% (n=81). A low rate was found in Ploceidae: 3.45% (n=58). Of 46 birds studied from Paridae, none was invaded.

Data on the invasion of the best-investigated bird family - Sylvidae show differences in prevalence between some species and genera (Table 1). Prevalence in the genus *Sylvia* is 37.3% (n=76), which is nearly double the rate of the genus *Acrocephalus* (20.0%, n=235), (Fisher's exact test, p>0.99, n=311). The comparison between the prevalence of invasion of the genera *Sylvia* and *Acrocephalus* is not affected by other factors than the host species (genus). We chose these two genera because they are suitable for such a comparison. First they include closely related species of birds, long-distance migrants, infected with the same species of haemoproteids, caught in the same time and in 75% of the cases at one site (Nova Cherna). Additionally the samples are enough by number. The age and the sex structure of the birds caught were of the same order. Of 16 birds of the genus *Locustella* studied, no invasion was found.

According to their migration status, the birds studied could be divided into 4 groups: local resident birds; local migratory birds (caught in the period 20.05 - 31.07 or individuals proved to be local breeders out of this period); spring migrants (caught in the period 1.02 - 20.05); and fall migrants (caught in the period 1.08 - 31.10). Birds with clear appearance of breeding, captured before 20.05, were considered as local breeders and birds from the species, which do not breed in Bulgaria, caught after 20.05 were considered as spring migrants. Local migratory birds are more often invaded than local resident birds (Fig. 1): 25.3% (n=91) and 5.8% (n=173), respectively (Fisher's exact test, p>0.999, n=264). Data on winter and late autumn periods were not included in the graph.

In Fig. 1 it is shown that spring migrants are more often invaded than fall migrants: 31.4% (n=236) and 13.3% (n=226), respectively (p>0.999, Fisher's exact test, p>0.999, n=462). This difference could be explained, on the one hand, by spring relapses of most haemosporidioses, and, on the other hand, by invasion of the birds during migration and wintering (Valkiunas 1997).

When studying the prevalence of invasions of birds by haemoproteids by months, the maximum was found in May (Fig. 2). The total prevalence in spring and summer is 23.4% (n=465), which is considerably higher than the autumn prevalence of 10.3% (n=291) (Fisher's exact test, p>0.999, n=756). This disparity varies among different taxonomical groups of birds and for some families, such as Turdidae; the rate is the opposite of that for birds as a whole (Fig. 3). In such cases, birds migrating from the north are probably from populations more heavily invaded than Bulgarian populations of the same species. Supporting this presumption is the fact that the invasion prevalence of local breeding birds is 12.5% (n=265), just over half the rate of transitory migrants (22.5%) (n=462), (Fisher's exact test p>0.999, n=727).

The intensity of haemoproteids invasions varies greatly. Most invasions are of low intensity, between 1 and 10 parasites per 100 microscope fields. This fact supports Valkiunas's (2000) assertion that heavily invaded birds are difficult to capture by the use of nets because they are more stationary. Very high rates of invasion have

been found in both spring and autumn. The highest intensity registered is 335 parasites per 100 microscope fields in the blood of a Lesser Grey Shrike (*Lanius minor*) (25.05.1999, Nova Cherna).

Three cases of mixed invasions of haemoproteids were observed in this study. Two Spotted Flycatcher (*Muscicapa striata*), were invaded with *H. balmorali* and *H. pallidus*, and a Marsh Warbler (*Acrocephalus palustris*), with *H. payevskyi* and *H. belopolskyi*. Similar cases have been reported frequently by other authors (Valkiunas 1997). Mixed invasions by haemoproteids and other groups of blood parasites (*Plasmodium, Leucocytozoon*) were observed in this study on 10 occasions. The prevalence of invasion by haemoproteids of birds infected with other genera of haemosporidians is 18.5 percent (n=54), a rate that is the same as that of all birds studied.

DISCUSSION

Of the 21 species of Haemoproteids found, 19 are new for the Balkan Peninsula. Finding *H. velans* in the Palaearctic is of considerable interest. To date, the only evidence of the distribution of this species in the Palaearctic has been finding in the blood of Palaearctic Wryneck (*Jynx torquilla*) wintering in the Indomalayan zoogeographical zone (Valkiunas 1997). The species *H. caprimulgi*, found in the blood of *Caprimulgus europaeus* in Bulgaria, is also very rare in the Palearctic (Valkiunas 1997). *H. attenuatus* was found in Bulgaria for the first time outside its typical locality. Several species of haemoproteids were found in new host species of birds: in Syrian Woodpecker (*Dendrocopus syriacus*) - *H. velans*; in Marsh Warbler (*Acrocephalus palustris*) - *H. payevskyi*; in Thrush Nightingale (*Luscinia luscinia*) - *H. attenuatus*; and in Reed Warbler (*Acrocephalus scirpaceus*) - *H. belopolskyi*.

In birds of local breeding populations, 14 species of parasites were found. Another 3 species were found in the blood of spring and fall migrants (*H. attenuatus, H. balmorali, H. pallidus*), 2 only in fall migrants (*H. anthi* and *H. motacillae*), and 1 only in spring migrants (*H. caprimulgi*).

The total prevalence of invasion of the birds studied is 18.5%. For a comparison with some other areas of Eurasia, information is provided in Table 7. These studies are comparable because the species composition, the number of birds studied, and the periods during which the birds were captured are similar. From these data, it is clear that the percentage of invaded birds in Bulgaria is higher than most other regions, including England, Poland, former Czechoslovakia and Kazakhstan. The prevalence of haemoproteids invasion in Bulgaria is lower than that of Curonian Spit in the Baltic Sea.

Variations in prevalence among the bird families have been reported by other authors (Jakunin 1972, Kučera 1981, Valkiunas 1985). Kučera (1981) identified the following families of passerines as the most heavily invaded in Central Europe: Hirundinidae, Emberizidae, Fringillidae, Paridae, Muscicapidae and Laniidae. All of these except the last 2 are among the least invaded in Bulgaria. At the same time, families such as Sylvidae, Turdidae and Motacillidae are considerably more often invaded in Bulgaria, as compared with Central Europe. It is possible that these differences depend not only on geographic location, but also on the year in which the birds are gathered.

In our study local migratory birds are more often invaded than local resident birds. Similar results were reported by Kucera (1981) for Central Europe. Valkiunas (1997) noted that in different studies there are contradictory data on this topic. The contradictions are mainly due to the differences in the composition of the species of the birds studied and the periods of capture (Valkiunas 1997).

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REFERENCES

Bennet G. F., Whiteway M., Woodworth-Lynas C. B. (1982) A host parasite catalogue of avian haematozoa. Occasional papers in biology, No 5, Memorial University of Newfoundland

Bishop M., Bennet G. F. (1992) Host - parasite catalogue of the avian haematozoa: Supplement 1, and Bibliography of the blood-inhabiting haematozoa: Supplement 2. Occasional papers in biology, No 15, Memorial University of Newfoundland

Dymowska Z., Żukowski K. (1965) Pierwotniaki pasożytnicze w materiale sekcyjnym z ptaków puszczy Kampinoskiej. *Wiad. parazytol*. **11:** 477-481

Dymowska Z., Żukowski K. (1968) Pierwotniaki krwi ptaków odłowionych na terenie Bieszczadów. *Wiad. parazytol*. **14:** 455-459

Jakunin P. (1972) Blood parasites of wild birds from South-eastern Kazakhstan. *Papers of Institute of Zoology AN Kazakhskoj SSR* **33:** 69-79 (in Russian)

Kučera J. (1981) Blood parasites of birds in Central Europe 3. *Plasmodium* and *Haemoproteus*. *Folia parasit. (Praha)* **28:** 303-312

Pasiotou M., Katsimpras A., Theodoropoulos G. (1992) A case of parasitism with *Haemoproteus columbae* in pigeons. *Bull. Hell. Vet. Med. Soc*. **43:** 196-197

Pierce M. A., Mead C. (1976) Haematozoa of British birds 1. Blood parasites of birds from Dumfries and Lincolnshire. *Bull. B. O. C.* **96:** 128-132

Pierce M. A., Mead C. (1977) Haematozoa of British birds 2. Blood parasites of birds from Hertfordshire. *J. Nat. Hist*. **11:** 597-600
Pierce M. A., Mead C. (1978) Haematozoa of British birds 4.Blood parasites of birds from Wales. *J. Nat. Hist*. **12:** 361-363
Plochinsky N. (1970) Biometry. Moscow University Press, Moscow (in Russian)
Ramisz A. (1965) Zależność występowania pasożytów krwi ptaków wróblowatych w Polsce od wędrówek oraz sezonowych zmian temperatury. *Wiad. parazytol*. **11:** 467-476
Theodoridis Y., Alexakis A., Matara C. (1998) The presence of *Haemoproteus* spp. in wild birds in Greece. *Bull. Hell. Vet. Med. Soc.* **49:** 307-310
Valkiunas G. (1985) Blood parasites of birds from Belomoro-baltijsky stream of migration. 2. Fauna and distribution of haemoproteids (Sporozoa, Haemosporida) *Parazitologia* **19:** 55-63 (in Russian)
Valkiunas G.(1997) Bird Haemosporida. *Acta zool. Lituanica* **3-5:** (monograph)
Valkiunas G. (2000) Sampling bias in bird Haematozoa investigations. EMOP, 8, Abstracts. *Acta parasit.* **45:** 160
Valkiunas G., Iezhova T., Golemansky V., Pilarska D., Zehtindjiev P. (1999) Blood protozoan parasites (Protozoa: Kinetoplastida and Haemosporida) in wild birds from Bulgaria. *Acta zool. Bulg*. **51:** 127-129
Voous K. (1977) List of recent holarctic bird species. Ibis
Wenyon C. M. (1926) Protozoology: a manual for medical men, veterinarians and zoologists, etc., part 2. Bailliere, Tindall and Cox, London
Wülker G. (1919) Über parsitische Protozoen Mazedoniens. *Archiv Schiffs Tropenhyg*. **23:** 425-431

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