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The Bulletin is a membership journal of the Scandinavian Society for Parasitology. Besides membership information, it also presents articles on all aspects of parasitology, with priority given to contributors from the Nordic countries and other members of the Society. It will include review articles, short articles/communications. Comments on any topic within the field of parasitology may be presented as Letters to the Editor. The Bulletin is also open for a short presentation of new projects. All contributions should be written in English. Review articles are commissioned by the editor, however, suggestions for reviews are welcomed.

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Cover: In Norse mythology, the giant ash tree - Yggdrasill - spreads its limbs over the entire mankind. The ash has three roots, each of them sucking water from its own spring.
The first spring- Hvergelmir - is found in the ice cold North; next to the spring, the serpent Níðhoggr is ceaselessly gnawing at the roots of the ash. The second spring - Mímisbrunnr - is the source of wisdom and is guarded by Mímir. The third spring - Urðarbrunnr - is guarded by three women, the Norns, which mete out man's thread of life.

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of the symposium on

ECOLOGY OF BIRD-PARASITE INTERACTIONS

arranged on behalf of the

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in Vilnius, Lithuania

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Ecology of Bird-Parasite Interactions

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PREFACE

The Baltic-Scandinavian symposium on "*Ecology of Bird-Parasite Interactions*" was held on behalf of the Baltic Society for Parasitology and the Scandinavian Society for Parasitology at the Lithuanian Academy of Sciences in Vilnius, Lithuania between 25th and 28th June 1998. It was the second parasitological meeting jointly organized by the Societies. The first Baltic-Scandinavian parasitological meeting "*Parasitic Zoonoses and the Ecology of Parasites*" was held in Lithuania in September 1994.

The Symposium on "*Ecology of Bird-Parasite Interactions*" was organized to strengthen the professional links, and to exchange ideas and information between parasitologists, ecologists, evolutionary biologists and ornithologists in the field of ecology of bird-parasite interactions. The purpose of the meeting was to present and discuss results and to stimulate future research in the area as well as to develop such co-operative projects in bird ecology that take parasitism into consideration. Owing to focusing on a single taxonomic host group, the symposium provided a unique opportunity for extensive interdisciplinary discussions on the subject. The meeting attracted more than 60 persons from 18 European countries, USA and Australia, as will appear from the present proceedings. During the symposium, the fascinating parasite-bird interactions were analysed ranging from a molecular level to the community spectrum with most participants interested in interactions on individual level and in populations. Several general problems of ecological parasitology were discussed. For example, migration and parasite dispersal, host fitness and population consequences, impact of parasites on bird population dynamics, bias of sampling in bird parasitology, etc. The papers based on plenary lectures given by invited speakers as well as abstracts of oral and poster presentations, are published in this issue of the SSP Bulletin. We hope the contributions will be stimulating for the advancement of ecology, parasitology, ornithology and evolutionary biology as well as for the interaction of these biological sciences.

On behalf of the organizing committee, we are pleased to express our deepest thanks to the invited lectures and other participants for their valuable contributions to the success of the symposium. We wish to record special thanks to the symposium sponsors: without this support the symposium would never have taken place. Support from the Scandinavian Society of Parasitology made it possible to produce the present issue of the Bulletin.

Through an editorial process, some linguistic corrections have been introduced, but the individual authors are responsible for the presented terminology, interpretations, etc.

28 September 1998

Gediminas Valkiūnas

Hans-Peter Fagerholm

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TICKS AND MITES AS PERMANENT AND TEMPORARY BIRD ECTOPARASITES, VECTORS AND DISSEMINATORS OF PATHOGENS

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Mites and ticks were first named by Aristotle, given the name ἄκαρής (Acaris - in Latin) that literally means "very short, small". The first description of a bird mite, most probably *Pteronyssus truncatus* - according W. Dubinin (1951), was made at the end of the XVII-th century. Now there are nearly fifty mite and tick families known to be parasites of birds (Fig. 1)*.

All representatives of the families can be divided into three large ecological groups:

1. Permanent bird parasites: mites, which are transmitted as a rule vertically - from parents to nestling (I in Fig. 1).
2. Temporary parasites - inhabitants of bird nests, transmitted mainly horizontally (II).
3. Temporary parasites, obligate bloodsuckers, which use ground-feeding and domestic birds as hosts (III).

Pathogen reservoirs and disseminators of disease agents are found mainly, if not exclusively, in the last two groups. There is a widely held opinion and increasing empirical evidence that vertically transmitted parasites, including mites, are less virulent than horizontally transmitted ones. A significant number of exceptions to this rule will be examined here. The principal scheme of mite development includes adults, ova, larvae and up to 3 nymphal stages. All, apart from the ova, may include parasitic stages. Amongst the bloodsucking ticks, ixodids have only three active stages, whereas argasids have one larval and a variable number of nymphal stages.

Freyanoidea mites - the typical representatives of the first ecological group - live on the barbs of the feathers mainly of aquatic birds. Their detrimental effects have not been adequately investigated. The majority of Pterolichoidea species live as external commensals or

* This scheme was made on the basis of the well known system constructed by Krantz (1978) and fulfilled and corrected by using the data of Russian scientists (Bregetova, 1956; Dubinin, 1951, 1953, 1957; Filippova, 1966, 1977; Gilarov, Bregetova, 1975, 1977; Volgin, 1969) and other acarologists (Kethley, 1982; O'Connor, 1982), whose systems were supported by the Russian taxonomists.

ACARI

Order	*Suborder*	*Supercohort / Cohort / Subcohort*	*Superfamily*	*Family*	*Subfamily*	*Localization*
OPILIOACARINA						
PARASITIFORMES	Ixodides (Ixodida)		Ixodoidea	Ixodidae	Ixodinae	II,III b,v
					Amblyomminae	III b,v
				Argasidae	Argasinae	II, b,v
					Ornithodorinae	II, b,v
				Nuttalliellidae		
	Mesostigmata (Gamasida)	Sejina				
		Cercomegistina				
		Antennophorina				
		Uropodina				
		Gamasina	*Gamasoidea*	Rhinonyssidae		I, rt
				Liponyssidae (*Macrinyssidae)*		II, b,v
				Dermanyssidae		II, b,v
				10 families		
ACARIFORMES	Sarcoptiformes (Acaridida, Astigmata)	Acaridides				
		Psoroptides	Analgoidea	13 families		I
				Apionacaridae		I, fq
				Dermoglyphidae		I, fq
				Epidermoptidae		I, s
				Knemidocoptidae		I, s,sc
				Laminosioptidae		I, sc,ff
			Freyanoidea	3 families		I, f
			Pterolichoidea	16 families		I, f,fq,sc
			Hypoderoidea	Hypoderidae		I, sc,ff
			Pyroglyphoidea	*Pyroglyphidae*		II,I s,sc
				Ptyssalgidae		I, fq
				Turbinoptidae		I, rt
			Psoroptoidea			
			Listrophoroidea			
			Sarcoptoidea			
			Cytoditoidea	Cytoditidae		I, rt
	Trombidiformes (Actinedida, Prostigmata)	Endeostigmatides				
		Labidostommatina				
		Eupodina	Tydeoidea	Tydaeidae		
				Ereynetidae	Ereynetinae	
					Speleognatinae	I, rt
					Lawrencarinae	
				Iolinidae		
			Eupodoidea			
			Adelloidea			
			Halacaroidea			
		Anystae				
		Eleutherengonina – Heterostigmae				
		Raphignathae	Raphignathoidea			
			Cheyletoidea	*Cheyletidae*	Metacheyletiinae	I, fq
					Ornithocheyletiinae	I, s
					Cheyletinae (Cheletosomatini)	I, fq,pr
					5 subfamilies	
				Harpirhynchidae		I, sc
				Syringophilidae		I, fq
				Cloacaridae	Pneumophaginae	I, rt
					Cloacarinae	
				4 families		
			Tetranychoidea			
			Eriophyoidea			
		Parasitengonae	Caliptostomatoidea			
			Trombidioidea	*Leeuwenhoekiidae*		II, s
				Trombiculidae		II, s,b,v
				5 families		
			Erythraeoidea			
			Hydrachnidia			
	Oribatida (Criptostigmata)					

Fig. 1 (previous page). Scheme of phylogenetic relationships of mite and tick bird parasites.

Bold letters - bird parasites only ; cursive bold letter - taxonomic groups in which bird parasites are present. I - first, II- 2-nd and III - 3-rd ecological group of acari-bird parasites.

Mite parasites of: f - feather; ff - feather follicles; fq - feather quill; rt - respiratory tract; s - skin; sc - subcutaneous tissues; al - mites as source of allergens; b - bloodsuckers; v - vector of pathogens; pr - predacious mites, inhabitants in the feather quill.

parasites on the wing and tail feathers, but some species are known to be very harmful bird parasites. *Pterolichus obtusus*, for example, causes agitation, weight loss, reduced egg production and ill-timed moult of wild and domestic birds. Syringobiidae mites differ from the other Pterolichoidea in that the species all inhabit the space within the quills on the flight feathers.

Six out of 13 families of Analgoidea mites inhabit wingfeathers and do not damage their host seriously, whereas all representatives of Epidermoptidae are parasites of the bird skin, often being a cause of serious diseases. *Epidermoptes bilobatus*, the "hen scabies" agent, injures the nape, throat and breast parts of the hen skin. Heavy invasion kills the host (Dubinin, 1953). Knemidocoptidae mites (Fain, Elsen, 1967) cause serious injuries of the bird legs (Dubinin, 1953), "scaly-leg" disease. Knemidocoptiasis is widely distributed among wild and domestic birds. When heavily infested by *Knemidocoptes mutans*, birds sometimes lose fingertips or a whole finger. Apionacaridae, Dermoglyphidae mites (Analgoidea) inhabit the space within the quills, feed on flaking tissues at the base of the quills and cause the host to react by pulling out their feathers. Laminosioptidae were most probably first parasites of the Mammalia (dogs and rodents) (Dubinin, 1951) which inhabit the follicles of developing feathers or subcutaneous tissues of birds.

Many mite families have a specific phoretic stage of their development - the deutonymph, also called the hypopus. In the suborder Sarcoptiformes, there is a very interesting family Hypoderidae (Fain, 1967) which inhabit nests of birds of many orders; their deutonymphs are parasitic in the subcutaneous, and more rarely the visceral, tissues of the host and increase their body size 4- to 5-fold during development. Deutonymphs of this mite have neither a mouth nor functional gut. The life cycle of Hypoderoidea is closely tied to those of their hosts, with new deutonymphs being produced near the hatching time of the hosts.

The group of Pyroglyphidae mites includes free living forms, nest inhabitants and parasites of bird skin and inner-skin layers (Gaud, 1968). Representatives of two first subgroups can serve as a strong source of allergens, from which not only birds suffer: inhabitants of synanthropic bird nests also cause allergies in man.

Trombidioidea (Trombidiformes) mites (Vercammen-Grandjean, 1968; Vercammen-Grandjean & Langston, 1971-1976, in: Krantz, 1978) are biologically distinct from the Sarcoptiformes bird-parasite. As a rule, their larval stage is parasitic but the deutonymph or adult are not. Some of them are even able to kill their hosts, e.g. *Apolonia tigipioensis* (Leeuwenhoekiidae) is fatal to chickens in Brazil (Torres & Braga, 1939: in Krantz, 1978). Some other Trombiculidae larvae use many species of birds as a source of blood (Tamiya, 1962, in: Kulagin & Tarasevich, 1972). These bloodsuckers include one of the main vectors of scrub typhus (tsutsugamushi fever), *Leptotrombidium akamushi*. It seems very probable that *Leptotrombidium deliense* - the major vector of scrub typhus in the Asian and Pacific region (Kethley, 1982) - uses migratory birds as hosts and in this way can serve to disseminate the scrub typhus agent. Harpirinchidae mites (Cheyletoidea) are skin parasites found on the surface of, or in, the skin of the throat, neck, breast and underside of the wings. Injuries are sometimes heavy: severe host tissue reaction appears, resulting in greatly enlarged tumorlike growths. Some species of Cheyletidae and all Syringophilidae live inside the quills of feathers and feed on subcutaneous fluids by piercing the wall of the quill. A single bird may host many mite species simultaneously, with each species inhabiting different feather tracts. Inside the feather quill, predacious cheyletids (Cheletosomatini) make a living by hunting on the other parasite mites (Volgin, 1969).

The whole bird respiratory tract, being a rich source of easily available food (mucus, frail cells, blood under the thin vessel walls) serves as a niche for many endoparasitic mite species of Acariformes. Turbinoptidae (Sarcoptiformes) are small and sluggish mites that inhabit bird nostrils and sometimes affect also the deeper parts of the nasal cavities (Fain, 1957). Cytoditidae, another representative of the same suborder, inhabit the mid to lower respiratory tract of birds. Speleognathid mites (suborder Trombidiformes), being much more mobile and pathogenic, are distributed along the whole respiratory tract and often cause bird death. Rhinonyssid mites are the only endoparasitic group among Gamasoidea (Parasitiformes). Their feeding stage is the protonymph. They inhabit the bird nostrils (Fain, 1957), and lungs (Butenko, 1984) and sometimes cause a lethal pneumonia. Many species of Rhinonyssidae are bloodsucking mites.

Clayton & Tompkins (1995) wrote that the virulence of ectoparasites (i.e. the harm they cause) is linked to mode of transmission, e.g. horizontally transmitted Mesostigmatid mites are much more harmful in comparison with vertically transmitted Analgesoides mites (Dubinin, 1951). Horizontally transmitted Gamasoidea, being bloodsucking mites, very often have as hosts not only different birds, but also mammals and reptiles, and can serve as the reservoirs, vectors and disseminators of many pathogens such as viruses, rickettsiae, bacteriae, spirochetes and protozoans (Bregetova, 1956). *Ornithonyssus sylviarum* (Liponyssidae) is known as a parasite of wild migratory birds, but in USA and Canada is a problem in the poultry houses where it can bite man and is suspected as an Ornithosis vector. The most dangerous bird parasites are in the Dermanyssidae family. Three stages of their development - adults, proto- and deutonymphs - are bloodsuckers. They can survive being frozen, their reproductive ability is great and their distribution is world-wide. *Dermanyssus gallinae* is a well known pest in the poultry houses. These mites spend most of their time in the nest material, emerging periodically to feed on the blood either of nestlings or of the lower belly of adults that are incubating eggs or brooding the young. They cause bird uneasiness, feather loss, decrease of weight and oviposition, and sometimes death of chickens. These are typical effects on wild birds also (Clayton & Tompkins, 1995). Being synanthropic, *D. gallinae* mites, parasites of pigeons and sparrows, often bite man and cause disease which even has the specific term acariasis (Zemskaya, 1973). Their ability to survive in a hungry state for more than 9 months makes this widely distributed species not only a vector of hen spirochetosis and Asian bird plague, but a reservoir and a disseminator of these pathogens.

Soft ticks (Argasidae, Ixodoidea), being inhabitants of nests and holes, have many features in common with the gamasid mites (2nd ecological group). All stages are bloodsuckers. They can survive many months (even years) in a hungry state (Filippova, 1966). They are distributed mainly in countries with a hot climate, are very resistant to the dryness and are a great pest in poultry houses. Birds can die through anaemia or from the effects of salivary toxins. Argasids are vectors of *Borrelia anserina*, the cause of the bird spirochetosis, and *Aegyptionella pullorum*, bird hemosporidiosis agent. They can also harbour arboviruses, some of which are pathogenic for man. Outbreaks of fevers in Dushanbe (Tadjikistan) caused by Issyk-Kul and Gissar arboviruses were connected with bites of *Argas persicus* and *Argas vulgaris*, parasites of synanthropic birds. We proved experimentally that Gissar arbovirus can be harboured and reproduced in the *A. persicus* body (Nemova *et al*, 1990).

Hard ticks (Ixodidae) belong to the second and third ecological groups. The latter plays the most important role as pathogen reservoirs and vectors. Ixodids have to be subdivided on 3 ecological subgroups. In the first subgroup are the permanent nest parasites such as *Ixodes lividus*. They can be reservoirs of many pathogens, from arboviruses to protozoans, but can rarely serve as the disseminators of pathogens, which are instead transferred mainly by their bird hosts (Filippova, 1977). *Ixodes uriae*, typical seabird parasite that inhabit cliff-nesting seabird colonies, belongs to the second subgroup. Its life is only partly connected with bird nests as it moults and survives off its hosts within the cracks in the rock face rather than in the nests themselves. They feed on the chicks of seabirds (e.g. on kittiwake during 3-6 days [Barton *et al*, 1995]) and can serve as the main pathogen reservoir. Migratory seabirds transport many pathogens (Lvov & Jliychev, 1979), whose survival and transmission cycles within foci are effected by *I. uriae*.

Ixodid representatives of the third subgroup are parasites of ground-feeding birds. They are represented mostly by larvae and nymphs caught on the host. The cause of such predominance might be due less to any preferential ability of host attachment by the pre-imaginal stages (adult females are much more mobile and aggressive [Alekseev et al, in press]), but the result of avian tick paralysis caused by engorged adult females, e.g. *Ixodes brunneus* engorged females kill passerines (Luttrell *et al*, 1996).

The representatives of the third group of ticks are 2- or 3-host parasites and, being the most ancient bloodsucking arthropods, can transmit pathogens of many taxonomic groups excluding Plasmodia (Alekseev, 1985). Parasites of ground-feeding birds (ticks as well as mites) can create extensive contacts between different reservoirs of pathogens: larvae engorged on rodents may continue their life cycle feeding on birds, emerged adults can transmit pathogen to man. Birds are a known reservoir of the *Borrelia garinii* - agent of neuroborreliosis (Van Dam *et al*, 1993) and sometimes serve as a source of more than one genospecies for the ticks that fed on them (Humair et al, 1996). The aggregated spatial pattern of preimaginal tick stages feeding on birds (Barton *et al*, 1995) allows the direct exchange of pathogens between cofeeding ticks (see survey: Randolf *et al*, 1996). The role of migratory birds and their parasitic ticks as disseminators of borreliae is now well proven (Anderson *et al*, 1988, 1990; Miyamoto *et al*, 1993; Nicholls & Callister, 1996 and other). Ticks that feed on birds transfer different borrelia species from North to South (Olsen et al, 1995), playing a role of pathogen mixers in the natural foci of borreliosis. *Ixodes ricinus* and *I. persulcatus* collected by us on the West-Europe migratory routes of birds (Finnish Gulf beach, Kurish Spit) demonstrated a marked difference in the borrelia species with which they are infected: *I. ricinus* were infected mostly by *Borrelia afzelii*, whereas *I. persulcatus* by *Borrelia garinii*. *I. ricinus* collected on the Kurish Spit in the fall contain 8 times more unidentified spirochetes than ticks collected in the spring (Alekseev *et al*, 1998). These results of our investigation concur with the data of Olsen et al. (1995). According to Postic *et al.* (1997) and our data (Alekseev *et al*, 1998), *Borrelia garinii* were found mainly in *I. persulcatus*. This phenomen may serve as proof that the interface in the triad: bird - *I. persulcatus* - *B. garinii* is much more important than has hitherto been considered. Ticks transferred by birds can re-establish natural foci of diseases on the territories where they were previously eradicated, e.g. by DDT (Chunikhin, 1966).

Our survey allows us to conclude that mites and ticks, creatures named by Aristotle "short, small", play not a small but a very significant role as bird parasites, vectors and disseminators of bird and man pathogens, and probably also host population regulators.

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PARASITES AS REGULATORS OF NATURAL POPULATIONS: FASHION AS A CONFOUNDING VARIABLE

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Fashion in science

We have come a long way since, in the 1960's, we were repeatedly warned that "The Ice Age cometh". In fact, we have come half-circle to the extent that "Global Warming" is said to be "the greatest environmental threat with which we are faced". The first of these fashionable exaggerations was promoted by a climatologist who wanted to establish a research institute. The second is energetically advocated by politicians who are anxious to divert attention, at the cost of a few millions, away from the overwhelming real environmental issues which actually face us today, and which would cost untold millions to deal with.

Fashion in parasitology

Though these examples of the effects of fashion are more dramatic than those affecting parasitology, our subject, I argue, is not immune to fashion.

In a review of Clayton Lane's (1932) monograph on hookworms Philip Manson-Bahr opened with: "Without doubt hookworms are the greatest source of human misery". This, remember, from the son-in-law of the 'father of tropical medicine'. (By the way, Lane justifies his monograph as providing a sound biological record for when the subject would be taken over completely by biochemists and mathematical modellers. Apart from the facts that some biochemists now call themselves molecular biologists, modellers call themselves ecologists, and both are still in the ascendancy, nothing much has changed in 66 years.) Hookworms are as abundant today as they ever were, except in Europe and USA, yet they are no longer perceived as a major problem. What has changed? Fashion! Hookworms have gone out of fashion.

Today it's malaria which is "the world's most important infectious disease", though for Croll (1973), malaria had ceded first place to schistosomosis. This was in the brief period between the euphoria of malaria eradication and the discovery of circum-sporozoite antigens as candidate vaccines. Malaria is, of course, promoted by organisations which need high-profile projects to justify their existence. In the same way that the Rockefeller Foundation needed hookworms, WHO and others need malaria. Desowitz

(1991), in "The Malaria Capers", is particularly eloquent on this point.

Molecules are also in fashion, so an enormous slice of malaria money goes towards technological innovation while, in actual fact, the malaria problem is almost wholly socio-economic. Malaria is generally easily diagnosed, easily, quickly and cheaply treated, very rarely fatal (except to visitors - hence our heightened perception of it as a problem); its epidemiology is well understood, and it is generally easily controlled. I've had malaria three times and influenza is much more unpleasant.

It cannot be denied that malaria does sometimes cause serious intractable disease, but not nearly as frequently as we are led to believe by the figures of one, sometimes two, sometimes three million deaths it is supposed to cause annually. The malaria PR machine rarely reminds us that the vast majority of these cases are easily avoidable nor that only one of the four malaria parasites regularly causes fatal disease, that nearly all deaths are in Africa, or that the problem is most serious in areas were the disease is epidemic, seasonal, or sporadic. For villagers living in holoendemic areas, who comprise the majority of cases, malaria is just one among numerous problems.

To some degree our fear of malaria was determined 100 years ago, when Ross himself, desperately campaigning for support in his search for the life cycle, 'confirmed' that the deadly kala-azar, now known to be quite a different disease, visceral leishmaniosis, was a form of malaria (Ross, 1899).

Malaria provides an excellent example of how fashion rather than reason has guided our approach to the study, interpretation and control of a parasitic disease.

Fashion in parasites and host populations

So malaria is today's fashion in human parasitology, but what of fashion in the study of the effects of parasites on natural populations of hosts?

In the early days of ecology parasites and disease were regarded as among the potentially important factors limiting population size: parasites were fashionable in ecology from the outset.

Comprehensive studies such as those of Findlay & Middleton (1932) on parasites as determinants of cyclic vole populations were at first very promising, with the discovery of the brain parasite, M organism later known as *Toxoplasma microti,* then *Frenkelia microti.* More detailed studies, however, failed to demonstrate significant effects on individuals, and certainly showed no measurable effect on populations (Elton, 1942). Similarly, early suggestions (Seligman & Sambon, 1907) that Scottish red grouse *Lagopus scoticus* populations were regulated by *Leucocytozoon lovati* could not be substantiated.

These and other examples led Lack (1954) among others to propose that parasites have little if any effect on populations. Fashion turned against parasites as ecological regulators and for some 25 years it became difficult to find more than a page or two on parasites in ecological text books.

Brilliant writers such as Baer (1952) and Esch (1977) kept alive the study of parasite ecology in its own right, but this was rarely related to host population dynamics or to general ecology.

Then in the late '70s and early '80s two major forces came to bear. On one hand, the intellectual duo of May and Anderson translated the recently developed models of insect population dynamics into parasite models (Anderson, 1977), opening the doors both for advanced video-games, and for focused field studies. On the other hand Hamilton, having made his major contribution to one of the great Darwinian anomalies, altruism, fixed his considerable mind on the other, sexual selection. Using very questionable methods and even more questionable data he and Zuk (Hamilton & Zuk, 1982) actually came up with a correlation which, surprisingly, agreed with their prediction.

The intrinsic value of May and Anderson's early parasitological excursions, or Hamilton's bizarre ideas is not important to the present argument. What is important is that, between them, they started a fashion. Parasites became fashionable both in ecology and evolutionary biology.

The new epidemiological field studies largely stimulated by Anderson led to a flood of excellent data on dynamics of parasite populations in relation to host populations. Other field studies designed to test Hamilton's ideas on sexual selection have led to a reawakening of interest in the effects of parasites on individuals, populations and species, from an evolutionary perspective.

Some comments on parasites in bird populations

Changing fashion regarding the importance of parasites in bird populations is reflected in studies on the Scottish red grouse. In the report of the Grouse Commission (Lovat, 1911), it was claimed that grouse populations are regulated by the nematode *Trichostrongylus tenuis*. Krebs (1978), in his excellent resumé of grouse population theories barely mentions parasites: populations were supposed to be regulated by the interacting effects of food supply and territory size. More recently, as shown by Hudson (1998) at this meeting , parasites have again become important. Even if we accept that grouse populations are regulated by parasites, grouse live at grossly inflated population densities in a semi-natural habitat managed specifically to encourage them. On a well-managed grouse-moor the only predation is by shooting (gamekeepers, encouraged by landowners, are notorious in their flouting of wildlife legislation, and remove natural predators), food is maintained at artificially high levels by management, and nesting sites are only limited by territory size. Grouse scarcely provide a good test of the effects of parasites on natural populations.

If parasites really were important in regulating populations, it would be expected that systematic natural changes in bird distribution or numbers would correlate with parasitological changes. A few examples of recent systematic changes in bird populations include the invasion of Europe by the collared dove *Streptopelia decaocto*, the decline in the British Isles of the house sparrow *Passer domesticus*, tree sparrow *Passer montanus*, song thrush *Turdus philomelos*, skylark *Alauda arvensis*. and the increase in siskin *Carduelis spinus*. None of these changes is fully understood, but changing habitat and food supply are thought to be responsible: there is no reason to suppose that parasites have had any influence.

It is quite clear that parasites may under certain circumstances have a disastrous effect on individuals and even, more rarely, on populations. Good examples are with malaria and trypanosomosis in Europeans and cattle trying to invade Africa or, possibly, the Hawaiian honeycreeper story (Warner, 1968). The effect of parasites on founder populations, either by protecting or eliminating the indigenous competitors is undeniable. I have called this the Wells effect: the protection of populations by their parasites (Ashford, 1997). The effect of parasites on host individuals is equally undeniable, though I would suggest that the broad assumption that any infection is harmful is a gross oversimplification. It is arguable that a light hookworm infection for example, may even be beneficial in maintaining normal homeostatic balances.

The most obvious instance where the factors which normally limit populations are inactive is in domestic birds or other animals The apparent importance of parasitic disease in domestic birds compared with natural populations (Bennett *et al*, 1991) is surely partially explained by the careful management of their habitat such that population densities can be increased by orders of magnitude.

All species produce young in excess of those required to maintain a stable population close to the carrying capacity, or equilibrium level of the habitat. It is only if parasites cause a population to be cropped excessively that they will reduce carrying capacity. The removal of the reproductive excess is frequently largely stochastic (weather etc.) or due to starvation, lack of habitat, or predation. Some of these factors are not density-dependent, so are additive. Others are density-dependent, so are not additive, but can replace one another. I suggest, it is only when all these parameters are ineffective that parasites become limiting.

Obviously, with r-selected hosts in unpredictable habitats, where there is a great reproductive excess, many individuals can be killed without reducing the subsequent numbers of breeders. With *K*-selected species in stable habitats, on the other hand, loss of even a few individuals may cause serious reduction in subsequent density. Presumably, therefore, parasites can 'afford' to be more pathogenic in r-selected than in *K*-selected hosts. As Moreau (1966) pointed out long before the *K*-r spectrum had been described, tropical passerines are astonishingly *K*-selected, so they should be excellent subjects for comparative study of any effects of parasites on populations.

Field studies

What we are interested to know, then, is not so much the effect of parasites on the mystical figure, R_0, which indicates the rate of increase of a population, but which factors limit the final, or equilibrium population density, that is, which factors determine the carrying capacity of the environment.

We have, over the past few years, attempted to find population studies on hosts, which were sufficiently detailed to allow the grafting of a parasite study to see if, indeed, parasites are important. Birds, of course, are the subjects of some of the best population studies but, to date, we have been unable to find a good candidate. We have looked, in association with ecological studies of varying depth, at some twenty host-parasite combinations. These studies cover haemoparasites in birds: sparrowhawk *Accipiter nisus* (Ashford *et al*, 1990, 1991) goshawk *Accipiter gentilis* (Toyne & Ashford, 1997), swift *Apus apus* (Ashford *et al*, 1994), and unpublished studies on the house martin *Delichon urbica*, dipper *Cinclus cinclus* and tawny owl *Strix aluco*; tapeworm larvae in rodents, and both blood and intestinal parasites of gerbils. In no instance have we found any of the predicted indicators that the parasites affect individuals sufficiently to have any measurable effect on populations.

One of the most serious problems we have faced is that of age as a confounding variable (even more than fashion, perhaps!). In our sparrowhawk studies we found that *Leucocytozoon toddi* infection was much higher in small broods than in larger ones indicating, possibly, that infection of adults reduced brood size. However, since most infection occurs at the nest and birds gradually lose their infection as they age and, further, older birds produce larger broods, the lower infection rate in larger broods may simply be because the parents are older and have lost their infection.

In our recent much more detailed (unpublished) studies on *Psammomys obesus*, the fat sand rat, in Tunisia, we looked at three blood parasites and a tapeworm. Using the eye-lens weight to give a reliable relative measure of age, we produced precise population pyramids for each sampling session, and superimposed infection rates. *Bartonella* infection was found to increase in prevalence with age, as was *Nuttalia meri* and an unidentified spirochete. Only the last parasite, which is the rarest, is absent from the oldest animals, indicating that the oldest animals are cured or that the infected ones are dead. There was no evidence of pathogenicity in the commoner parasites, but without precise measures of age, the results would have been very misleading..

With the tapeworms, there was close agreement between parasite load and age which, since older animals are heavier, gives the misleading impression that body weight is increased by infection.

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LONG-STANDING ASSOCIATIONS BETWEEN BIRD HOSTS AND NEMATODE PARASITES AS MANIFESTED IN CONSERVATIVE STRUCTURAL FEATURES IN SOME ASCARIDOID NEMATODES

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Sprent (1983), reviewing the classification of ascaridoids, aptly attributed the initiation of critical systematic investigations on this nematode group to the studies of Hartwich (1954, 1964, 1974). Dr. Gerhard Hartwich, who died in January 1998, made important investigations on different ascaridoids, including the enigmatic genus *Contracaecum* Railliet and Henry, 1912. The species of this genus occur mainly in bird- and mammalian hosts in the aquatic environment. Hartwich introduced the use of the "excretory" system, as observed by Jägerskiöld (1893), as a tool for classification. Hartwich (1964) also revised the classification of species of *Contracaecum* and established *C. microcephalum* (Rudolphi, 1809), a bird parasite, as the type species of the genus. Recent studies using isozyme electrophoresis and structural data have addressed the concept of species within the group (See Paggi and Bullini ,1994; Fagerholm 1988, 1991).

Caudal structures of the male have traditionally been shown to be important in delimiting species within this genus. If one recognizes an ordered distribution of the sense organs into distinct groups (Fagerholm, 1991) it appears that the numerous species of *Contracaecum* from birds, although occurring in different host species and regions of the world, are structurally isolated from species occurring in other host categories.

However, it has been noted that this apparent strict pattern is broken by the occurrence of one species, *C. ogmorhini* Johnston & Mawson, 1941, in otariid seals. This parasite, which has been shown to be found off all continents mainly in the Southern Hemisphere, (also the Pacific coast of S. Am: new data) is structurally similar to the species from birds (Fagerholm & Gibson, 1987). It is thus likely that the species has been secondarily adapted to otariid seals from a bird host, and is not a "primary exploitation" *sensu* Sprent (1986) (although mammalian origin the species occurring in birds can not be excluted). The hosts involved (only otariid seals) could indicate that this is a case of host-succession-extension, seals feeding on bird prey, although fish vectors could also have been directly involved (host-range expansion), although the latter alternative has sofar not been substantiated. (Still to be analysed is the systematic position of the bird parasite *C. multipapillatum* (Drasche, 1882) in which the proximal sense organs in the male may reach posterior to the cloaca (Fagerholm 1988), a feature, as a rule, not occurring in species found in birds). Host-range-expansion of anisakids between different animal phyla is a rare phenomenon in spite of existing trophic links. Instead, species tend generally to be host specific as is exemplified in a recent study by Olafsdottir and Hauksson (1997) on parasites of the gray seal.. Althoug rather host specific, detrimental effect on individual birds by these often very common parasites can be demonstrated (e.g. in *C. magnipapillatum* Chapin, 1925; see Fagerholm et al. 1996). However, a potential to regulate host populations remains to be shown (Fagerholm, 1996).

The present observations are supportive of a hypothesis of a long-standing co-evolutionary process of birds and the parasites of the genus *Contracaecum.* This can be inferred from the specific structural caudal features which are different from those found in species from phocid seals.. The occurrence of a "bird-type" *Contracaecum*-species in otariid seals represents a rare exception. Specific cladistic studies to suggest early events in the evolution of both the hosts and their parasites are needed. Homologous structural features also in ascaridoid species of other families are suggested to reveal exisisting morpho-clades. However, much additional basic descriptive work of numerous nematode species is needed to facilitate such studies (Fagerholm, 1991).

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PARASITES IN RELATION TO LIFE HISTORY AND SECONDARY SEXUAL TRAITS

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Field experiments on the collared flycatcher have demonstrated a number of trade-offs between life history traits. Antiparasite adaptations such as immune functions may also be costly. Therefore the possibility exists of trade-offs between reproductive effort and the ability to resist parasitic infections. Brood size manipulations of collared flycatcher females had negative effects on immune functions and resulted in increased intensity of haematozoan parasites at the end of the breeding season and increased prevalence the subsequent breeding season. Secondary sexual traits may also be costly. In male collared flycatcher the size of such a character also relates to immune function and degree of parasitism.

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THE CONSEQUENCES OF PARASITE INDUCED EFFECTS ON THE POPULATION DYNAMICS OF BIRDS

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Historically, the discipline of population ecology has had an interesting relationship with that of parasitology and nowhere has this been better illustrated than in the relationship between studies of birds and their parasites. While most birds carry parasites, and there have been many studies that have listed the parasites of birds, relatively few have examined what impact parasites have on the bird's population dynamics. Indeed, not until recently have field and experimental studies been undertaken which allow us to test the statement made by David Lack, more than forty years ago (Lack, 1954), that "While further evidence is needed, it seems unlikely that disease is an important factor regulating the numbers of most wild birds".

The failure of ecologists to study the impact of parasites on the demography of bird populations was principally because parasites were seen as benign symbionts that would have little impact on the host population. Ecological texts, such as Ricklefs (1973), considered parasites to be a special form of predator that did not lead to the death of its prey but one that adjusted its food supply to a level the hosts could withstand. As such, ecologists believed parasites and their hosts had evolved a balance with parasites reducing their virulence and the host developing defence mechanisms to maintain a balance.

In a series of papers, Anderson and May (1978, 1991) synthesised the disciplines of population biology and parasitology and demonstrated that parasites may operate in a density-dependent manner and are thus quite capable of regulating a host population. In particular, they identified the conditions when we could expect parasites to stabilise a host population and when the parasite could destabilise host numbers to an extent that could lead to cyclic or even chaotic changes in host abundance. Exploration of the characteristics of parasites indicated that attenuated virulence is not necessarily an advantage since this could compromise transmission, so we should expect virulence to be at a level that maximises transmission. As a consequence of these plenary studies, the patterns and processes of several parasite-host systems have been examined to determine whether parasites have an impact on the survival and breeding production of birds and thus have a consequence for avian population dynamics.

This paper will attempt to examine a number of features of parasite-bird relationships at the population level. Previous papers have examined the impact on individuals (Hudson & Dobson, 1995, 1997). Specifically, I address the question "What are the consequences of parasite induced effects at the population level?" and I examine this question by addressing three minor questions:

1. Do parasites regulate host abundance?
2. Do parasites cause population sinks?
3. Do parasites exclude host species?

I answer these questions using the premise that a combination of monitoring, experimentation and modelling is a productive approach to understanding disease dynamics. Within this paper I consider both macroparasites and microparasites and make no apologies for selectively using examples from my own work on gamebirds to explore these questions.

Parasites and host regulation

Regulation of host abundance will arise when there is a density dependent increase in parasite induced reduction in host fecundity or survival. Increased host density leads to higher transmission rates and an increased impact of parasites which if sufficiently large may regulate host abundance. We know from the work of Anderson & May (1978) that parasite induced reduction in host survival and an aggregated distribution of parasites within the host population will stabilise host numbers. In contrast, time delays in development, parasite reduction in host fecundity and a random distribution of parasites within the host population will tend to destabilise the dynamics (May & Anderson, 1978). The outcome for any system, given the constraints of other ecological processes, will then be a consequence of the tension between these various components.

Demonstrating regulation at the population level is not a simple task, and the only real approach is to manipulate, in an experimentally controlled manner the relative abundance of host or parasite and quantitatively predict changes in host abundance. Such an approach is relatively simple when you can predict when and where parasites are going to have a large impact on their host abundance and if experiments can be replicated both within and between populations. In this respect, investigating the role of parasites in cyclic species can be productive since we can expect the parasites to have a large impact during the decline phase of cyclic fluctuations and we can replicate the experimental removal of parasites within and between populations just prior to the cyclic crashes.

Detailed monitoring of grouse demography coupled with field experiments and mathematical modelling have demonstrated that the parasitic nematode *Trichostrongylus tenuis* reduces the fecundity and survival of red grouse and these effects are sufficient to cause the cyclic fluctuations observed in red grouse (Hudson *et al*, 1992, Hudson, 1992, Dobson & Hudson, 1992). Experimental treatment of a large proportion of grouse in 6 populations has prevented populations of grouse undergoing cyclic declines in abundance and demonstrated that parasites are not only sufficient but are necessary cause of population cycles of red grouse (Hudson & Dobson, 1997, Hudson *et al*, in ms).

Parasites and population sinks

Directly transmitted microparasites that induce a lifelong immune response in their host may die out in small populations after the number of susceptible individuals in the host population falls and any remaining susceptibles are protected from infection through herd immunity. Persistence depends on the influx of more susceptible individuals, recruited to the population either by birth or immigration from uninfected areas. Indeed, virulent pathogens can persist within a spatially structured metapopulation when hosts disperse between sub-populations, even when coexistence would not occur at the local population scale. The pattern of disease flow through the metapopulation will depend specifically on the type of system. Directly transmitted diseases may spread through the host population in a series of waves but tick borne diseases are relatively sedentary since ticks are restricted to specific habitats and can survive for a year or more in the absence of hosts. In this respect, tick borne disease may generate "host population sinks" by significantly reducing a local group of hosts, leaving a suitable and empty habitat for immigrants, which in turn subsequently become infected and die. Such areas are identified by immigrants as uninhabited suitable habitat, particularly since immigration by susceptibles may occur at a time of year when ticks are not active.

Preliminary population data from estates with the tick borne disease, louping-ill indicates that the heavy mortality caused by the pathogen is in effect causing population sinks. Such patterns contrasts with the areas without louping-ill where winter losses are consistently higher than breeding losses (Hudson *et al,* 1995, 1998). Levels of infection with louping- ill are independent of grouse density and consequently will not regulate grouse populations and disease could wipe out in local pockets. These can be considered true population sinks, not a pseudo-sink where immigrants artificially increase the population above a density dependent regulated density.

Parasite mediated competition

Competition, mediated through a shared natural enemy, is known as "apparent competition" and could be an important force determining community structure and biodiversity. Parasite mediated competition is particularly significant, given the rise in emerging diseases and the opportunity that pathogens have to reduce host abundance.

Ticks and other invertebrate vectors take their blood meal from a range of vertebrate hosts and provide an opportune route for between-species transmission. The bacterium *Borrelia burgdorferi,* that causes lyme borreliosis in humans, has increased dramatically in North America as tick numbers have multiplied following the expansion of white-tailed deer in rough scrub. The pathogen normally circulates in populations of the white-footed mouse, but changes in the acorn crop have altered the movement of mice and, together with other ecological factors, resulted in the increased passage of the pathogen from mouse to tick to humans (Jones *et al,* 1997).

Interestingly, parasite-mediated competition can occur through the presence of a second species that need not be a host for the pathogen. For example, in tick borne pathogens not all hosts are amplifiers; some produce a strong immune response so there is insignificant multiplication of the pathogen within the host and no transmission from host to vector. However, by providing a blood meal for the vector, they maintain the vector population and help the pathogen to persist. For example, in the louping-ill system, the mountain hare (*Lepus timidus*) is not an amplifier of the virus but is an important host for the ticks that carry the pathogen. As such the hares multiply the ticks and allow both ticks and virus to persist in red grouse (*Lagopus l. scoticus)* (Hudson *et al*, 1995). Therefore, competition is being mediated through the effects of a pathogen even though the host may not play any role in amplifying the virus. This is still parasite-mediated competition, however, because in the absence of the hares the impact on the grouse would be reduced.

Conclusion

Detailed experimental studies of individuals have demonstrated that parasites can reduce the survival and breeding production of individual hosts. More recently field experiments are starting to demonstrate that parasites have an impact at the population level. Some of our recent studies have shown that parasites cause the cyclic population crashed in numbers of red grouse, other parasites can cause population sinks and the presence of secondary hosts can act as a reservoir that can effectively eliminate a host. Parasites have an important role to play in the population dynamics of some bird species.

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AQUATIC BIRDS AS AGENTS OF PARASITE DISPERSAL: A FIELD TEST OF THE EFFECTIVENESS OF HELMINTH COLONISATION STRATEGIES

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The distribution of freshwater fish parasites is notoriously patchy, and considerable differences may exist in the helminth fauna of neighbouring catchments (Kennedy, 1981, 1985). The mobility and vagility of birds and their ability to serve as definitive hosts for many helminths whose larval stages are found in fish gives them the potential to cross inhospitable barriers, breakdown habitat isolation and introduce new species into localities (Kennedy, 1981). Esch *et al,* (1988) therefore suggested that allogenic species, and especially those maturing in aquatic birds, should have greater colonisation potential than autogenic species in that they could be dispersed more widely and rapidly. They tested this hypothesis indirectly by comparing helminth communities in selected species of fish and in different localities, and found that there were significantly higher levels of similarity within and between localities due to allogenic species when compared to autogenic ones in cyprinid and percid species. These findings were considered to support the hypothesis, but there has hitherto been no direct test of the hypothesis. In the present paper, an account is given of the changes in the helminth fauna of fish in a small lake over 28 years. The population crash and almost complete disappearance of the fish populations provided a unique opportunity to study the disappearance of helminth species and their recolonisation of the lake, and so a field test of the relative effectiveness of autogenic and allogenic colonisation strategies.

The lake under study is Slapton Ley, a small (0.7 km^2) shallow (maximum depth 2.5m), isolated, coastal, freshwater lagoon in Devon of recent origin (c. 1000 yrs) (Kennedy et al, 1994: Kennedy, 1996). The lake and its catchment have been the subject of investigation for many years and the fish and their helminth fauna have been studied regularly since 1970 (Kennedy, 1996). Attention has focused on the helminths of roach *Rutilus rutilus*, rudd *Scardinius erythrophthalmus*, perch *Perca fluviatilis* and pike *Esox lucius*. Eel *Anguilla anguilla* are also present in the lake, but studies on their parasite fauna did not commence until 1993. Information on the composition of the parasite fauna up to 1973 was summarised by Canning *et al,* (1973) and up to 1975 by Kennedy (1975). After

1973 samples of all species except eel were taken regularly, at least three times a year and in some years monthly, by the author and examined for parasites by standard methods. Over the period the lake has become progressively more eutrophic and by the end of the 1970s it approached the hypereutrophic state (Johnes & Wilson, 1996). During the severe winter of 1984/85 the lake froze over, and this produced the ideal conditions for winterkill of the fish (Kennedy, 1996). Populations of roach, rudd and perch especially fell to levels at which only a few, or even single specimens, were caught in the samples (Kennedy *et al*, 1994). A nucleus of species remained in the region of the main inflow river to the lake, and this formed the basis for the subsequent re-colonisation of the lake. Re-colonisation by rudd was first detected in 1987, but by roach and perch not until 1990. Pike were always catchable throughout the period, although they tended to be emaciated and in poor condition. Eel numbers appear to have been unaffected.

The lake has always been attractive to aquatic birds: flocks of *Larus ridibundus* regularly roost there, and both *Phalacrocorax carbo* and *Ardea cinerea* are regularly to be found fishing there. The expansion of the roach population in the early 1970s, however, attracted *Podiceps cristatus* to the lake for the first time in over 30 years. One pair bred in 1973, and the breeding population increased to between 5 and 8 pairs in the late 1970s. Following the crash of the fish populations, numbers declined and only one breeding pair was present in 1985, but by 1995 this had increased again to 9 or 10 pairs (Elphick, 1996). Other species of aquatic bird also declined between 1985 and 1990.

Prior to 1973, 9 species of helminth were reported from the 4 species of fish in the lake (Canning *et al*, 1973). Only 2 of these species were allogenic: *Diplostomum spathaceum* and *D. gasterostei.* The 7 autogenic species comprised 3 species of monogenean, 2 species of cestode and 2 species of acanthocephalan, (Table 1). Overall, the helminth fauna was species poor: the absence of proteocephalid cestodes, nematodes and adult digeneans from fish and the paucity of dactylogyrid species on roach and rudd are all believed to reflect the isolation of the lake and the difficulty of autogenic species in colonising it. Between 1975 and 1984 the autogenic species *Acanthocephalus lucii* became locally extinct and this was followed by *A. clavula* after 1987. However, *Podiceps cristatus* had introduced the allogenic species *Ligula intestinalis* and *Tylodelphys clavata* into the lake, both species being recorded for the first time in 1973, and later a third species, *T. podicipina*, in 1977 (Kennedy & Burrough, 1981: Kennedy, 1981). Thus by 1987 the composition of the helminth fauna had changed significantly from 7 autogenic species and 2 allogenic ones pre-1973 to 5 autogenic species and 5 allogenic ones.

Fish mortality following the 1984/85 severe winter, and the only slightly less severe 1985/86 winter, was catastrophic. The number per "standard" day's netting fell from 91.4 in 1984 to 1.6 in 1985 and 1.3 in 1986 (Kennedy *et al*, 1994). Recovery and re-colonisation was very slow and it was not until 1990 that populations again reached normal levels.

Table 1 Changes in the composition of the helminth parasite fauna of fish in Slapton Ley before and after the host population crash

Parasite species						**Year**						
	Status	**Pre 1973**	**1973**	**1977**	**1984 //**	**1990**	**1991**	**1992**	**1993**	**1994**	**1996**	**Host**
Dactylogyrus vistulae	Au	P	P	P	P	A	A	A	A	A	A	Ro, Ru
Neodactylogyrus sp.	Au	P	P	P	P	A	A	A	A	A	A	Ro, Ru
Tetraonchus monenteron	Au	P	P	P	P	P	P	P	P	P	P	Pi
Caryophyllaeus laticeps	Au	P	P	P	A	A	A	A	A	A	A	Ro
Caryophyllaeides fennica	Au	P	P	P	P	A	A	A	A	A	A	Ro, Ru
Ligula intestinalis	Al	A	P	P	P	P	P	P	P	P	P	Ro
Diplostomum spathaceum	Al	P	P	P	P	P	P	P	P	P	P	Ro, Ru Pe, Pi
D.gasterostei	Al	P	P	P	P	A	P	A	A	P	A	Pe
Tylodelphys clavata	Al	A	P	P	P	P	P	P	P	P	P	Ro, Ru Pe, Pi
T.podicipina	Al	A	A	P	P	A	P	A	A	P	P	Pi
Acanthocephalus lucii	Au	P	P	A	A	A	A	A	A	A	A	Ee
A.clavula	Au	P	P	P	P*[1]	A*[1]	A	A	A	A	A	Pe, Ee

*[1] = last recorded in perch in 1980 and from eels in 1987

2. = Eels are not included in the above table as they were not surveyed thoroughly until 1995. By that time *Pseudodactylogyrus* spp. (Av) and *Anguillicola crassus* (Av) were present. Neither taxon had been recorded in samples taken in 1987 or earlier years.

Au = autogenic; Al = allogenic

Ro = roach, Ru - rudd, Pe = perch, Pi = pike, Ee = eel.

When regular sampling became productive again in 1990, it was found that all the autogenic species with the exception of *Tetraonchus monenteron* on pike had disappeared from the lake (Table 1). The most plausible explanation of this is that the populations of roach, rudd and perch had fallen below the threshold level at which the helminth populations could survive and transmit i.e. below the break point, and so the parasite populations became locally extinct. The pike population, which remained at a higher level over the same period, was clearly large enough to permit the survival of *T. monenteron.* To-date, none of the autogenic species that went extinct have re-colonised the lake. By contrast, all the allogenic species have survived or re-colonised (Table 2). It seems probable that *D. spathaceum* and *T. clavata*, the most prevalent and abundant and least specific of the allogenic species, survived in the nucleus of the fish population: both species occurred in pike and in the few roach and perch caught between 1985 and 1989, and both species occurred at high levels of prevalence and abundance in 1990. By contrast, *D. gasterostei* and *T. podicipina*, the most specific and least common of the digeneans, did not re-appear in numbers until 1994 although a very few specimens of each were found in 1991. No roach infected with *Ligula intestinalis* were found from 1985 to 1989 inclusive (Kennedy *et al*, 1984) and only a single specimen in an old fish was found in 1990. By 1991, however, infection levels had risen to epidemic proportions It seems very likely, therefore, that *L. intestinalis* did not survive the roach population crash, but was re-introduced into the lake by *P. cristatus*, as were *T. podicipina* and *D. gasterostei.*

The impact of *L. intestinalis* on the fish populations has been major. It is specific to roach in the lake, and by 1975 it had reduced the roach population to a level at which intra-specific competition had declined and this in turn had relieved the inter-specific competition pressure on rudd, the population of which increased again (Kennedy & Burrough, 1981: Wyatt & Kennedy, 1998). Thereafter, as the transmission window for *L. intestinalis* narrowed (Wyatt & Kennedy, 1989), so the population declined until in 1984 it was barely detectable in the samples. The second cycle of infection commenced in 1991, and events were repeated. The expansion of the roach population after the population crash was checked (Kennedy *et al*, 1994), permitting a more equitable balance between roach and rudd numbers. By 1997 the *L. intestinalis* population had again fallen to barely detectable levels, and the species again appeared to be on the verge of local extinction. Thus, one allogenic species has had a profound effect on the relative abundance and population dynamics of the fish species (Kennedy, 1996).

At the time of writing, little seems to have changed since 1995 and 1996. Only 6 species are present in the 4 species of fish compared to the 11 recorded before the population crash, but 5 of these species are allogenic. Only one autogenic species has survived the crash: the others disappeared and have not re-colonised. Indeed, very few autogenic species appear to have been able to colonise the lake in its 1000 years of existence, let alone any re-colonise it. By contrast all 5

Table 2 Infection levels of selected helminth species in fish in Slapton Ley before and after the host population crash

Parasite species and infection level	Year									
	1979	1981	1983	1984 //	1990	1991	1992	1993	1994	1996
a) Perch										
Tylodelphys clavata										
Prevalence	100	98.2	100	100	100	100	100	100	100	80.0
Abundance	52.7	11.9	75.3	39.4	72.1	42.2	32.3	30.1	43.9	12.8
± SD	23.4	9.4	37.9	13.3	41.3	37.6	29.4	17.4	16.8	11.9
T.podicipina										
Prevalence	100	98.2	100	84.8	0	11.1	0	0	5.2	40.0
Abundance	7.2	8.8	6.7	2.9	0	0.05	0	0	0.05	0.4
± SD	3.3	3.6	2.8	2.2	0	0.2	0	0	0.2	0.2
Diplostomum gasterostei										
Prevalence	16.9	3.5	9.1	2.0	0	18.0	0	0	10.5	0
Abundance	0.04	0.003	0.12	0.02	0	0.18	0	0	0.23	0
± SD	0.001	0.06	0.3	0.001	0	0.04	0	0	0.4	0
b) Roach										
Ligula intestinalis										
Prevalence	16.3	11.4	2.1	3.1	1.4	71.4	69.7	45.6	16.7	2.1
Max. intensity	2	2	1	1	1	8	21	4	1	1
D.spathaceum										
Prevalence	77.1	88.2	N	N	100	100	100	94.1	100	100
Abundance	5.9	13.3			12.9	17.1	15.5	12.0	17.0	7.9
± SD	2.9	17.2			27.1	7.2	7.1	11.0	10.0	6.2

allogenic species are still present, and 3 are believed to have re-colonised since 1994. Allogenic species are thus clearly the more successful colonists and the role of birds as the agent of their dispersal and colonisation is of major importance. The hypothesis of Esch *et al,* (1988) is now supported not only by indirect evidence, but also by a direct test comparing the effectiveness of autogenic and allogenic colonisation strategies.

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BIRDS-PARASITES-VIRUSES: INTERPOPULATIONAL INTERACTIONS

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Objective: The birds are the most ancient reservoir of hundred viruses of 14 families. High population density determines the development of mass epizootics. Seasonal migrations promote virus distribution for long distances and their introduction in various ecosystems.

Materials and Methods: During the last 10 years ecological sounding of over 10 million km^2 of Northern Eurasia including Arctic, Northern-Middle Southern taiga, leaf-bearing forests, steppes, deserts belts was carried out.

Results: Among isolated 69 viruses 25 were described as new for the science. The features of interpopulational interaction of birds-arthropods viruses which lead to the development of epizootics and epidemics were studied. Such situation was examined in the following models: 1) transmitted by mosquitoes of the viruses of Karelia fever in eastern Fennoscandia Geta fever in eastern Siberia (Togaviridae, Alfavirus), West Nile virus of encephalitis in the South of Russian Plain (Flaviviridae, Flavivirus); 2) the group of viruses from Flaviviridae, Bunyaviridae, Reoviridae families the obligated hosts of which are birds and ticks *Ixodes uriae*; 3) influenza viruses.

Conclusions: For the purpose of revealing the emerging and re-emerging infections and prognosis of epidemic situations it is necessary to carry out the monitoring in key points of Northern Eurasia as a part of international program.

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DARWINIAN MEDICINE? LESSONS FROM AVIAN BLOOD PARASITE ECOLOGY

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The application of evolutionary biology to infectious disease research - what is optimistically called Darwinian Medicine (Williams & Nesse, 1991; Nesse & Williams, 1994; Ewald, 1994) - has generated much excitement, particularly among evolutionary biologists (e.g., Westoby, 1994; Futuyma, 1995; Stearns, 1999). In the context of infectious disease, the enterprise mostly involves application of optimality models to pathogenic organisms. Optimality models normally assume population dynamic equilibria, yet this is not an obvious feature of infectious diseases, where rich epidemiological dynamics are expected and frequently observed (Anderson & May, 1991; Nowak & May, 1994). Hence, the applicability of optimality models to infectious disease remains to be demonstrated empirically (Read *et al*, 1999).

Sex allocation theory, when applied to free-living organisms, has provided some of the best evidence in favour of the optimality approach to trait evolution (Charnov, 1982; Frank, 1990). If this body of theory can not be readily transferred to disease-causing organisms, there is little reason to expect that optimality models will successfully predict evolution of traits we understand even less well, such as parasite virulence. Let us consider how the former theory has fared in predicting sex ratios of blood parasites of the protozoan suborder Haemosporina. Each of the genera we consider produces sexually dimorphic transmission stages (gametocytes) in the peripheral blood of their vertebrate host. As we have argued elsewhere (Read *et al*, 1992, Shutler & Read, in press), gametocyte sex ratios should be under intense natural selection. Simple models can be used to predict a relationship between gametocyte prevalence (proportion of infectious hosts) in a host population and the sex ratio that should be favoured by natural selection (Hamilton, 1967; Read *et al*, 1992; Read *et al*, 1995). In populations where gametocyte prevalence (and hence proportion of hosts which are infectious) is low, transmission rates and hence frequency of multiple infections will be low. In such circumstances, gametes contributing to the mating pool within a vector blood meal will likely come from the same parasite clone. Self fertilisation will dominate, with natural selection therefore favouring female-biased gametocyte sex ratios. In contrast, where gametocyte prevalence is high, multiple infections will be common, and hence outcrossing more frequent. Under these circumstances, natural selection will favour gametocyte sex ratios closer to unity (Read *et al*, 1995).

Data from various populations of the avian protozoan genus *Leucocytozoon* conform remarkably well to this relationship (Read *et al*, 1995); data from the apparently similar genus *Haemoproteus* do not (Shutler *et al*, 1995). Irrespective of gametocyte prevalence, mean sex ratios in *Haemoproteus* populations fall in a relatively narrow band between 0.30 and 0.42. In most instances, the sex ratio is closer to 1:1 than to that predicted by theory. Elsewhere we have considered at length possible explanations for this disparity (Shutler & Read, in press). Three of these hypotheses have the merits of being plausible and relatively easily falsified. First, the gametocyte prevalences relevant to sex ratio evolution might be systematically underestimated in the genus *Haemoproteus*. This could occur if, for example, *Haemoproteus* is more readily cleared by host immunity than is *Leucocytozoon*. This would mean that transmission patterns responsible for sex ratio evolution in *Haemoproteus* would be those predominantly found in younger birds; the key parameter is thus gametocyte prevalence in those birds. Second, sex ratios close to 1:1 would be favoured even where selfing rates are high if rather few viable gametes are released per male gametocyte: natural selection should never favour sex ratios which result in unfertilised female gametes. This idea requires that *Haemoproteus* microgametocytes release fewer microgametes at exflagellation than do *Leucocytozoon* microgametocytes. Finally, *Haemoproteus* parasites in the populations considered by Shutler *et al.* (1995) are probably all vectored by midges; *Leucocytozoon* parasites are vectored by larger-bodied black flies (Simuliidae). If gamete numbers in a blood meal are more often limiting for *Haemoproteus*, sex ratios closer to 1:1 would be favoured to ensure that fertilisation occurred.

In principle, these ideas could be readily addressed with the right data:

- Are *Haemoproteus* infections more readily controlled than *Leucocytozoon* infections? How do host age-prevalence profiles compare for the two genera?
- Are there differences in the number of viable gametes per gametocyte at exflagellation? It may be possible to determine this on morphological grounds alone.
- Are gamete numbers more often limiting in blood meals within which *Haemoproteus* fertilisation occurs? It may be possible to assess this directly; of great interest would be *Haemoproteus* sex ratios in populations where substantially larger hippoboscid flies are the principle vector.

Finally, it would also be of considerable interest to have sex ratios of *Haemoproteus* and *Leucocytozoon* parasites drawn from the same bird population (better yet, the same birds). This would confirm that the different sex ratios reported by Read *et al.* (1995) and Shutler *et al.* (1995) reflect biological differences between the two genera.

There are at least three reasons why gathering such data would be a worthwhile exercise. First, at first glance (and even after serious consideration), the *Haemoproteus* data fly in the face of otherwise successful sex ratio theory; violations of theory may point to interesting (and currently unrecognised) biological factors which violate assumptions of the model. Second, gametocyte sex ratio is potentially a very cheap way of assessing population genetic structure in malaria populations (Read *et al*, 1992); we need to know if and when it is accurate. Third, if sex allocation theory can not make quantitatively successful predictions about infectious disease agents, the prognosis for Darwinian medicine, which concerns traits such as virulence for which we know substantially less about fitness consequences than we do in the case of sex ratio, is rather gloomy. Our data thus provide both a stimulus and a note of caution with which to temper the euphoric rush of optimality theorists into infectious disease biology.

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MACROPARASITES AS SELECTIVE AGENTS IN BIRDS

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Take any kind of bird, dissect it carefully, and the chances of finding macroparasites such as flukes, tapeworms, acanthocephalans or nematodes are very high. These worms will always extract resources from the host, and will often induce disease symptoms such as bleeding, immunopathology or diarrhoea. Intuitively, in a world where resources are limited and individuals are competing to leave most descendants in the next generation, adaptations to resist macroparasites must be of some importance. Still, despite the almost epidemic rise in the interest of parasites, there are surprisingly few studies on the evolutionary effects of macroparasites in birds.

From a practical point of view it is easy to understand why most workers have chosen other kinds of parasites as their models. Prevalences of blood protozoans can be estimated by taking blood samples and infection levels of ectoparasites like mites or lice can be determined by inspection. Most macroparasites of birds are endoparasites, and the level of infection can only be accurately determined by killing the bird and time-consuming dissection in the laboratory. Our knowledge of both the evolutionary and population dynamic effects of macroparasites in wild birds is therefore scant. The few good studies that exist typically come from game birds where large samples can easily be obtained (e.g. Hudson, 1986). Still, birds have probably been challenged by endoparasitic helminths throughout their evolutionary history, and these parasites can be found in almost every organ. If we are going to understand how parasites may affect important aspects of bird biology, such as life histories, mating systems or foraging behaviour, we certainly need more studies on macroparasites.

Selective pressure of macroparasites is density-dependent

Macroparasites are usually much larger than microparasites and can only infect the host via transmission stages. The number of parasites within a bird at a particular time is therefore a direct consequence of the number of successful infections. Usually, both the negative effect of a macroparasite on its host and the host-response to the parasite is density-dependent (Behnke & Barnard, 1992). This means that the selective pressure on the host to develop efficient resistance mechanisms is also density-dependent. If a particular parasite is to play any role as a selective agent on the host, the rate of exposure must therefore be sufficiently high over several generations to affect host fitness. We do not know whether this is a common phenomenon or not, since long-termed studies of exposure rates of macroparasites are extremely rare. We do know however that many macroparasites may show large variations in infection levels over time. In the example given in Fig. 1, the two nematodes, *Splendidofilaria papillocercus* and *Capillaria caudinflata*, show marked temporal variations in prevalence in willow ptarmigan (*Lagopus lagopus*) from an area in northern Norway during a seven year period. During the last years both nematodes have been rare, and any selective pressure exerted during earlier years, when they where more common, must recently have been considerably relaxed.

Observed infection patterns: Exposure or susceptibility?

Goater & Holmes (1997) suggested three requirements that must be met if parasites should play any role in the evolution of host traits: 1. Parasite numbers must vary within a host population; 2. This variation must be associated with variation in host fitness; and, 3. The traits selected for (e.g. resistance) will have to covary with parasite numbers. The evidence for the two first requirements are overwhelming; almost all macroparasites are nonrandomly distributed among their host individuals and in most cases where fitness effects on the host have been looked for experimentally, it has been found. The third requirement is harder to confirm.

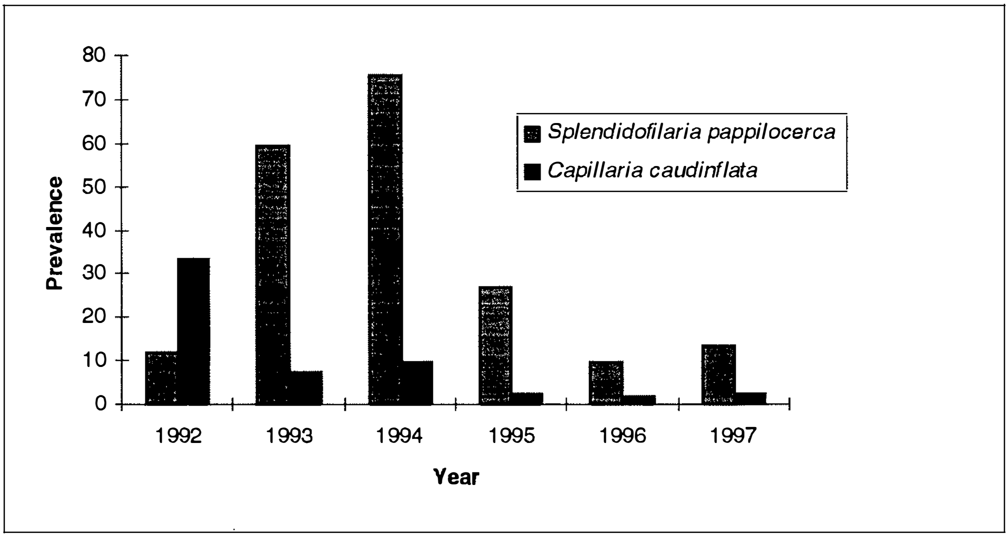

Fig. 1. Prevalence of two nematodes in willow ptarmigan from samples shot in the autumn each year in the period 1992 - 1997.

If a host trait, like resistance, is going to evolve, host individuals which develop this trait must on average have lower parasite burdens than those that do not. Although we know that many traits may affect the number of parasites in experimental hosts, it is much more difficult to demonstrate this from natural situations. Here, variations in parasite numbers will be determined both from variability in susceptibility and by external, ecological factors related to exposure. Many macroparasites tend to show marked variations not only in time (Fig. 1) but also in space (Fig. 2). Much of the variation in parasite numbers observed within a host population could therefore be caused by highly variable exposure rates where some host individuals have high infections simply because they happened to be at the wrong place at the wrong time, while others are parasite free because they accidentally have avoided being exposed. Variations in parasite numbers do not therefore necessarily tell us anything about host differences in susceptibility.

It might be argued that although exposure is highly variable and that hosts may acquire high burdens just because of bad luck, individuals that develop some resistance will still, on average, have lower parasite burdens. This is probably true, but given the large stochasticity in exposure, the effect of having different susceptibility on the realised parasite burden may be quite small. How can we separate the effect of exposure versus susceptibility in natural populations? Experimental laboratory infections are of limited value because hosts are not subjected to natural variability in exposure. Experimental field studies where hosts can be individually tagged and recaptured, or correlative studies between parent and offspring parasite loads (see for example Boulinier *et al,* 1997) would be better, but are limited to parasites that can be quantified without killing the host. The alternative is to do a cross-sectional study on the covariation of parasites with different routes of transmission.

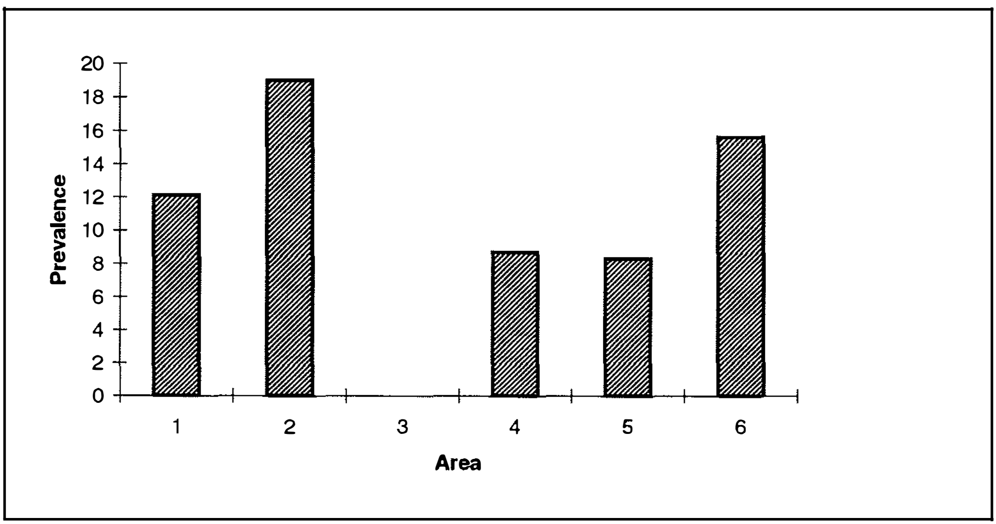

Fig. 2. Variation in prevalence of the filarian nematode *Splendidofilaria papillocerca* from 6 different areas in Tromsø county, Norway.

A cross-sectional study in willow ptarmigan

If differences in host susceptibility has an important impact on the distributional pattern of parasites, and if susceptibility is determined by some general host characteristic (e.g. nutritional level), we would expect that intensities of different parasite species will covary. We should therefore look at the distributional pattern - not of one parasite - but of many different species with different routes of infection. The typical overdispersed distribution of one parasite species tells us that it tends to accumulate faster in some host individuals then in others. If we look at another parasite species this would probably also show an overdispersed distribution, and so would a third and a fourth and so on. Then we could ask the question: Do the different parasite species tend to accumulate in the same host individuals? If various parasite species, with different transmission biology, tend to covary in intensities, it must be because they evaluate the host susceptibility similarly - some host individuals are generally good hosts and others are bad.

With this problem in mind we shot a sample of 55 willow ptarmigan (*Lagopus lagopus*) at a small locality within a few days (Holmstad & Skorping, 1998). The birds were infected with 8 different species of parasites. Some, like blood protozoans and the filarian nematode *Splendidofilaria papillocerca*, were transmitted by insect vectors, others, like coccidians and *Trichostrongylus tenuis* were monoxenous. We ranked the host individuals with respect to the numbers they contained of each parasite species. Then we performed a non-parametric anova to test if the ranking deviated from random. Within the whole sample we found a significant agreement in how different parasite species ranked the birds. Birds with high numbers of one parasite species tended to have high numbers of other parasites as well. This study therefore suggests that variations in host susceptibility do affect infection patterns, despite a large stochasticity in exposure. It therefore supports one of the basic conditions necessary if parasites are to play any role in the evolution of host traits.

Benefits of host adaptations must exceed costs

If variability in susceptibility does play a role in the parasite burden observed in a host individual, should we then expect hosts to evolve resistance mechanisms? This question is related to another requirement that should be added to the list of Goater & Holmes (1997). *If host traits are to evolve as a selective response to parasitism host individuals who develop the trait must on average have higher fitness than hosts that do not.* If the advantage of having some trait that confers resistance is small, because much of the variability is determined by the lottery of exposure, and the evolved trait in addition is costly, hosts that do not evolve the trait may have higher fitness. Both theoretical and empirical considerations suggest that most resistance mechanisms are expensive. Immune reactions require substantial metabolic investment that otherwise could have been used for other purposes (Wakelin & Apanius, 1997). An immune response will also have pathological consequences for the host - indeed immunopathological damage may be more harmful to the host than the parasite itself (see Wakelin &

Apanius, 1997). Behavioural adaptations to reduce exposure may also be costly - switching to another prey to avoid a food-transmitted parasite, could require longer search time and lower rates of energy intake. Finally, since hosts are usually exposed to many different parasites, developing an immune response to one may make it more vulnerable to others (Wakelin & Apanius, 1997).

One way that hosts could get around these problems is to develop the ability to respond to parasites in a flexible manner. The idea that animals are equipped with sets of rules that that can be used to adjust the investment optimally in different kinds of activities such as foraging or reproduction has dominated evolutionary ecology for several decades (e.g. Krebs & Davies, 1997). Within parasitology it has been suggested that the immune response of a host must be flexible and be traded off against other demands (Behnke & Barnard, 1992, Sheldon & Verhulst, 1996). The fitness cost of having a parasite may vary, not only with parasite burden, but also because parasite species differ in pathogenicity, depending on factors such as size, fecundity or location (Skorping *et al*, 1991, Read & Skorping, 1995, Skorping & Read, 1998). Recent developments suggest that the fitness effects of parasites may also depend on reproductive investment, age or other host-related factors and that the host should flexibly respond accordingly (e.g. Forbes, 1993, Skorping, 1996, Møller, 1997).

This idea of the evolution of an optimal immunological behaviour fits well with numerous observations on modulation of immunity by host factors such as stress or nutrition (Lloyd, 1995), and with the observed difficulties of inducing sterile immunity against macroparasites by vaccination (Behnke & Barnard, 1992). So far, however, it remains a fascinating idea. Developing testable models on immunological behaviour under specified ecological conditions is therefore a major challenge for the future.

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HAEMATOZOA OF WILD BIRDS: PECULIARITIES IN THEIR DISTRIBUTION AND PATHOGENICITY

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Abstract

Certain aspects of the ecology of haemosporidian parasites (Sporozoa: Haemosporida) of birds which await future research in ecology and evolutionary biology are highlighted. These include: (i) the difficulty of estimating the true level of infection by blood-film surveys, (ii) sampling bias in netting, trapping and shooting of birds, (iii) the influence of migratory behaviour of birds on infection prevalence at a place of investigation, and (iv) the problem of parasite species identification.

Key words: haematozoa, birds, pathogenicity, evolutionary biology, *Haemoproteus, Plasmodium, Leucocytozoon, Trypanosoma*

Much theoretical work in ecology and evolutionary biology has been based on the results of surveys of blood parasites. The investigation of avian blood using harmless for host methods gives a perfect opportunity to take large samples from both common and protected birds. These parasitological methods are particularly attractive to ornithologists. However, the investigations have also presented potential theoretical traps because of the complicated life histories of these haematozoa, the epidemiology of the diseases and the migratory behaviour of their avian hosts. The main aim of this paper is to highlight some important aspects of the ecology of haemosporidian parasites [phylum Sporozoa (=Apicomplexa), order Haemosporida, genera *Haemoproteus, Plasmodium* and *Leucocytozoon*] that may await future research. These groups of bird haematozoa have been investigated particularly well and have often been used in research on ecology and evolutionary biology.

Haemosporida of birds are obligate-heteroxenous parasites which use blood-sucking Diptera (families Culicidae, Ceratopogonidae, Simuliidae and Hippoboscidae) as final hosts and vectors. The life cycles of the parasites are reviewed by Atkinson and van Riper (1991) and Valkiūnas (1997).

The difficulty of estimating the true level of infection by blood film surveys

An advantage of ecological research using haemosporidian parasites as a model is that, once infected, birds remain infected either for life or many years (see Valkiūnas, 1997). This allows a long-period control of infected ringed bird specimens in natural populations. However, the period of patent infection is seasonally restricted and totally different in species of *Plasmodium*, *Haemoproteus* and *Leucocytozoon*. In the northern part of the Holarctic, most species of malarian parasites (genus *Plasmodium*) cannot be found in the blood in early spring and during the autumnal migration. The period of chronic parasitemia of *Haemoproteus* is longer than *Plasmodium*; however, gametocytes of most species of *Haemoproteus* are usually still absent in the blood in the early spring migration, and they disappear from the blood during the autumnal migration. Extensive search of blood smears may reveal a few gametocytes of *Leucocytozoon* in the early spring migration as well as during the late autumnal migration and even in winter. As a rule, birds infected with *Plasmodium* and *Haemoproteus* cannot be recorded during early spring or late autumnal migration by blood film survey, but *Leucocytozoon* is often registered. That is why the data on prevalence of infection, which are based on blood film microscopy, should be critically used in ecological investigations of Haemosporida. One should observe that absence of parasites in the blood does not necessarily mean that the investigated birds are not infected. The best season for blood investigation using a microscope is May-July in the northern part of the Holarctic. During this period, most infections are patent. Moreover, for *Plasmodium* the period of acute infection is very short with few parasites present in the blood during the chronic parasitemia even during the season of active transmission. An extensive examination of blood films is necessary; however, even this is not always enough to detect a *Plasmodium* infection. It should be mentioned that even when recorded, most of these chronic infections of *Plasmodium* cannot be identified to species, even by experts, because of low intensities and common mixed infections (Laird, 1998). Experimental inoculation of blood from wild birds into susceptible captive hosts gives better results but is expensive. As a rule, searching blood films reveals only a part of the real distribution of malaria. It is important to note that the same is true for *Trypanosoma as the* intensity of *Trypanosoma* parasitemia is usually low. The microscopy of blood smears is an insensitive method to determine the prevalence of *Trypanosoma* infection in birds. The method of cultivation of the parasites is at least 5-7 times more sensitive (see Kirkpatric, Lauer, 1985; Valkiūnas, 1997). Thus, data on prevalence of *Plasmodium* and *Trypanosoma* infections obtained by the blood-smear technique does not reflect the parasitological situation in free-living populations. Such data cannot be used to illustrate theories in evolutionary biology. Immunological methods are applicable for the estimation of the prevalence of infection (Graczyk *et al*, 1994) and promising on the generic level but are still inaccurate for parasite species determination.

Sampling bias in netting, trapping and shooting of birds

The majority of ecological investigations on Haemosporida are based on birds caught in mist nets or special stationary traps, for example big Rybachy traps on the Curonian Spit in the Baltic Sea. Only relatively healthy specimens that have been leading an active life in nature are available for investigation using these method of netting and trapping, but birds weak by parasitic infections are under sampled. All active birds are below a threshold level of parasitemia in the wild (Valkiūnas, 1997). That is about 40-50 parasites per 1000 erythrocytes in species of *Haemoproteus* in young (juvenile) birds, and it is even less for *Plasmodium* and *Leucocytozoon.* This explains why the heavy parasitemia has been extremely rarely registered in birds captured by netting even on endemic territories, but it is common in experimental captive birds and may be detected in the wild using special methods. One example is analysed here. On the Curonian Spit, the intensity of parasitemia of *Haemoproteus fringillae* does not exceed 5 % of the erythro cytes and it is usually considerably less in juvenile chaffinches *Fringilla coelebs* that have been caught in mist nets and big Rybachy traps (Table 1). The maximum level of the parasitemia in adult birds may be higher, but it usually does not exceed 10 %. Exceptions are extremely rare and have been recorded only in adult birds (Bennett *et al*, 1993). However, the primary parasitemia significantly exceeds the above-mentioned level, and may reach 25 % at the top of parasitemia in spontaneously infected juvenile chaffinches that have been monitored in the laboratory. Moreover, heavily infected young chaffinches were shot, and also recorded as road killers (Table 1). It is interesting to note that one male great tit *Parus major* heavily infected with *Haemoproteus majoris* was recorded by the author in the north of Lithuania. This bird was caught by a domestic cat. In this case the intensity of the parasitemia exceeded 30 % of erythrocytes infected. These facts can be explained in the following way. It has been shown that infected young chaffinches become less mobile at the top of

Method	Infected	Intensity of parasitemia Number of parasites per 1000 erythrocytes	
		minimum	maximum
Catching by mist nets and big Rybachi traps	674	<1	34 (24-48)
Shooting	49	<1	122 (100-141)
Killed by cars on the road	68	<1	69 (55-87)
Taken from nests and kept at the laboratory	5	<1	250* (233-278)

(95% confidence limits are given in parentheses) *data are given at the peak of parasitemia

Table 1. Intensity of *Haemoproteus fringillae* parasitemia in juvenile chaffinches depending on method of investigation (June -August 1983-1992, 1994)

parasitemia (Valkiūnas, 1997). Reduced mobility during the heavy phase of infection makes the birds more vulnerable to predators and other unfavourable conditions. It implies a reduced ability to compete and an increased mortality rate in nature. If birds survive the primary acute attack of the parasites, then they may be caught in mist nets. This situation creates two important conclusions. Firstly, only a relatively healthy part of a bird population is usually available both for ornithologists and parasitologists that have been using netting and trapping for catching birds. So, to measure the real impact of the parasites, special methods of investigation should be designed. These methods must allow the observer to follow the fate of birds during the critical phase of infection. Secondly, data on recaptures of wild ringed infected and non-infected birds, that are based on the netting and trapping, do not necessarily contribute to the understanding of the vitality of the individuals because the infected birds are specimens that have already passed through a heavy phase of the infection and have acquired premunition (Ahmed, Mohammed, 1978; Garnham, 1980; Valkiūnas, 1997). Furthermore, the method does not provide information on the fate of birds from the group of non-infected specimens which have caught the parasites between two periods of recapture. Data on recapture of chaffinches, either non-infected or infected (low chronic parasitemia) with *Haemoproteus fringillae,* on the Curonian Spit are shown in Table 2. Based on ringing studies, the proportion of chronically infected and non infected birds during the first year of life were almost identical. Surprisingly, the data shows that significantly fever non-infected than infected birds were recaptured in the successive year. One may speculate that some non-infected birds have subsequently gained the infection and have not survived the primary attack of the parasites. According to our data, over 20 % of non-infected chaffinches gain the infection in the second year of life on the Curonian Spit.

Status	Examined	Recaptured			
		in the year of birth (age up to 4 months)		in subsequent years (age up to 15 months)	
		n	%	n	%
Non-infected	502	26	5.2 (3.4-7.4)	20	4.0 (2.4-5.9)
Infected	299	17	5.7 (3.3-8.6)	28	9.4 (6.3-13.0)

(95 % confidence limits are given in parentheses)

Table 2. Recaptures of chaffinches, either non-infected or infected with *Haemoproteus fringillae,* on the Curonian Spit (breeding season in 1983-1992, 1994, 1996)

Probably, some of the infected birds have been eliminated as is found in juvenile specimens during the first year of life (Valkiūnas, 1997). These examples show that, in order to measure the real impact of the parasites, the results on recapture of infected and non-infected birds should be carefully interpreted taking all aspects of disease epidemiology into account. Ideally, field studied should also be supplemented by experimental work.

It is important to note that much of research in ecological parasitology has been based on blood parasites of game birds obtained by shooting. The shooting season is usually strictly restricted to a nonbreeding period when parasitemias are chronic or latent. This explains the rarity of recordings of heavy parasitemias in shot gamebirds (Valkiūnas, 1997). Consequently, the shooting data on infection intensities in gamebird populations should be carefully interpreted when used in ecology and evolutionary biology. It is important to note that, according to our data, the heavily infected (more than 5 % of erythrocytes infected) pied flycatchers *Ficedula hypoleuca* and great tits *Parus major* have never been recorded in bird samples from nest-boxes (see Valkiūnas, 1997). It is likely that birds with heavy parasitemia do not enter the boxes. These examples further show that special methods of investigations should be designed to be able to monitor the heavily infected part of the bird population.

The influence of migratory behaviour of birds on infection prevalence at a place of investigation

Migratory behaviour of birds should also be taken into consideration in parasitological investigations. One example is analysed here. A set sequence of migration of different populations of birds occurs during the seasonal migrations (Payevsky, 1985). As a result, data on infection of birds belonging to different populations are available at each place of investigation. Mixing of data from different populations causes difficulties in interpretation of the parasitological situation at any site of investigation. Infection of birds with *Leucocytozoon* on the Curonian Spit is an illustration (Fig. 1). In summer, only breeding chaffinches of the local Curonian population are present, and birds infected with *Leucocytozoon* are extremely rare. This is explained by (i) the absence of transmission of the parasites on the Spit due to lack of vectors (there is no breeding places of Simiiidae and, as a result, the young generation of chaffinches is non-infected), (ii) rarity of infection of chaffinches at wintering places and migratory routes and (iii) relative stability of the Curonian population of chaffinches (the local birds arrive to breed only on the Spit and the number of inhabited infected chaffinches from populations migrating over the territory is quite negligible) (Sokolov, 1991, Valkiūnas, 1997). A number of infected young and adult chaffinches were recorded on the Spit during migration of birds from northern populations (Karelian, Finnish, etc.) in spring and autumn. It is worth noting that especially high prevalence of the infection has been recorded in April and October when the birds of the northern populations migrate over the Spit. According to the ringing data, in autumn, the local population of chaffinches leave for the wintering places before the migration of birds of the northern populations starts. Conversely, in

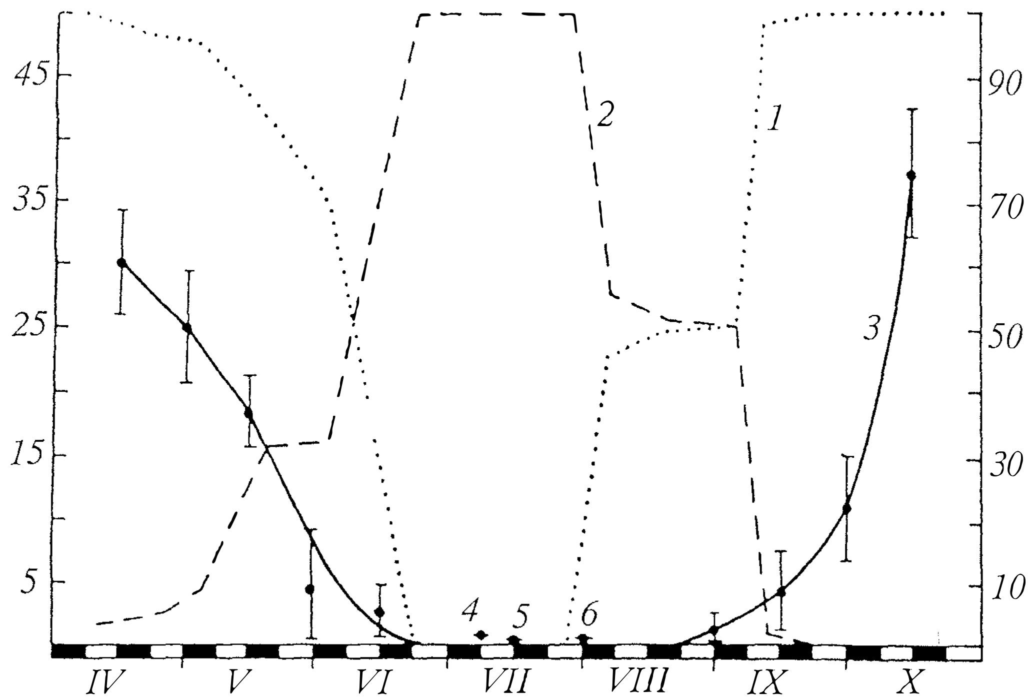

Fig. 1. Infection of adult chaffinches, trapped on the Curonian Spit, in relation to the affiliation of the bird population

1 - chaffinches from the northern populations migrating over the Spit; 2 - chaffinches from the local Curonian population (according to Sokolov, 1982); 3 - prevalence of *Leucocytozoon*, 4-6 - several cases of *Leucocytozoon* infection recorded in birds of the Curonian population. The abscissa is the calendar (months) and the ordinate: on the right - the number of trapped birds (percentage); on the left - prevalence of infection (percentage). Vertical lines are 95-% confidence limits.

spring, the northern populations migrate through the Curonian Spit before the local population arrives from their wintering grounds. This well explains the dynamics of infection of chaffinches with *Leucocytozoon* on the Spit (Fig. 1). The prevalence of infection strongly depends on the number of investigated birds belonging to the northern populations. This situation also leads to important conclusions. Firstly, to estimate the actual frequency of infection in a particular bird population, the data must be carefully analysed with reference to the ornithological situation in the area of investigation. Secondly, prevalence of infection in nonringed birds reflects the local parasitological situation only during a very short period in summer when migrating birds are absent from the region (for example, from 10 June until 10 August on the Curonian Spit in the Baltic Sea); however, the period might be prolonged for about a month by investigating only ringed specimens and birds caught on the nests.

An important feature of ecological studies on bird parasites in every geographical area is the necessity to estimate the relative number of long-distance immigrants inhabiting the territory following juvenile dispersal and seasonal migrations. Immigrants may introduce parasites into local populations. Sometimes, the number of immigrants is large enough to significantly influence the prevalence data. It is important to note that unusual parasites may be brought in by immigrant birds. That causes difficulties in the interpretation of the epidemiology of infection at the study site. For example, high prevalence of *Leucocytozoon* in the breeding populations of *Parus major* (prevalence of the infection is 14.3 %, 95-% confidence limit is 7.6-23.7), *Phylloscopus sibilatrix* (14.2 %, 4.7-27.9) and *Sylvia atricapilla* (47.6 %, 38.9-61.1) on the Curonian Spit is a result of active interchange observed between widely separated populations of these birds (Sokolov, 1991; Valkiūnas, 1996). As it was explained above, the transmission of parasites does not occur on the Spit. This creates a situation where only low chronic parasitemias (relatively benign in comparison to heavy ones) are present in the bird populations. Without question, such territories are not suitable for investigation of parasite influence on free-living populations.

Some species of bird Haemosporida are very common in Palearctic birds but are never (or infrequently) transmitted in the Northern Palearctic. As a rule, birds gain the infection at wintering places and on migratory path ways. The data on prevalence of such infections should be very carefully interpreted as they are not connected with transmissions during the breeding season. As a result, the heavy parasitemias are totally absent in the study area and only low chronic parasitemias may be recorded. For example, *Haemoproteus pallidus* is very common in *Ficedula hypoleuca* and *F. albicollis* in North Europe, but a great majority of the birds are infected in over-wintering sites in Africa (Valkiūnas, 1997).

The problem of parasite species identification

It is important briefly to note that the identification of species of bird Haemosporida is either rarely performed or not always correct in studies on evolutionary biology. Some misidentifications are common. For example, *H. pallidus* parasitizing *Ficedula hypoleuca* and *F. albicollis* has rarely been distinguished from *H. balmorali*. Correct identification is important because the life histories and virulence of different species are different and unknown for many species of bird parasites. Papers on evolutionary biology that are based only on generic identification do not correspond to demands of current parasitology.

To stimulate the progress in ecology and evolutionary biology using parasites as a model, joint projects on parasitology, ornithology and evolutionary biology are to be recommended. The participation of parasitologists is important not only during the phase of investigation of blood smears and identification of species of parasites (as usually is the case), but also during the phases of planning and data analysis. This would reduce the epidemiological mistakes (see Valkiūnas, 1997) that so often occur in ecological and evolutionary studies using parasitological data.

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ABSTRACTS OF SUBMITTED PAPERS: ORAL AND POSTER PRESENTATIONS

AVIAN PARASITE DATABASES AND COLLECTIONS: CURRENT STATUS OF THE INTERNATIONAL REFERENCE CENTRE FOR AVIAN HAEMATOZOA (IRCAH)

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The IRCAH collection is a unique resource which consists of over 64,000 specimens of avian blood parasites in stained blood films. The collection was begun with samples collected in Malayasia in 1959 by H. Elliot McClure, and examined for parasites by Dr. Marshall Laird with financial support from the U.S. Army Medical Research Unit based at Kuala Lumpur. This collection was expanded in 1963 under the joint auspices of the U.S. Army Research & Development Command (Tokyo, Japan) and the Walter Reed Army Institute of Research (Washington, D.C., U.S.A.). In 1968, the World Health Organisation (WHO, United Nations) established the International Reference Centre for Avian Malarial Parasites at Memorial University, Newfoundland, Canada under the leadership of Dr. Marshall Laird and Dr. Ellis C. Greiner. In 1975, the collection was reorganized and its title amended to the more appropriate, International Reference Centre for Avian Haematozoa (IRCAH), under the direction of Professor Gordon F. Bennett. In 1995, on Gordon Bennett's retirement, the IRCAH was donated to the Queensland Museum in Brisbane, where it now resides. The IRCAH collection has now been incorporated into the collections of the Queensland Museum and each specimen has been issued with a museum registration number in addition to its former IRCAH accession number. The collection will retain its integrity, be promoted as the recognised global repository for specimens of avian haematozoa, and its future protected by the policy of the Queensland Museum to preserve specimens in perpetuity. Although Australia now houses the IRCAH, there are records of haematozoa from only 16 species of Australian birds from a total of 770 species recorded. Research to document the blood-borne parasites of birds has commenced in a collaborative program between the Queensland Museum and the Currumbin Sanctuary, Gold Coast, Queensland. Preliminary results show relatively high intensities of haematozoa in species of the avian families Cracticidae and Meliphagidae/Oriolidae.

WSEVOLOD BORISOVICH DUBININ (1913-1958) AS A RESEARCHER OF BIRD PARASITES

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Wsevolod Borisovich Dubinin (1913-1958), being a researcher of the Zoological Institute and Deputy Director for the Zoological Museum, worked in different areas: ecological-parasitological studies of different vertebrate animals, a study of nest parasites and other inhabitants of burrows and nests, broad zoogeographic studies. A particularly convenient object of this research were feather mites. The study of these mites permitted him to reveal a number of patterns in distribution and relationships of Tubinares (1949, 1953), Anseriformes (1950, 1953), Galliformes (1950, 1956), Alcidae (1952), Pelicaniformes (1953) and ratite birds (1956). The important role of Antarctica (Archigea) in the Eocene and Miocene for the settlement of many birds from Indo-Malayan and Australian region to South America and much later invasion to Africa, Asia, Europe, and North America (1950-1956) was shown on the basis of the vast parasitological material. A thorough study was conducted of feather mites. This permitted him to create a three-volume monograph of the series Fauna of the USSR (1951, 1953, 1956). It is a comprehensive study of feather mites including not only fauna, morphology, taxonomy of this group of parasites, but also data on their ecology, host specificity, formation of parasite fauna, zoogeography, and paleontology. Up to now it remains the most comprehensive study of this group of bird parasites in the world.

W.B. Dubinin created a new system of Acari as a whole and determined the position of Acari within the system of Chelicerata (1956, 1957). Classification of separate groups of mites of superfamilies Analgesoidea, Demodicoidea and Cheyletoidea was elaborated in detail (1952-1954, 1956, 1957). Many representatives of these superfamilies are bird parasites.

In a study of parasitic Acari of birds and mammals W.B. Dubinin elaborated and widely used zonal-microclimate principle of the study of habitat of these parasites, principles of simultaneous integrated study of specific traits of Acari structure (their morpho-functional characteristics) and their biological functions. Such approach permitted to give up considering many Acari as "aberrant" species and show origin of separate species and parasitic fauna of the host as a whole (1947, 1951, 1953, 1956).

CHANGES IN POPULATION STRUCTURE OF AN ARGASID TICK *ARGAS ARBOREUS* DURING NESTING SEASON OF ITS HOST, THE CATTLE EGRET *BUBULCUS IBIS*, IN SOUTH AFRICA

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Objective: The life cycle of *Argas arboreus* Kaiser et al., a common parasite inhabiting rookeries of the Cattle Egret *Bubulcus ibis* (L.) all over the African continent, was studied earlier only in

Egypt (Kaiser, 1966; Guirgis, 1971; Hafez et al, 1971,1972). Comparative data on its life cycle from other areas are desirable.

Materials and Methods: Collections of *A. arboreus* from a rookery of the Cattle Egret during its nesting season in the Orange Free State (South Africa) were made and treated afterwards in laboratory to learn seasonal changes in the tick population.

Results: The nesting season in the studied bird colony lasts from October till March. At the beginning of the season (November) the population of ticks is composed of overwintered, freshly-engorged adult ticks (64%) and nymphs III (36%), as well as of numerous freshly-laid eggs. The only change in December consists in the hatching of larval ticks which actively attack the nestlings. More essential changes occur in January due to appearance of numerous nymphs I-II (66% of the whole population) and a decrease in number of nymphs III (9%) and adult ticks (25%). At the end of nesting season (February) the changes in tick population had opposite direction (a strong decrease in number of all nymphs from 75 to 44%, with an increase in number of adult ticks from 25% to 56%). The sex ratio among adult ticks is characterised by a male dominance with its decrease from 61.3% (November) to 52.6% (January) and with a further increase up to 60.2% (February).

Conclusions: The changes in population structure of the tick *A. arboreus* in the Cattle Egret rookeries in South Africa are similar with those in Egypt being synchronised with seasonal rhythms of the host. The usual univoltine life cycle of this tick can be complicated partly by its lengthening due to some adaptive seasonal delays of development at nymphal stage and of reproduction at adult stage.

PARASITE INFECTION IN THE GREAT TIT

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The parasite fauna of the great tit (*Parus major* L.) population on Gotland, Sweden has been studied for the last seven years. This study, from 1996-1998, focuses on the sexual signal, parasite status and immune response.

Fifty fields of a thin blood smear, taken from the brachial vein (at various times of the day), were examined using a x100 oil immersion objective. Parasite and leukocyte counts taken from two separate smears of the same blood sample were repeatable.

The two most common blood parasites identified: *Haemoproteus majoris* and *Hepatozoon parus* were less prevalent than in the years examined by Allander & Bennett(1994). *Isospora* sp. were identified in faecal samples. There was no significant difference between the leukocyte counts of chicks at day 14 then resampled as breeding adults. Whether the leukocyte count of individuals is significant in terms of fitness is still to be demonstrated in this population. Interestingly initial analyses shows that the chin area (ranked) is negatively correlated with the total white blood cell count ($r2= -0.31$, $p<0.05$, $n=53$), however; the sample can be increased and work still continues.

Reference
Allander K. & Bennett G.F. Prevalence and intensity of hematozoon infection in a population of great tits *Parus major* from Gotland, Sweden. J Avian Biol 1994; 25: 69-74

THE INTERMEDIATE HOST AS ECOLOGICAL DETERMINANT OF TAPEWORM FAUNA OF GULLS

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Objective: The role of intermediate host in the forming of cestoda fauna of birds is discussed.

Material and Methods: The life cycles of 26 species of cestodes were used for analysis, including our own data concerning the life cycles of 8 species from tundra of West Chukotka and 3 species from the Northern Sea of Okhotsk. Fourteen species of gulls from the North Pacific basin, Alaska and Antarctic as well as their cestodes were divided into two ecological groups with respect to association in the breeding season with marine or inland fresh or brackish-waters. The first group of gulls includes 4 species, the second one consists of 10 species. Respectively, the first group of cestodes includes 8 species: Hymenolepididae -2, Dilepididae -4, Tetrabothriidae -2. The composition of the second group is: Hymenolepididae -10 species, Dilepididae -3 and Schistocephalinae-1. Only 4 species of Pseudophyllidae occurring in both groups indicates the connection of birds with both fresh-water and littoral feeding sites.

Results and Conclusions: The cestoda fauna show clear subdivision of seawater and freshwater species. Hymenolepidids and dilepidids in seawater use polychaets, gammaridian amphipods and euphausiacean crustacean as intermediate hosts. Tetrabotriids use different species of fish as paratenic vertebrate hosts. The fresh water species of *Hymenolepis* (sensu lato) (Hymenolepedidae) of gulls use only branchyopodien artropods, Anostraca, Notostraca, and Conchostraca, as intermediate hosts. It is known from the paleontological data that (i) just Polychaeta may have given rise of Branchiopoda, (ii) the distribution latter in sea took place during Cambrian time and (iii) than Branchiopoda have been found only in inland waters. Current tapeworm fauna of birds feeding on branchiopods is determined by the species of cestoda which has historically developed in these invertebrates. Freshwater oligochaets are intermediate hosts for 4 species of *Aploparaksis* of gulls which are usually parasites of shorebirds. Dilepidids use gammarids and dipteran larvae (chironomids) as intermediate host. The life cycle of *Wardium fryei* give the opportunity to understand the role of the intermediate host in evolution of life cycles. Comparison of the data dealing with the process of host-speciation for large gulls, the main hosts for *W. fryei*, with the data on the distribution of parasite clearly has confirmed the correctness of hypothesis that tapeworm phylogeny does not mirror vertebrate host phylogeny. At the same time this comparison has corroborated the theory that in these cestodes evolutionary history of the cestode-invertebrate relationships was more archaic.

HELMINTH FAUNAE OF CHARADRIIFORMES IN ALASKA: PECULIARITIES OF ZOOGEOGRAPHY AND ORIGIN

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The original investigations and the literature on helminths of Charadriiformes (except Alcidae) in Alaska are generalised. The number of the Holarctic species of helminths in Alaska is significantly bigger than the number of their final hosts. Most probably that the current faunae of Charadriiformes helminths in Alaska maintains the features of the ancient fauna of the single Pleistocene territory of the East-Siberia and Alaska. Problems of (i) the helminths settling in new territories during settling in new places their final hosts and (ii) the relationship of parasitic worms with the ecosystems through their intermediate hosts, are discussed.

PARASITIC INFECTIONS IN BIRDS OF PREY IN THE NETHERLANDS

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From 1975-1990, the Working Group on Wild Bird Mortality in the Netherlands, and from 1991-1995 ID-DLO have investigated the cause of death of 4720 birds of prey (3685 Falconi- and 1035 Strigiformes). Of these birds, 820 (17.4%) died of illness. Of the ill birds, 470 (57.3%) died of infections with parasites. The most common birds were *Buteo buteo* (n=2027, 278 died of illness, of which 127 due to parasites), *Accipiter gentilis* (341, 44, 28), *Accipiter nisus* (462, 62, 44), *Falco tinnunculus* (603, 181, 111), *Tyto alba* (283, 38, 31), *Strix aluco* (187, 49, 34), *Athene noctua* (176, 43, 18) and *Asio otus* (361, 85, 62). Owls died more frequently from parasites (67% vs 54%) than Falconiformes. In Falconiformes, coccidiosis was common in *B. buteo* and *F. tinnunculus*. Infections with *Capillaria* spp. and ascarids were common in all above mentioned bird species. Infections with spirurids were commonly observed in *B. buteo, F. tinnunculus, T. alba* and *A. otus*, occasionally in the other mentioned species. Strigeid trematode infections were frequent in *B. buteo*, less in *F. tinnunculus, A. gentilis* and the owls, but absent in *A. nisus*. Cestode infections were common in *B. buteo* only. The airsac worm *Cyathostoma* spp. was found in *B. buteo, A. gentilis* and all owls. Acanthocephalan infections were only common in *S. aluco*.

ANALYSIS OF RETALIATORY REACTIONS IN DOMESTIC QUAILS AFTER CHALLENGE BY *SALMONELLA ENTERITIDIS*

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Objective: Domestic quails (*Coturnix coturnix japonica*) differ in shorter time of growth and higher intensity of metabolic processes comparing with hens and turkeys. Intensity of metabolic processes causes quails resistance to contamination with salmonellas. However, this question has no widespread investigation. In reference to it we decided to evaluate reactions of quails after challenge by *S. enteritidis* wild strain. For this aim several indexes were analysed: 1) death rate; 2) changes in concentration of carbohydrates; 3) dynamics of egg laying; 4) eggs and droppings contamination with *S. enteritidis*.

Materials and Methods: Forty quails were separated into two groups each of 20 birds. First group (V) consisted of birds which were vaccinated twice (on 30th and 45th days of life) with inactivated "TALOVAC 109 SE" vaccine. Second group (N) was formed of nonvaccinated quails. Both V and N groups were challenged orally by virulent *S.enteritidis* culture of one day growing in broth medium in dose 0.2 ml/bird. Registration of death cases and dynamics of egg laying was started at first day after challenge. Blood samples were obtained from wing vein in such order: one week before, one day post and one week post challenge. Peculiarities of metabolism of carbohydrates were evaluated according to concentrations of glucose, lactates and pyruvates. Droppings and eggs were examined for presence of *S. enteritidis* one month after challenge.

Results: During first week after challenge 25 eggs in group V and 5 eggs in group N were collected. Further laying in group N was disturbed entirely and didn't recover at all. Two weeks after challenge dying of birds in group N began. Mortality rose up to 20% . There was no dying in group V. Presence of salmonellas in droppings and eggs shell, yolk and albumen was examined by traditional cultural methods. No serotype of salmonellas was isolated one month after challenge. Breaking down of amount of glucose and lactates in quails blood samples was significant. Arising of concentration of pyruvates was ascertained at the same time.

Conclusions: Inactivated vaccine "TALOVAC 109 SE" prevents quails from mortality and breaking down of egg laying after challenge by virulent *S. enteritidis* culture. Challenge disturbed metabolic processes of carbohydrates both in groups V and N, however, concentration of glucose in group V recovers in significantly shorter time. No salmonella could be isolated from droppings and eggs one month post challenge.

SPECIAL FEATURES OF FORMATION OF FAUNA OF HELMINTHS IN URBAN AND WILD MALLARD *ANAS PLATYRHYNCHOS* L. POPULATIONS

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Civilization process causes formation of urban populations of wild birds near big cities and health-resort areas. Mallard shows a clear tendency for location near big cities. The high density of mallards in urban populations and special features of ecology influence the helminthfauna of this bird. In 1995- 1997, 106 mallards from an urban (Minsk) and a wild (Minsk and Neswizh districts) populations were dissected and examined for helminth parasites. Examinations showed the following results. The infestation was higher in the wild population of Mallard than in the urban one (75.6%, 53.8%; χ^2 =5.08, P=0.03). However, the abundance of certain species of helminths [*Echinoparyphium recurvatum* (Linstow, 1873), *Bilharziella polonica* (Kowalewsky, 1895), *Echinostoma revolutum* (Frohlich, 1802)] was higher in the urban population. The trematodes were the dominant parasites in both the wild and the urban populations (32.0%, 74.0% accordingly). The acanthocephales were common only in the wild population (32.0%). In the wild population, the dominant complex of parasitic worms was formed by *Plagiorchis multiglandularis* Semenov, 1927, *Cotylurus cornutus* (Rudolphi, 1808), *B. polonica.* The differences of infestation of males and females in the urban and the wild populations are insignificant (88.2% and 66.7%; 46.2% and 63.4%; $\chi^2 = 2.49$, P=0.1; $\chi^2 = 1.85$, P=0.25 accordingly). In the urban population, the infestation of adult birds was 3 times higher than young ones. The differences of infestation of adult and young mallards from the wild population are insignificant (82.4%, 70.8%; $\chi^2 = 1.97$, $P = 0.25$).

Thus the differences in helminth assemblages of mallards from the urban and the wild populations are connected with ecological conditions, first of all with its environment.

PARASITES OF FALCONS IN BELARUS

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The fauna of bird parasites of family Accipitridae has not been studied in Belarus because many species of raptors are under protection of law.

79 birds from eight species of falcons collected in Belarus were examined for helminth parasites between 1986-1996.

A total of 14 helminth species (8 nematodes, 5 trematodes, 1 cestode) were recorded from birds of family Accipitridae. Helminths were found in 49 birds (62.0%). 30 birds were free of helminth parasites. Eight helminth species were classified as the host specialists of falcons, and 6 species were noted to be the generalists in raptors and other bird species. Several widespread species [*Porrocaecum depressum* (Zeder, 1800), *P. angusticolle* (Molin, 1860), *Synhimantus laticeps* (Rudolphi, 1819)] are the basis of helminthfauna of falcons. The high intensity of infection of juvenile forms of *P. depressum* and *Cladotaenia globifera* (Batsch, 1786) was recorded from April to December in *Talpa europaea* L. (1-222) and *Sorex araneus* L. (1-18). It shows that these species of helminths are widespread on territory of Belarus. The prevalence of the infection was especially high in Buzzard (75.8%) and Marsh Harrier (66.6%).

Thus, the falcons are heavily infested with helminths. The fauna of the parasites includes both stenoxenic and euryxenic species.

EXPERIMENTAL TRIALS TO INFECT DOMESTIC DUCKS WITH COOT DIORCHIDS (CESTODA, HYMENOLEPIDIDAE)

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Many authors report about common coot diorchids parasitizing numerous species of Anseriformes. In order to verify if the domestic ducks may play the role of the final host of *Diorchis brevis* Rybicka, 1957, of *D. inflatus* (Rud., 1819) and of *D. ransomi* Johri, 1939, sixty birds of different age (from one day, one week, one month, two months to adults) have been exposed to experimental infestation. Invasive oncospheres have been taken from cestodes found in *Fulica atra* L. and contacted with *Heterocypris incongruens* (Ramd.), *Cypridopsis vidua* (O.F.M.), *C. newtoni* Brady et Rob., *Cyclocypris laevis* (O.F.M.), and *Notodromas monacha* (O.F.M.), in which invasive cysticercoides have been obtained. The experiments were carried out from June to December. The following numbers of ducks have been exposed to infestation with cysticercoids of:

D. brevis	6
D. inflatus-	23
D. ransomi	22
D. brevis + *D. inflatus*	2
D. brevis + *D. inflatus* + *D. ransomi*	7

After infestation faeces were examined every day, and from 14^{th} to 18^{th} day, sometimes later) and afterwards post-mortem examinations were done. In each case negative results have been obtained. Therefore, we agree with the opinion of Tolkacheva (1991) who examined rich Russian and Asian collections of diorchids and came to conclusion that there is no natural exchange of these tapeworms between coots and ducks. Of course, exceptions cannot be excluded, but they need careful and exact confirmation.

HEMATOLOGICAL AND BIO-CHEMICAL INVESTIGATIONS ON EXPERIMENTAL COCCIDIOSIS IN MEAT CHICKENS

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Objective: The aim of this study was to establish hematological and biochemical modifications in *Eimeria tenella* experimentally infested meat chickens, following different treatments with the Romanian anticoccidial Colidiniu.

Materials and Methods: The experiments were carried out as follows: group 1 - control; group 2 - 25,000 *E. tenella* oocysts were administrated to 30 days old chicken; group 3 - 25,000 *E. tenella* oocysts were administrated to 30 days old chicken and in the 5th day p. i., when the clinical signs have been appeared, 120 mg/l Colidiniu in drinking water was administrated and continued for 5 days; group 4 -25,000 *E. tenella* oocysts and 120 mg/l Colidiniu in drinking water were simultaneously administrated to 30 days old chicken; the anticoccidial administration was continued for 10 days. Blood was collected by cubital vein puncture from the 40 days old chickens and hematologic (hemoglobinemia, hematocrit, mean corpuscular hemoglobin concentration (MCHC) as well as biochemical (glycemia, proteinemia, ascorbic acid and calcemia) parameters were determined by current methods of the clinical laboratory.

Results: It was emphasized a marked lowering of hemoglobinemia in infected untreated chickens. The hematocrit

showed a marked decreasing tendency in group 2 compared with group 3, which was ameliorated for group 3. The MCHC as well as glycemia decreased in the untreated infested chickens. The glycemia also diminished in a hypoponderable chickens group infested with *E. tenella*. The lowest values of the proteinemia and ascorbinemia were recorded for the groups 2 and 3. Higher levels of calcemia were registered in untreated infested chickens compared with the treated ones.
Conclusions: The hematological and biochemical parameters emphasised serious perturbations in the meat chicken experimentally infested with *E. tenella*. They proved the therapeutic and prophylactic effects of the Romanian anticoccidial Colidiniu. It has no toxic or adverse action in concentration of 120 mg/l in drinking water. Further studies are needed to determine the therapeutical schedule to prevent or to treat the chicken coccidioses.

THE ASCORBIC ACID, STRESS AND POULTRY REACTIVITY IN PARASITIC DISEASES

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Objective: This paper presents the results of hematological, biochemical and behaviour investigations in chickens which were put to a caloric stress in comparison with chickens which received a supplement of ascorbic acid (AA) in food, also the AA status in chickens with experimental ascaridiosis.
Materials and Methods: We made the experiments on 10 days old broilers (chickens), supplementary fed with 2 g AA/kg fodder, monitored in comparison with some broilers left as control. Both groups of broilers were subjected to heat stress; the environmental temperature was 28-32^{0}C, the normal one for this age category being 22-26^{0}C. Another experiment, the cockerel Leghorns were infected with 1,200 *Ascaridia galli* eggs. Blood was collected by puncture in the cubital vein, using heparin as an anticoagulant. The AA content in the whole blood and tissue was determined according to the technical indications described by Roe and Kuether.
Results: After 4 weeks of breeding at temperature 28-32^{0}C, the weight increases, the hematologic and biochemical investigations have made evident a series of modifications as: lowering of hematocrit and pyruvic acid, as well as of AA in bursa Fabricius; increase of mean corpuscular haemoglobin concentration (MCHC) and of protein concentration, of turbidity with zinc sulphate and of AA content in: adrenal glands, kidneys, liver, spleen and total blood. The experimental infestation with *A. galli* eggs revealed decrease of the AA concentration in adrenal glands, starting the 9th day, leukocytosis, heterophilia and eosinopenia; lymphopenia was reported only during the first days after infection, subsequently followed by eosinophilia and a slight lymphocytosis.
Conclusions: The pathogenic action of the higher environmental temperature as the parasitic infection are permanent stressing factors, which affect the host's life as well as the evolution of the relationships between the organism and the

parasites, including the haematological and immunological restructuring and also the morphological and physiopathological modifications.

CONSEQUENCE OF A HIGHLY PROBABLE ERROR IN LABELING *DIORCHIS INFLATUS* AND *D. RANSOMI* FROM *AYTHYA NYROCA* GÜLDENSTÄDT

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Czapliński (1956) noticed and figured *Diorchis inflatus* and *D. ransomi* in 2 out of 23 examined *Aythya nyroca* Güld., determined at that time as *Nyroca rufa* (L.), shot at the Druzno Lake (Mazurian Lakeland in Poland). A re-examination of this material revealed that both white-eyed ducks were infected exclusively by these two species of tapeworms: 2 and 176 specimens of *D. inflatus* and 1 and 141 specimens of *D. ransomi.* Because no tapeworm species characteristic of Anatidae have been simultaneously found, and no similar result has been repeated in over one thousand anseriform birds post-mortem examinations, one explanation seems acceptable: the tapeworms were erroneously labeled as coming from white-eyed ducks instead of from coots. The relatively good figures of both mentioned tapeworms caused their citations by many authors and led to erroneous conclusions, among others, to the wrong synonymy of *D. parvogenitalis* with *D. ransomi* as it has been done e. g. in two known monographs by Spassky (1963), and by Spasskaya (1966) and numerous incorrect determinations of the cestodes found by many authors in ducks. It is so not only because of the wrong synonyms, but also because of identical number and similarity of shape and size of the rostellar hooks of following tapeworms: 1) *Diorchis ransomi* from coots with *D. parvogenitalis* from ducks, 2) *D. inflatus, D. americanus* and *D. brevis* from coots with *D. stefanskii* as one of the most common parasites of ducks. Czapliński B., Szelenbaum D. (1974) and Tolkacheva (1991) indicate how to distinguish each of the above mentioned tapeworm species. In our opinion the common coot diorchids are, as a rule, unable to parasitize ducks.

DIORCHIS ACUMINATUS (CLERC, 1902) CLERC, 1903 (CESTODA, HYMENOLEPIDIDAE) - A COMPLICATED TYPE OF THE GENUS *DIORCHIS*

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The present authors, thanks to Dr. C. Vaucher, were able to study a preparation deposited in the Museum of Natural History with inscription: "(T) Institut de Zoologie, *Diorchis acuminata* (Clerc, 1902), *Fulica atra,* Oural, M.M.V. 6/64 13/76 Universite de Neuchatel". This preparation contains 15 tapeworm fragments stained in the state of strong contraction not useful for exact morphological studies. However, there are among them two fragments with scolices: the first with 10 diorchoid hooks 68 μm long, belongs to one of the three possible coot diorchids: *D. americanus, D. brevis* and *D. inflatus,* the second being the most probable because of the characteristic recurvation of the blade. The fourth possibility - *D. stefanskii* is excluded because of the lack of a small incision at the blade base. The second fragment with scolex with 10 diorchoid (close to arcuatoid because of short guard and blade and long handle) hooks 28 μm long belongs to *D. elisae,* which is a typical tapeworm parasitizing Anatidae, until now not reported from *Fulica atra. D. brevis* was probably not noticed by Clerc (1903), because its length of hooks does not correspond with his own description. *D. acuminatus* is, as a matter of fact, a name referring to several species and begins to be out of use in recent papers. We consider *D. elisae* to be a synonym of *D. acuminatus,* as the type species of the genus *Diorchis,* albeit its presence together with *D. brevis* is probably a mistake, or a very rare case that needs experimental confirmation.

HOST SPECIFICITY OF *CLADOGYNIA PITTALUGAI* (LOPEZ-NEYRA, 1932)

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Cladogynia pittalugai has been described for the first time from *Anas platyrhynchos* L. coming from Grenada (Spain). Two specimens of this species were found for the second time by Krotov in one *Anas platyrhynchos* dom. in Sachalin and described as a new species *Dicranotaenia bisacculata* Krotov, 1949. It is noteworthy that Ryzhikov (1963) summarising results of helminthological research done in the Far East, indicates among potential final hosts of this tapeworm 1202 speci-

Table 1. Records of *C. pittalugai* in representatives of the genus *Aythya*

Region	Host	No of birds: infected	No of birds: examined	Intensity	Author(s)
Sachalin	*A. marila*	1	-	2	Krotov 1952
Kamchatka	*A. marila*	1	24	>200	Spassky, Bobova 1952
Poland	*A. fuligula*	1	130	8	our data
Slovakia	*A. fuligula*	"rare"	-	-	Macko, Birova 1985
Turkmenia	*A. fuligula*	1	13	16	Golovkova 1972
Chany Lake	*A. ferina*	1	14	2	Krotov 1949
Kazakhstan	*A. ferina*	5	32	1- 1237	Maksimova 1967
Tadjikistan	*A. ferina*	1	12	35	Borgarenko 1981
Canada	*A. affinis*	25	30 adult	1 - 7282	Hair 1975
Canada	*A. affinis*	12	52 juv.	1 - 77	Hair 1975

mens of the genus *Anas* and 195 specimens of the genus *Aythya* dissected in that region, in which only 3 times single hosts were infected with *C. pittalugai* (including the above mentioned report of Krotov (1949), the remaining two see below). Until now nobody has confirmed the occurrence of *C. pittalugai* in the final host of the genus *Anas,* but in Table 1 authors who have found this tapeworm several times in representatives of the genus *Aythya* are presented.

According to the data above, *Aythyini* spp. are the most common hosts of *C. pittalugai,* and most intensively infected hosts are adults of *A. affinis* in Canada.

ISOSPORA COCCIDIA (PROTOZOA, EIMERIIDAE) OF PASSERINE BIRDS ON THE COURISH SPIT

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Objective: We studied the level of *Isospora* infection in different species of wild passerine birds in nature during breeding period and autumnal migration. We had no possibility to dissect the hosts, but we tried to estimate the harm of the infection for these birds in nature by indirect data.

Materials and Methods: 518 passerine birds of 50 species were trapped in mist nets on the Courish Spit (=Curonian Spit) in the Baltic Sea during summer and autumn 1995-1997. Droppings from every individual bird were collected at the moment of capture. Later the droppings were checked for *Isospora* oocysts. The number of oocysts in each sample was counted after flotation by standard method.

Results: The peak of oocyst production is in the afternoon, between 16 and 19 o'clock in summer and between 17 and 19 o'clock in autumn. The intensity of infection is higher in the species of birds that collect food on the ground than in those collecting it in the air. Young birds have higher intensity and prevalence of infection (some species with "island inhabitations" are an exception). At the beginning of autumnal migration, the infection prevalence and intensity are greatly increased in all investigated species of birds, and these parameters become lower at the end of the migration. In summer, birds with a low level of fat are especially heavily infected, and in autumn, the birds with an average level of fatness have the highest intensity of infection.

Conclusions: It seems that *Isospora* have no great pathogenic influence on wild passerine birds in nature, because a great number of these parasites in birds doesn't prevent them from accumulating fat and also from migrating in the propitious period.

BORRELIA GENOSPECIES PREVALENCE AS A MARKER OF THE POSSIBLE ROLE OF BIRDS IN THE DISTRIBUTION OF TICK-BORNE SPIROCHETOSES IN THE BALTIC REGION

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Migratory birds were proven to be host-reservoirs of the tick-borne borrelioses agents (Humair et al, 1993), and sometimes even of more than one genospecies simultaneously (Humair et al, 1997). American authors (Nicholls, Callister, 1996) found 1 *Borrelia burgdorferi* infected *Ixodes scapularis* 8 years ago. Swedish authors (Olsen et al, 1995) suggested that birds migrating from the North were transferring mainly, if not exclusively, *B. garinii* infected *I. ricinus* ticks, whereas ticks had spirochetes pathogenic for human beings. Analysing our own results (Alekseev et al, 1998) we found that *I. persulcatus* from the northern beach of the Finnish Gulf mostly contained *B. garinii* (70-81%, 1995-1997 y data) with a very high percentage of dual infection: *B. garinii* and *B. afzelii* (12.5-52%), whereas in the *I. ricinus* ticks from the Kurish Spit (=Curonian Spit) (Kalinigrad Region) mainly *B. afzelii* were found. Dual infection in *I. ricinus* ticks was very rare.

Both localities of the survey are connected by Italian-Spanish way of bird migration. We stated the great difference between *I. ricinus* tick infection by borrelia genospecies in the spring and fall during the first and second seasonal peaks of tick abundance: in the spring using darkfield technique of borrelia detection we estimated spirochete prevalence as very low, i.e. 7.3±0.9%, whereas 75.8% of spirochetes were identified as genospecies pathogenic for human being. Just the opposite: in the fall spirochete prevalence were 3.5 higher than in the spring (25.2%), but ticks contained only 9.5% of the pathogenic borrelia genospecies. *B. garinii* prevailed in *I. persulcatus* (North) mainly in the second half of their seasonal activity whereas in *I. ricinus* (South) - in the spring. All these facts might be explained by the differences of the sources of pathogens, which can be transferred by birds during the spring and fall waves of their migration.

TICKS (IXODOIDEA, IXODIDAE) OF MIGRATORY BIRDS ON THE KURISH SPIT

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Objective: To investigate the role of migratory birds in the carrying and feeding of *Ixodidae ticks.*
Materials and Methods: 14501 specimens of migratory birds (81 species) were examined on the Kurish Spit (=Curonian Spit) in the course of a seven year period investigation in spring and in autumn. 412 specimens of birds were infested with 1421 larvae and nymphs of *Ixodes ricinus* L.
Results: The number of birds with ticks was higher in spring (2.9% of infected birds) than in autumn (0.8%). In spring, the main hosts of *I. ricinus* were *Fringilla coelebs* L. (carried 47.8% of collected ticks), *Coccothraustes coccothraustes* (L.) (11.5%), *Sylvia borin* (Bodd.) (6.2%), and in autumn - *Parus major* L.(44.9%), *Erithacus rubecula* (L.) (20.4%) and *Turdus philomelos* Brehm.(8.2%). The damage of legs of *Fringilla coelebs* by *Knemidocoptes jamaicensis* was recorded. Virologists have isolated four strains of TBE virus from the blood serum of *P. major* and *Turdus merula* L. as well as from the internal organs of *Phoenicurus phoenicurus* (L.).
Conclusions: The discovery of arboviruses in the blood and internal organs of migratory birds in spring testify to the

possibility of carrying the infection from wintering grounds. *I. ricinus*, carried by migratory birds, may be responsible for some features in the distribution of arbovirus infections. It should be taken into consideration that the period of the activity of *I. ricinus* coincides with the period of bird's seasonal migrations. As the preimaginal stages of *I. ricinus* parasitize on the birds, they can be carried in other regions. In connection with the discovery of TBE virus in migratory birds, this fact indicates the possibility of introducing arboviruses in the local biocenoses as well as the formation of new and the maintenance of existing natural foci of the arbovirus infections.

PARASITIC ARTHROPODS OF BIRDS AND THEIR ROLE IN MAINTENANCE OF NATURAL FOCI OF ARBOVIRUS DISEASES IN BELARUS

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Objective: To investigate blood-sucking arthropods of bird in Belarus.

Materials and Methods: In 1973-1996, parasitic arthropods from 1590 bird nests were collected and studied. 2195 specimens of birds were examined, and 435 specimens of the birds were recorded to be infested with 1714 specimens of blood-sucking arthropods.

Results: Ixodidae ticks *(Ixodes ricinus* L., *I. arboricola* Schulze and Schlottke and *I. lividus* Koch.*)* were prevailing among the ectoparasites (91.2% of collected arthropods). Virologists have isolated the strains of TBE virus from *Lullula arborea* (L.) *Coracias garrulus* L., *Gamasina* (5 species) and *I. lividus.* Antihemagglutinins to the West Nile, Sindbis, Uukuniemy and TBE viruses were discovered in migratory birds in spring (Gembitsky, 1989).

Conclusions: The discovery of the arboviruses and antibodies to the viruses in migratory birds in spring is the witness of the possibility of carrying infection from wintering grounds. The activity of parasites of pasture and the bird's nest-burrow type begin exactly at this time, and the transmission of the arboviruses from infected birds to blood-sucking arthropods is possible. The nest-burrow parasites of synurbic and colonial species of birds, which repeatedly settle the nests, are particular dangerous. The greatest quantity of blood-sucking arthropods were registered in the nests of *Sturnus vulgaris* L., *Columba livia* L., *Delichon urbica* (L.), *Riparia riparia* (L.).The isolation TBE virus from *Gamasina* ticks (in summer) and the isolation of the virus seven years later from *I. lividus,* which was collected from the nests of *R. riparia* of the same settlement, indicate the stability of natural foci of TBE virus. The discovery of TBE virus in spring before the arrival of birds showed that the infection reserved in the diapaused Ixodidae ticks. The results show that the bird ectoparasites have the potential possibility for long-term preservation and dissemination of the infection agents in the natural foci of diseases in Belarus.

BLOOD PROTOZOAN PARASITES (PROTOZOA: KINETOPLASTIDA AND HAEMOSPORIDA) OF WILD BIRDS FROM BULGARIA

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Objective: Relatively little has been recorded concerning the haematozoa of the avifauna of the Balkan Peninsula. So far, there is no information on distribution of the parasites in Bulgaria. This paper presents results of a study on prevalence and fauna of blood protozoan parasites of birds from the Northern Bulgaria.
Materials and Methods: A total of 63 birds of 11 species of Passeriformes were investigated for blood parasites. The birds were sampled at the Biological Experimental Station "Kalimok" of the Institute of Zoology (Bulgarian Academy of Sciences), Nova Cherna, Tutrakan, during the period from June, 1993 to September, 1994. Captured birds were released after blood was obtained by clipping a claw. All blood smears were air-dried, fixed in absolute methanol, stained with Giemsa's stain. A minimum of 100 fields were examined under both low (×25) and high (×100) power objectives.
Results and Conclusions: A total of 17 examined passeriform birds (27.0 per cent) of 6 species were infected with one or more species of blood Protozoa. At least, 9 species of the parasites belonging to the orders Haemosporida (genera *Haemoproteus*, *Plasmodium* and *Leucocytozoon*), Adeleida (*Hepatozoon*) and Kinetoplastida (*Trypanosoma*) have been recorded. Mixed infections of birds with two or more genera of the protozoans were common. Most common blood protozoans were *Haemoproteus belopolskyi*, *Plasmodium* (*Haemamoeba*) sp. and *Trypanosoma everetti*. Our preliminary findings suggest a similarity in fauna of avian blood protozoans in Bulgaria and in adjacent territories of Europe. However, large samples are needed before conclusions can be drawn regarding ecology and fauna of all genera of the parasites in the country.

THE PREVALENCE OF *SARCOCYSTIS* IN SOME WILD BIRDS AND POULTRY IN LITHUANIA AND IN NEIGHBOURING TERRITORIES

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Objective: No published records are available of *Sarcocystis* in muscles from wild birds or poultry in Lithuania or neighbouring countries. Our objective was to determine the prevalence of *Sarcocystis* spp. infection among some wild birds and poultry in Lithuania and in South Curonian Spit (Russia).
Materials and Methods: Three hundred and seventy five wild birds of 45 species belonging to 5 orders (Passeriformes, Piciformes, Charadriiformes, Columbiformes and Strigiformes) and 97 poultry (76 hens and 21 turkeys, Galliformes) were examined for the presence of sarcosporidia in muscles. Birds were obtained from a number of sources including birds collected for other studies by various researchers at the Institute of Ecology

during the period 1986-1997. In many cases, frozen carcasses were used. Skeletal muscle samples from pectoral, wing, leg or neck muscles were examined microscopically in a compressor after staining them with methylene blue. Some of the samples were examined by means of squash preparation. 16 passerine birds were investigated histologically.

Results and Conclusions: The prevalence of *Sarcocyctis* spp. infection among investigated wild birds and poultry was low. *Sarcocysts* were detected only in 3 passerine birds of 339 investigated - 1 of 58 robin *Erithacus rubecula*, 1 of 6 pied flycatcher *Ficedula hypoleuca*, and 1 of 2 fieldfare *Turdus pilaris*. All the infected birds were collected in South Curonian Spit. The species of *Sarcocystis* in passerine birds were not identified as no cystozoites were examined. Out of 76 investigated fowl, sarcocysts were found only in one free-ranging cock. A radially striated cyst wall, 2.5-3 μm thick, and the banana-shaped cystozoites, 9-11 μm in size, were morphologically similar to those of the species *S. horvathi* known for the fowl. This is the first record of muscle cysts of the genus *Sarcocystis* in birds in Lithuania and in South Curonian Spit.

OCCURRENCE OF *BORRELIA BURGDORFERI* SENSU LATO SPIROCHETES IN PASSERINE BIRDS

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Objective: In Europe, the etiological agent of Lyme disease - *Borrelia burgdorferi*, is transmitted primarily by the tick *Ixodes ricinus* (L.) which may feed on a wide range of mammals, birds and reptiles. Passerine birds are important hosts for immature *Ixodes ricinus* (L.). In order to determine the possible role of avian hosts in the maintenance of this pathogen in nature, we examined birds blood for the presence of *Borrelia burgdorferi*.

Materials and Methods: Birds were captured on April, May, June, August and September 1996, in the Masurian Lake region (North-East Poland), proved to be an area where Lyme disease is endemic. Small volumes of birds' blood were obtained from brachial vein and analysed for the presence of *Borrelia burgdorferi* spirochetes by the nested-PCR technique (a DNA fragment containing the *hbb* gene of *Borrelia burgdorferi* sensu lato was amplified).

Results: A different tick infestation rate was observed in birds in dependence of species. The most parasitized by ticks bird species belonged to three families Turdidae, Fringillidae and Troglodytidae were chosen to investigations. A total of 152 blood samples were analysed and positive results were obtained in 6 cases. All the birds in which *Borrelia burgdorferi* sensu lato spirochetes were detected belong to species chaffinch (*Fringilla coelebs*). There was only 24 individuals (15,8%) of this species, and infection rate was 25%.

Conclusions: Statement of *Borrelia burgdorferi* presence in passerine birds blood confirmed that birds can serve as natural reservoir of spirochetes on the study area. They can be a bacteria source for ticks engorging on them and play an important role in Lyme disease dissemination.

ON THE SPECIFICITY OF *FIMBRIARIA SARCINALIS* (CESTODA: HYMENOLEPIDIDAE) IN RELATION TO HOSTS

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The four species of diving duck of the genus *Aythya* occurring in Poland are *A. ferina, A. nyroca* and *A. fuligula*, which nest, and *A. marila*, which is only found on passage and in winter. It was from two of these duck species, *Aythya fuligula* and *A. nyroca*, that Grytner-Zięcina and Cielecka described a new *Fimbriaria* species, named *F. sarcinalis,* in 1994. The characteristic features of the species are packets of eggs containing up to 30 oncospheres, which differentiate it clearly from *F. fasciolaris* - the only *Fimbriaria* species known for nearly 200 years. However, on the basis of analysis of preserved material collected in Poland and made available by other authors, it becomes clear that tapeworms originally identified as *F. fasciolaris* are in many cases specimens of *F. sarcinalis*.

In this way, it has been possible to add all four *Aythya* species to the list of final hosts for *F. sarcinalis* in Poland. The material providing confirmation of this derived from the Baltic coast, the Mazurian Lakeland, the Warsaw area, the Slonsk Reserve and the area of the Milicz Fishponds.

The developmental cycle of the new species is not yet known, and no success has been achieved in several experimental contacts between oncospheres and the cyclops species *Acanthocyclops viridis* and *Macrocyclops albidus*, or the ostracod *Heterocypris incongruens*. It is probable that the packets of eggs of *F. sarcinalis* are too large to be ingested by small crustaceans of this kind. In line with this, potential intermediate hosts should perhaps be sought among much larger representatives of the Amphipoda or Oligochaeta, which deep-diving *Aythya* ducks would be capable of taking, along with silt from the bottom of a body of water.

F. sarcinalis has not yet been recorded from ducks other than *Aythya* species.

THE ECOLOGY OF THE HAEMATOZOAN PARASITES OF EUROPEAN BLACKBIRDS *TURDUS MERULA,* AND THEIR EFFECTS ON HOST FITNESS

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The haematozoan parasites of a rural population of European blackbirds *Turdus merula* were studied to investigate parasite prevalence and their effects on host morphology, condition, a putative sexually-selected trait (bill colour) and reproductive performance. Prevalence was high (83% of adults were infected by at least one species) and parasites belonging to eight species from four genera *(Leucocytozoon, Plasmodium, Haemoproteus* and *Trypanosoma)* were identified. A significant non-random association was found to exist between two of these genera. There was no sexual difference in infection rates, and in both sexes body condition decreased as the number of parasite genera infecting them increased. There were no discernible effects of haematozoa on the bill coloration of either sex, and despite the effects of parasitism on body condition there was no evidence that reproductive parameters were influenced by infection with haematozoa. Future work will involve experimental study of the potential trade-off between reproductive effort and parasite infection, and the examination of two potentially sexually-selected traits.

A NEW NASAL BIRD SCHISTOSOME FROM EUROPE

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The life cycle of *Trichobilharzia* schistosomes includes water snails and various aquatic birds as intermediate and final host, respectively. The study concerning the occurrence of bird schistosomes in the Czech water snails revealed a schistosome infection in *Radix peregra*. The experimental infection of *Anas platyrhynchos* f. dom. and *Cairina moschata* with cercariae showed that a new *Trichobilharzia* species was found. The adults were detected in the nasal blood vessels where they lay eggs. The hatching of miracidia was observed directly in the tissue of the infected host.

The finding of new schistosome species supports necessity of a critical re-evaluation of *Cercaria ocellata* (i.e. larvae of *T. ocellata*) descriptions from the European freshwater snails. There are serious reasons to expect that the morphologically similar cercariae of different *Trichobilharzia* species were misdetermined in case where the life cycle and adult parasites were not studied. Moreover, the parasitological examination of naturally infected birds should reflect the small size (thread like character) of *Trichobilharzia* adults, their location in different organs and intimate contact within the host tissue.

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HAEMATOZOA AS BIOLOGICAL TAGS IN BIRD SUBSPECIES STUDIES

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Objective: Investigation into new signs for differentiation of bird subspecies is important for ornithology. The parasitological methods can be used for this purpose. The aim of this work is to highlight the peculiarities of infection of several subspecies of Yellow Wagtail *Motacilla flava* with haematozoa during spring migration.

Materials and Methods: 131 specimens of *M. flava* belonging to three subspecies were caught during seasonal migration in South Kazakhstan in April - May 1986 and investigated by blood smears technique. Among them were: *M. f. feldegg* - 33, *M. f. flava* - 45, *M. f. thunbergi* - 53.

Results: The species of *Haemoproteus, Plasmodium, Leucocytozoon, Trypano-*

soma, *Atoxoplasma* and *Microfilaria* were recorded in birds. *M. f. flava* can be easily distinguished from the other two subspecies by a significantly higher prevalence of *Haemoproteus* (48.9 %, 95-% confidence limit is 34.3-63.6; the same parameters are 12.1 %, 3.1-24.2 in *M. f. feldegg* and 17.0 %, 8.5-30.0 in *M. f. thunbergi*). Moreover, *Haemoproteus anthi* clearly dominates in *M. f. flava*, and it is rare in other investigated subspecies. *M. f. thunbergi* has an exceptionally high prevalence of *Leucocytozoon* (22.6%, 13.1-37.0; the same parameters are 2.2, 0.0-8.7 in *M. f. flava* and 0.0, 0.0-2.8 in *M. f. feldegg*). Species of *Plasmodium* are especially rare in *M. f. thunbergi* (5.7 %, 1.1-14.4) and most common in *M. f. feldegg* (42.4 %, 24.3-56.8).
Conclusions: During late stages of spring migration, subspecies of *M. flava* can be distinguished by prevalence of infection and some peculiarities of the fauna of haematozoa. The investigated birds have similar wintering places (Africa and South Asia), but different breeding areas. Prevalence of *Plasmodium* infection is especially high in birds breeding in the South Palearctic (*M. f. feldegg*), *Leucocytozoon* in birds breeding in the North Palearctic (*M. f. thunbergi*), and *Haemoproteus* in birds with an intermediate position of the breeding areas in comparison to those mentioned above. Among the investigated subspecies, *M. f. flava* is the main host for *H. anthi*. The mass investigation of birds during late stages of spring migration is a promising technique for bird subspecies studies.

INVESTIGATIONS INTO BIRD PARASITOSES IN ESTONIA

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Objective: To present a review about investigations on bird parasitoses in Estonia.
Results: The most thoroughly investigated bird parasitosis in Estonia is chicken eimeriosis. This research has been carried out during many years under the leadership of J. Parre. Studies on eimeriosis in chicken have been carried out by E. Olkonen, T. Schattschneider, H.-E. Simovart a. o. in the years 1968-1993. The following problems have been treated: 1. Haematologic changes after invasion with *Eimeria tenella* in nonimmunized and immunized chicks. 2. Influence of superinvasion on the protein composition of the blood serum in chicks in the case of eimeriosis caused by *E. tenella.* 3. Changes in lymphoid organs of chicken in the case of infection with *E. tenella.* 4. Anticoccidial immunity in poultry flocks. 5. The manufacture and use of chicken eimeriosis polyvaccine. 6. Elaboration of control measures against chicken eimeriosis. The helminthofauna of domestic duck and goose has been thoroughly investigated by L. Veldemann (1950-1960). 73% of ducks and 48% of geese were invaded with parasites. 29 species of parasites have been diagnosed in ducks, 15 species have been found in geese. The most important parasitoses were ducks tetramerosis, geese amidostomosis, ducks notocotylosis, geese and ducks ganguleterakidosis, geese and ducks eimeriosis.

The results of the investigations into flukes (Trematoda) of water and shore birds on the western coast of Estonia have been presented by V. Jõgis (1959). 52 birds belonging to 27 species (5 orders) were examined and 57 species of flukes, belonging to 19 families, were recorded. Observations on the epidemiology of histomonosis in turkeys (Parre *et al.*, 1977) showed that histomonosis was widely spread in the flocks of various ages. Outbreaks occurred in the young flock during stress-situation. Geese eimeriosis, fowl prosthogonimosis and plagiorchosis and blood parasites in great tits have also been investigated by Estonian authors. An interesting finding was the avian tapeworm *Schistocephalus solidus* in the dog (Järvis, 1994).

Conclusion: For the most part the investigations into bird parasitoses in Estonia have resulted from practical needs (economic interest) and are related to domestic birds.

BEHAVIOURAL RESPONSE OF THE CHICKEN MITE, *DERMANYSSUS GALLINAE*, TO HOST-RELATED STIMULI

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Objective: *Dermanyssus gallinae* is a well-known ectoparasite of domesticated poultry and a wide range of wild birds. It spends most of the time hidden in cracks and crevices, and will only come out to feed when a potential host is near. The question addressed in this study was how the mite detects the presence of a potential host.

Materials and Methods: Adult female mites were stimulated with controlled vibrations, both with and without prior stimulation with CO_2. Experiments were conducted in the laboratory under different light intensities.

Results: Under "night" conditions (light intensity<10-20 lux), *D. gallinae* is activated by CO_2 stimulation, and a subsequent vibration stimulation will increase the level of activity (at the best frequency 2 kHz, the threshold is 5-10 μm/s, peak-peak). Without the initial CO_2 stimulation the vibrations need to be 50-100 times higher in order to activate the mites. Under "day" conditions (light intensity>40-50 lux), stimulation with CO_2 will not act as an activator but rather as a primer so that a subsequent stimulation with low-level vibrations will activate the mites but only for the duration of the vibrations. Mites already active will respond to CO_2 with a "stopping" reaction; the mites stop and remain motionless unless further stimulated with vibrations. This behaviour is interpreted as a defence against being eaten by the potential host. A blow of CO_2 could mean that the bird is close enough to see the mite moving whereas vibrations indicate that the bird is moving and thus its attention is not focused on the mite.

Conclusion: *D. gallinae* can detect potential hosts by means of expired CO_2 and vibrations of the substrate induced by host movements, but the behavioural response depends on the light intensity.

CERCARIAL CHAETOTAXY - AN EFFICIENT MEANS FOR THE IDENTIFICATION OF *TRICHOBILHARZIA* SPECIES?

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Objective: In order to evaluate the importance of cercarial chaetotaxy in the identification of *Trichobilharzia* species, papillary patterns of the European avian schistosomatids *T. ocellata* and *T. franki* were examined and compared.
Materials and Methods: Sensory papillae were revealed by staining with silver nitrate. Scanning electron microscopy (SEM) was also employed to confirm their number and distribution.
Results: The chaetotaxy of *T. ocellata* and *T. franki* were identical. A comparison of the papillary pattern of *T. ocellata* with the pattern of some non-European and, as such, presumably more distantly related *Trichobilharzia* species, revealed significant differences in the number and distribution of sensilla. Some sensory papillae stained insufficiently with silver nitrate or were difficult to examine using light microscopy.
Conclusions: The obtained results indicate that papillary pattern analysis represents a method of discriminating distantly related species of *Trichobilharzia* but is inadequate for the discrimination of closely related species. However, when studying the chaetotaxy of cercariae neither the possibility of subjective evaluations nor the misleading effects of fixation artefacts can be totally excluded. Thus, the use of SEM in future examinations of *Trichobilharzia* chaetotaxy will ensure the collection of data that is comparable between studies, even though some argentophilic structures are not visible in SEM.

ONTOPHYLOGENETIC DIFFERENTIATION OF CYSTICERCOIDS

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Objective: The study of ontophylogenetic adaptations of larval cestodes of birds.
Material and Methods: Investigations were conducted on seven types of cysticercoids from the families of Hymenolepididae (14 species) and Dilepididae (6 species). Larvae (mature, developing and transplanted into an intermediate host) were studied based on electron micrographs and histochemical techniques.
Results: At the early stages of development, cysticercoids are covered with primary tegument. It is characterised by the presence of a microvilli border and lack of specific inclusions. Mature larvae retain such a tegument on their tails only. The tail structure is essentially distinct in different types of cysticercoids. It is most simply arranged in essentially distinct in different types of cysticercoids. It is most simply arranged in monocercus which follicles are formed by the tegument only. The hypertrophy of microvilli and intensification of the membrane secretion from their tops take place after the transplantation. The basic function of the tail is to protect larvae from the host's hemocytes. It is effected by the cytolytic properties of tegumental membranes. The cyst structure is most versatile. Specific distinc-

tions show up in the tegumental structure, amount and thickness of fibrous layers, number of muscle and secretory cells, presence of a pseudo-myeline layer. The basic functions of the cyst include the protection of larvae in the digestive tract, activation and evagination of the scolex. Differentiation of the scolex tegument occurs after the invagination. It is followed by the replacement of the microvilli for microtriches, as well as by the accumulation of inclusions in the syncytium matrix. Thus, the cyst ensures the conditions for progressive evolution of the tail and its transformation into an additional protective envelope.

Conclusion: The comparative study of cysticercoids has shown that they are a progressively developing type of larval cestodes of birds. The intensification of the protective function of larval elements can be associated with a migrant way life of the definitive hosts.

MICROMORPHOLOGICAL ALTERATIONS IN THE ROOK *(CORVUS FRUGILEGUS* L.) INTESTINE DURING EXPERIMENTAL CAPILLARIOSIS

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The purpose of this work was to study the developmental dynamics of micromorphological changes in the rook intestine during experimental capillariasis. The dynamics of the alterations in the small intestine of experimental rook infected with *Capillaria corvorum* (Rudolphi, 1819) Travassos, 1915 was investigated.

It was established (Šlikas & Kaspersone, 1978) that larvae are formed in the capillaria eggs in the faeces of birds. In the intermediate host - the earthworm - larvaehatch and moult once. In the intestine of a definitive host (rook) larvae moult three times and in about 30 days become mature. *C. corvorum* parasitises in the small intestine of a definitive host for about 7-9 months and produces eggs. After that, the helminths are eliminated from the intestine of birds.

38 two-three-week-old rooks (*C. frugilegus* L.) were used in the experiment. The rooks were infected with the nematode *C. corvorum* L. by feeding them on the earthworms. The experimental birds were decapitated every day over the period of 7-31 days after the infection. Some pieces of the small intestine were taken for a micromorphological investigation, and histological preparations were made in an ordinary way.

At the early stages (on the 7th and 11th days) of infection the catarrhal type of inflammation in the tissues of the small intestines was observed whereas from the 12th to the 25th day a strongly pronounced cellular infiltration on the mucous membrane of the small intestine was noticed. Lymphocytes, histiocytes and eosinophils were predominating. In many places there was a distinct epithelial desquamation; the epithet cells were peeled off and localized in the lumen of the intestine. At this period of infection, *C. corvorum* was localised deeply in the mucosa of the intestine wall, which caused distinct inflammatory breaches and petechiae.

On the 30th day after the infection helminths reached their puberty and were localised in the opening of the small intestine of the bird. However, the helmiths fastened to the mucous membrane with their front end.

The results of the histological investigations have shown that the infection with nematoda *Capillafia corvorum* has a pronounced destructive effect causing necrotic-degenerative processes and cellular infiltration in the small intestine of the rook.

ON THE DISTRIBUTION OF *SARCOCYSTIS* IN WATERFOWL BIRDS IN LITHUANIA

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Objective: Sarcosporidia in waterfowl birds in Europe are not yet sufficiently investigated. Also, some uncertainties still remain in differentiating *Sarcocystis* species. The objective of this research was to investigate the occurrence of *Sarcocystis* in waterfowl birds (order Anseriformes) accidentally stuck in fishnets in the Nemunas delta and in the Curonian Bay (Lithuania) in the period of 1997 - 1998.

Materials and Methods: Under the light microscope we have investigated 25 birds belonging to the following eight species: 7 white - fronted geese (*Anser albifrons*), 1 bean goose (*Anser fabalis*), 3 goosanders (*Mergus merganser*), 2 wigeons (*Anas penelope*), 1 pochard (*Aythya ferina*), 1 tufted duck (*Aythya fuligula)*, 1 shelduck (*Tadorna tadorna*) and 9 mallards (*Anas platyrhynchos*). Head and neck muscles were examined. Infection intensity was determined in compressor by counting sarcocysts in 28 muscle sections stained with methylene blue. The morphometric analysis of cyst walls and cystozoites was performed in native preparations.

Results and Conclusions: Sarcocysts were detected in 10 (40%) of investigated birds, i.e. in 5 white - fronted geese, in 4 mallards and in 1 shelduck. On the basis of morphometric analysis of cyst walls and cystozoites two sarcocyst types were detected in both geese and ducks. The obtained data testify to high infection level of waterfowl birds.

DISTRIBUTION OF CHAFFINCH HAEMOPROTEIDS AND THEIR POSSIBLE VECTORS ON THE CURONIAN SPIT

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Objective: Haemoproteids of chaffinch *Fringilla coelebs* L. are unique objects for investigations of vectors of *Haemoproteus* on the Curonian Spit. The ecology of chaffinch and the fauna of the haemoproteids in this bird have been investigated exceptionally well here. Preliminary data on the distribution of chaffinch *Haemoproteus* and their possible vectors are given in this presentation.

Materials and Methods: 146 specimens of chaffinch were investigated by blood smear technique on the Curonian Spit in the Baltic Sea during May - August, 1997. Ceratopogonids (genus *Culicoides*) were collected several times per week using standard methods.

Results: Species of *Haemoproteus*, *Trypanosoma* and *Microfilaria* were recorded in chaffinches. Haemoproteids were dominant parasites. *Haemoproteus*

fringillae, *H. dolniki* and *H. magnus* were recorded. The former two species were most common. The overall prevalence of *Haemoproteus* infection was 36.2 % (95 %-confidence limit is 26.1 - 48.9) in adult birds and 14.3 % (8.0 - 23.3) in juveniles. This testifies the active transmission of the parasites on the study site. Six species of *Culicoides* (*C. arcantidus, C. obsoletus, C. punctatus, C. pinctipennis, C. segnis* and *C. impunctatus*) were recorded feeding on birds. *C. impunctatus* was the most abundant species (over 90 % of all collected specimens of *Culicoides*). The highest density of ceratopogonids was in June. In July, the density of *Culicoides* decreased dramatically, and only *C. impunctatus* was recorded in the end of July. *Culicoides* were not found feeding on birds in August.

Conclusions: Especially active transmission of *Haemoproteus* takes place in June on the Curonian Spit. Experimental work on vectors of the parasites should be recommended during this period of summer. *C. impunctatus* is incriminated to be one of the possible important vectors of species *Haemoproteus* on the Spit.

RELATIONSHIP BETWEEN IMMUNITY OF JAPANESE QUAILS AND ACTIVITY OF MICROFLORA OF THE DIGESTIVE TRACT

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Objective: Due to antibiotic and adhesive activity, microflora of the digestive tract can influence the processes of macroorganism immunity. The impact of the vaccination of Japanese quails (*Coturnix coturnix japonica*) on antibiotic and adhesive activity of microflora of the digestive tract of Japanese quails have been investigated.

Materials and Methods: Two groups of Japanese quails were compared. The first group was vaccinated twice with inactivated *Salmonella enteritidis* Talovac 109 SE vaccine, and the second (control) group was unvaccinated. The composition of bacteria of the digestive tract of Japanese quails was determined by method of Bergy, and the antibiotic activity was investigated by method of Ayzeman and Egorov. Adheric features of microorganisms of digestive tract of quails were investigated using express-method. Adherence was regarded to be nil when mean adherence index (MAI) is 0-1.0; weak - MAI = 1.01-2.0; medium - MAI = 2.01-4.0, strong - MAI = > 4.

Results: Antibiotic activity of microflora of the digestive tract was very high. Antagonistic activity was 78.26% of the bacteria in unvaccinated birds, and this parameter was 91.66% in vaccinated birds. The majority of the investigated bacteria were capable to inhibit the development of several bacteria. A zone of inhibition was 20-30 mm. In the vaccinated quails in comparison to unvaccinated ones, the antagonistically active bacteria were especially common, the zone of inhibition was considerably higher and the spectrum of the inhibitory activity was wider. The higher antagonistic bacteria activity against *Staphylococcus aureus* have been recorded in vaccinated quails. However, the bacteria nearly completely inhibited the development of *Candida albicans* and *Bacillus subtilis* in unvaccinated quails. Mean values of adherence of intestinal microorganisms in vaccinated and unvaccinated quails indicate that vaccination considerably increase the ability of normal microflora to adhere the intestinal walls. MAI in the intestine of unvaccinated quails was 1.65, and it was 2.84 in vaccinated ones. Among microorganisms of the digestive tract of unvaccinated quails, nil (35.0%) and weak (35.0%) MAI were dominate, and strong MAI was recorded in 50.0% of intestinal microflora and medium in 25.0%. In vaccinated quails, medium (42.1%) and strong (36.8%) MAI were most common, whereas weak MAI was recorded in 21.0% of bacteria.

Conclusions: Microflora of the digestive tract of Japanese quails has high antibiotic and adhesive activity. The vaccination of Japanese quails with *Salmonella enteridis* effects both the microflora activity of the digestive tract and the immunity of birds.

LOW PREVALENCE OF FLEA INFESTATION IN NESTS OF BLUE TIT *PARUS CAERULEUS*

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Objective: Blue Tits *Parus caeruleus* are expected to be particularly exposed to contamination of fleas during early spring, mostly because of their early breeding activity, but many studies reveal low prevalence of fleas in Blue Tits' nest.

Materials and Methods: New nestboxes were used on two forest areas (Kampinoski National Park in 1995 and Mlociny Forest Park in 1996) near Warsaw, Poland. During breeding season nesting species were identified, and on the day of fledging, nests were collected and analysed for the occurrence of ectoparasites.

Results: Examination of nests of hole-nesting species on both study areas revealed that prevalence of adult fleas (*Ceratophyllus gallinae*) in Blue Tits nest is always lowest (KPN: *P. caeruleus* - 20%, Great Tit *P. major* - 43%, Pied Flycatcher *F hypoleuca* - 32%; MFP: *P. caeruleus* - 13%, *P. major* 25%, Starling *S. vulgaris* 82%). The average number of adult fleas in Blue Tits nests was similar to that of Great Tit (KPN: Blue Tits - 13, Great Tits - 14.5; MFP: Blue Tits - 7, Great Tits - 3) and either greater than (in KPN Pied Flycatchers - 2.5) or lower than (in MFP Starlings - 27.5) other migratory species.

Conclusions: The intensity of infestation with fleas was similar in both species of Tits, but the prevalence of fleas was lower in Blue Tits nests. Apparently, when Great Tits are more numerous than Blue Tits, the latter has limited access to areas with old nesting sites - where the spring infections with after-wintered adult fleas occur. The average number of adult fleas in Blue Tits nests depended on the presence of particular migratory species of hole-nesters - Pied Flycatchers in KPN started breeding later than Tits and were exposed to fleas in much lower degree, but Starlings in MFP started breeding at the same time as Tits, and - due to their dominance, and aggressive behaviour - limited Tits mobility or territory selection, and consequently chances of infections with fleas.

PARENTAL FEEDING EFFORT AFFECTS BOTH NESTLING QUALITY AND ENDOPARASITE INFECTION LEVELS

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Objective: Besides investigation of the relationship between Starling *Sturnus vulgaris* nestlings' weight and levels of infection with endoparasite *Isospora lacazei* (Coccidia: Apicomplexa), the effect of the third factor - parental feeding effort was analysed. The food compensation of the effect of ectoparasites was previously suggested, but in the case of orally transmitted endoparasites, any increase in feeding effort may also bear increased risk of transmission.

Materials and Methods: Starling nestlings were weighed on the 17th day of life. At the same time, samples of excrement were taken from most nestlings - and promptly preserved in 2% K_2CrO_7. Shortly afterwards, samples were analysed under light microscope (×40). Average levels of coccidian infections were calculated for each nest. Parental feeding effort - the average number of feeding trips per nestling per hour - was estimated using two subsequent, 30-minutes observations of feeding trips on the 15th day of nestlings' life.

Results: The average level of coccidian infections of nestlings didn't affect the average weight of the fledging nestlings (Rs=-0.20, n=19, p=0.40). However, parental feeding effort, correlated positively with average weight of nestlings (Rs=0.53, n=19, p=0.03), and negatively with average level of coccidian infection (Rs=-0.50, n=19, p=0.04).

Conclusions: The quality of nestlings is affected by the quantity of food they receive, but surprisingly, the infection level with orally transmitted *I. lacazei* is decreased by the increase of the parental feeding effort. We suggest that expected increase in *I. lacazei* infections could have been masked by better immune response of better-fed nestlings. Additionally, as parental feeding effort seems to be the causative factor here, it should be taken into account in further studies of endoparasite effect on nestlings - just like it was suggested in ectoparasite studies.

ECTOPARASITE DIVERSITY IN STARLINGS' NESTS IN RELATION TO THE AGE OF THE NEST-SITE

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Objective: As studies of the composition of ectoparasite fauna in nests of Starling *Sturnus vulgaris* didn't take into account neither the age of the nest-site nor the time of nest collection, our study attempt to compare the infestation of the one-year and two-year-old nestboxes.

Materials and Methods: New nestboxes were placed in the Młociny Forest Park (in the vicinity of Warsaw, Poland) before the 1996 breeding season. Just before Starlings fledged, nests were collected and analysed for the ectoparasites. Some nestboxes were not cleaned, and in 1997 we collected nests that were built both in cleaned and not-cleaned nestboxes.

Results: In one-year-old nestboxes mostly fleas *Siphonaptera* were present (83% nests infested). In two-year-old nestboxes that contain no old nest material both fleas (100% nests), mites and ticks *Acarina* were found. In addition to these groups, in two-year-old nestboxes with old nest material also feather lice *Mallophaga* were found.

The intensity of infestation with fleas was greater in these two-year-old nestboxes that contain old nest material.

Conclusions: Age of the nestsite influence the diversity of the ectoparasites in nests of Starlings. In 1996, where there were no nestboxes with old nest material at the start of breeding season, only fleas were present in Starlings nest. In 1997, when some nestboxes containing old nest material allowed for the development and wintering of ectoparasites, both diversity and intensity of ectoparasites were increased. The presence of the old nest material influences intensity of ectoparasites. Starlings' behaviour (high mobility, nestsite usurpation, brood parasitism) greatly facilitates fleas transmission rates, causing the prevalence to remain high on both seasons.

FEATHER MITES: GENERAL MORPHOLOGICAL ADAPTATIONS, PHYLOGENY AND COEVOLUTIONARY RELATIONSHIPS WITH BIRDS

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Feather mites (FM) are highly specialised permanent obligatory ectoparasites associated with almost all recent orders of birds (Aves). According to recent concept FM are a paraphyletic group consisting of 3 superfamilies Analgoidea, Pterolichoidea, Freyanoidea of the mite suborder Astigmata. FM are variously adopted for inhabiting different types of microhabitats on a bird body. They live on different types of plumages and even specialised to certain structure elements of feathers, on a skin of birds, in nasal cavities and air sacs.

A comparative morphological studies of different groups of all recent subfamilies show that representatives of different taxa of higher (familial) rank adapted to the same microhabitats display similar main morphological adaptations even if they are rather distantly related one to another. Five general morphotypes could be recognised. It is concluded, that development of certain adequate morphotypes was independent in several different phyletic lines. A phylogenetic hypothesis elaborated by cladistic methods for the superfamily Analgoidea allowed to propose a hypothesis of the evolution of general morphological adaptations of FM during the pioneering and settling in the different microhabitats.

A cladistic analysis of phylogenetic relationships of the FM families Avenzoariidae and Alloptidae based on morphological characters and subsequent comparative analysis of obtained hypotheses for FM and recent phylogenetic hypotheses of aquatic birds indicate a basic pattern of coevolutionary relationships of feather mites with their hosts. The clear pattern of phylogenetic parallelism, which could be expected, is disturbed by different evolutionary events as a host shift, incoherent evolutionary rate in mite lineages within same host phyletic branch, and probably by extinction of certain phyletic lines of FM.

CONTRACAECUM MICROPAPILLATUM (STOSSICH, 1890) (NEMATODA) - NEW SPECIES TO THE PARASITOFAUNA IN POLAND

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The paper deals with the results of parasitological autopsy of cormorants collected in the area of the Vistula Lagoon and the Gulf of 'Gdansk in May 1995 and August 1997. Seven birds were infected with *Contracaecum micropapillatum*; the nematode location on the host were proventriculus and gizzard. The intensity was from 2 to 35 specimens (males, females and larvae). Description and measurement concerning the present material of *Phalacrocorax carbo* corresponded to those published by Barus et al. (1978). Information on the nematodes of *P. carbo* in Poland is poor. Up to now only Okulewicz (1989) has recorded *Capillaria carbonis* (Rud.,) on one cormorant in the Milicz area in Lower Silesia. This nematode is hosted by: *Podiceps ruficollis, Pelecanus crispus, P. onocrotalus, P. carbo, Phalacrocorax. pygmaeus, Ardea purpurea, Egretta alba, Mergus squamatus, Stercorarius pomarinus.* The distribution: Europe (England, Yugoslavia, Bulgaria, Romania), Asia (Kazakhstan and republics of Middle Asia, Far East, Afghanistan). Outside the Palearctic Region in North America, Africa, Australia. The biology of *C. micropapillatum* was described by Semenova (1971) focusing on its development in different specie of Copepoda and fry. Infective larvae may also concentrate in paratenic hosts: dragon-flies, tadpoles and different fish species.

HEALTH IMPACT OF BLOOD PARASITES IN BREEDING GREAT TITS

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Objective: Hypotheses of hemoparasite-mediated sexual selection and reproductive costs rely on the properly untested assumption that avian blood parasite infections are harmful to their hosts. We hypothesised that if blood parasites impose any serious health impact on their avian hosts, then infected individuals must differ from uninfected ones in respect to hemato-serological general health and immune parameters.

Material and methods: Health impact of *Haemoproteus* blood parasites on their great tit (*Parus major*) hosts was examined during three years in two populations, breeding in contrasting (urban and rural) habitats in south-east Estonia.

Results: *Haemoproteus* blood parasites affected the health state of their avian hosts. Infected individuals had elevated lymphocyte hemoconcentration and plasma gamma-globulin levels, indicating that both cell-mediated and humoral immunity are involved in host defence. Besides, the effect of parasites on cell-mediated immunity was both age- and sex-specific, as infection status affected peripheral blood lymphocyte counts only in males, and among these, the magnitude of response was greater in old individuals as compared to yearlings. Heterophile hemoconcentration, plasma albumin levels and hematocrit were not affected by infection status, suggesting that blood stages of *Haemoproteus* infection do not cause severe inflammatory response or anemia. In two years, infected individuals were heavier than uninfected ones in the urban but not in the rural study area. This suggests, that under certain circumstances breeding great tits may avoid losing body mass in order to save resources for anti-parasite immune response.

Conclusion: Our results support the suitability of using hemoparasites for testing hypotheses regarding sexual selection and physiological mechanisms of reproductive cost.

THE ROLE OF GENETIC POLYMORPHISM IN BIRD-PARASITE INTERACTIONS

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The studies have revealed that different population and species of both the parasites and the hosts may have different genetic polymorphism and heterozygosity. Our population dynamic studies which consider genetic polymorphism of helminths and birds have shown fluctuations of different genotypes in space and time. We studied the genetic variation of trematodes *N. attenuatus* and *N. ephemera* (multiple-host parasite with low host specificity) and their intermediate (molluscs) and definitive (birds) hosts. The investigation of genetic variation within and between 7 populations of these trematodes showed that levels of genetic variation had different values and ranged from P=0.33, H=0.059 to P=0.61, H=0.177 for *N. attenuatus* and from P=0.47, H=0.134 to P=0.59, H=0.23 for *N. ephemera*. On the other hand the genetic polymorphism among host species and population also different: for intermediate host (for example molluscs) ranged from P=0.0, H=0.0 (*Arion* sp.) to P=1.00, H=0.63 (*Cerithium caerulleum*), and for definitive host - birds: from P=0.06 (*Larus marinus*) to P=0.54, H=0.169 (*Anas platyrhynchos*). Genetic variation of parasite between populations from different species of host and between populations from the same host species in different localities is different. In the case of maximum specificity for a host species and population the parasite genome is strictly bound to one host genome and must imperatively find it from generation to generation. Evolution of the host polymorphism is thus determinant with regard to that of the parasite. Parasite strains which are adapted to their local host population are more virulent than parasite strains introduced into host populations which previously had no experience with this parasite strain. The existence of such large polymorphism in parasite and host populations gives an opportunity for the parasites to be adapted to the environmental changes. The rate at which such high heterozygosity occurs in natural helminth population defines the genetic structure of the helminth population and can influence the ability of the helminth to respond to selection pressure.

CHROMOSOME STUDIES ON SOME CYCLOPHYLLIDEAN CESTODES, THE PARASITES OF BIRDS OF NORTHWESTERN CHUKOTKA

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Objective: Only scattered data exist on the karyology of cyclophyllidean cestodes, undoubtedly due to the small chromosomes and the difficulties in obtaining good cytological preparations. A karyological approach can contribute to a better knowledge of the group. We have, therefore, studied the chromosome sets of 14 species belonging to the families Hymenolepididae and Dilepididae.

Materials and Methods: The study was carried out on strobilae of mature helminths, obtained at the dissection of naturally infected birds (Anatidae and Scolopacidae). The birds were collected from Chauna lowland (Northwestern Chukotka). Chromosome materials were prepared from cell suspension by using an air-dried method and stained with Giemsa.

Results: Cell divisions were mainly observed in developing embryos. The karyotypes of five studied species of genus *Aploparaksis, A. furcigera, A. brachyphallos, A. retroversa, A. occidentalis* and *A. filiformis*, contained 6 pairs (2n=12) of small chromosomes, ranging in size from 1.5 to 4.0 µm. The first pair of homologues was larger than the remaining elements, which decrease in size fairly gradually. The site of centromere localisation in chromosomes could not be established exactly. Such general peculiarities of chromosome set structure are also characteristic for *Dicranotaenia fallax, Dicranotaenia sp., Retinometra giranensis, Anatinella spinulosa, Wardium retracta*. The karyotypes of *Sobolevicanthus mastigopraedita* and *S. spasskii* consisted of 4 pairs of subtelocentric, 1 pair of subtelo-submetacenrtic and 1 pair of small metacentric homologues. *Fimbriaria* sp. possessed symmetric chromosome set, composed of 5 pairs (2n=10) of metacentric chromosomes. The karyotype of *Dichoanotaenia bacilligera* (fam. Dilepididae) consisted of 8 pairs of biarmed chromosomes fairly gradually decreasing in size from 4.0 to 2.1 µm.

Conclusions: Cyclophyllidean cestodes are karyotypically conservative. There was noted a tendency to maintain a constant chromosome number and morphology within genus. According to the existing data, diploid chromosome numbers in fam. Hymenolepididae ranges from 2n=6 to 2n=12. The most species have 12 chromosomes in their diploid sets and this can be considered the basic number for the family. The most studied representatives of fam. Dilepididae have 16 chromosomes in their diploid sets.

DEVELOPMENTAL STAGES OF BIRD TREMATODES IN POPULATIONS OF THE POND SNAIL *LYMNAEA STAGNALIS* (L.) INHABITING ANTHROPOGENIC WATER ENVIRONMENTS IN THE UPPER SILESIAN INDUSTRIAL REGION (SOUTHERN POLAND)

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Objective: In this paper results of preliminary investigations on larval trematodes parasitizing in populations of the common pond snail (*Lymnaea stagnalis*), inhabiting typical sinkholes and sand-pits situated in the Upper Silesian Industrial Region are presented. Sinkholes were the direct result of coal-mining activity. Usually they are shallow and without-flow ponds, with muddy bottom and strong mineralization of water, what is related to their high trophy. Sand-pits originated from the inflow of atmospheric or ground water due to sand-excavations. The degree of water pollution in sand-pits in connection with their flow-through and usually considerably depth, is smaller in comparison to sinkholes.

Materials and Methods: The material in selected anthropogenic water reservoirs was collected during the years 1996-1997, from April to October.

Results: In the examined reservoirs 254 adult snails were collected (mean shell height 42 mm). Results of the parasitological examinations are presented in the table below.

	C	c
D	XIPHIDIOCERCARIAE: * *Cercaria pseudogracilis* Zdun [1,2] (syn. *Cercaria gracilis* Wes.-Lund) FURCOCERCARIAE: * *Cercaria longiremis* Wes.-Lund [1,2] * *Cercaria ocellata* La Val. (=*Trichobilharzia ocellata* (La Val.) Brumpt cerc.; Schistosomatidae) X[1] ECHINOSTOMATA: * *Cercaria echinata* Siebold (=*Echinostoma revolutum* (Frolich) Looss cerc.; Echinostomatidae) X[1,2]	
d	FURCOCERCARIAE: * *Cercaria ocellata* La Val. (=*Trichobilharzia ocellata* (La Val.) Brumpt cerc.; Schistosomatidae) X[2] MONOSTOMATA: * *Cercaria monostomi* Linstow (=*Notocotylus seineti* Fuhr. cerc.; Notocotylidae) X[2]	XIPHIDIOCERCARIAE: * *Cercaria gibba* Sin. (syn. *Cercaria tenuispina* Luhe =*Opisthioglyphe ranae* (Frolich) Looss cerc.; Plagiorchiidae) [1,2] FURCOCERCARIAE: * *Cercaria cristata* La Val. (=*Sanguinicola* sp. cerc.; Sangunicolidae) [2]

Explanations: C - common ‘species’, c - rare ‘species’, D - numerous ‘species’, d - small ‘species’; X - cercariae known as larvae of trematodes parasitizing in birds, [1] collected in examined sinkhole-ponds, [2] collected in examined sand-pits.

Conclusions: In *L. stagnalis* collected in both types of examined anthropogenic water reservoirs, the dominant larvae of bird trematodes were cercariae of *E. revolutum*, while cercariae of *T. ocellata* were common and numerous only in examined sinkhole-ponds.

ABILITY OF HOST TO RECOVER FROM BLOOD PARASITE INFECTIONS - A LONGITUDINAL STUDY IN THE BLACK GROUSE

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Objective:. Sampling each host individual only once gives us momentary information on blood parasite infection status of individuals. However, the understanding of parasite-host interaction demands also knowledge on dynamics of infections within individual hosts. Very little is known about ability of free living hosts to recover from different blood parasite infections.

Materials and Methods: We studied a black grouse (*Tetrao tetrix*) population in central Finland during 1988-1994. We sampled blood from 284 black grouses 391 times (up to 5 times/individual) for examination of haematozoan parasites. Blood smears were air-dried and fixed with 100 % methanol and sent to the International Reference Centre for Avian Haematozoa (Memorial University of Newfoundland) where they were stained with Giemsa stain and examined by G. F. Bennett.

Results: The most common blood parasites in studied black grouse population were *Leucocytozoon lovati* and microfilaria. The probability of an individual to have a *Leucocytozoon* infection decreased with increasing age and was highest in yearlings (50%). The incidence of microfilaria was lowest among yearlings (12%) but increased with age.

Conclusions: Repeated examination of haematozoan infection status revealed that black grouse are often able to recover from *Leucocytozoon* infection. There was no evidence that *Leucocytozoon* affected survival of black grouse. Contrary, black grouse seldom recovered from microfilaria infection. Moreover, microfilaria infection seemed also to reduce life-span of male black grouse. These findings suggest that black grouse immune system is able to successfully eliminate or at least control *Leucocytozoon* infection but not microfilaria infection.

PISCIVOROUS BIRDS IN THE HELMINTHS DEVELOPMENT CYCLE OF THE GULF OF GDANSK (THE BALTIC SEA)

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Birds are an important link in the development of some parasites occurring in the Gulf of Gdansk. There are seven species of them : Digenea: *Cryptocotyle concavum* (Creplin, 1825); *Diplostomum spathaceum* (Rudolhp, 1813); *Tylodel-*

phys clavata (Nordmann, 932); Cestoda: *Ligula intestinalis* (L.); *Schistocephalus solidus* (Müller, 1776); Nematoda: *Contracaecum micropapllatum* (Stossick, 1890); Acanthocephala: *Corynosoma strumosum* (Rudolphi, 1802).

The most often occurring species are *Diplostomum spathaceum* and *Schistocephalus solidus.* Most of the noted parasites were found on fish and only occasionally on birds or molluscs. Most of the 30 piscivorous bird species occurring in the Gulf of Gdansk are migrating and sometimes wintering ones. Fish make a basic food only for some of them. The most abundant, typical piscivorous birds are the following species: *Phalacrocorax carbo* and *Podiceps cristatus.*

PARASITES OF THE ROCK PTARMIGAN (*LAGOPUS MUTUS*) IN ICELAND

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Objective: To present preliminary results of examinations on the parasite fauna of the rock ptarmigan (*Lagopus mutus*) in Iceland.

Materials and Methods: Endoparasites: In 1994 and 1995 the small intestines of 88 ptarmigans and the caeca of 93 birds were examined for helminth parasites. Also, 87 faecal samples from rectum were examined by the formalin-ethylacetate concentration method for the presence of protozoans and helminth eggs. Tissue parasite: In 1998 an examination for the filarial nematode *Splendidofilaria papillocerca* was carried out on 12 ptarmigans by examining the oesophagus, trachea, crop and the connective tissue and fat deposits surrounding these organs. Ectoparasites: Eight birds were examined in 1998 for feather lice. In September 1997 louse flies were sampled, or their occurrence noted, on 175 ptarmigans which were life-captured and ringed in Hrísey, N-Iceland. Haematozoans: Blood smears were collected and stained from the 175 life-captured ptarmigans in Hrísey as well as from further 94 birds ringed in NE-Iceland in August 1997. However, as only few of the blood smears have been examined, the results on the occurrence of haematozoans have to be regarded as preliminary.

Results: Endoparasites: Two different sized *Eimeria* oocysts were found in the faecal samples. A relatively large species (oocysts measuring 25.2 x 17.7µm, range 21.3-31.0 x 12.4-21.7µm, n=114) was found in 46 birds (prevalence 52.9%). A relatively small species (oocysts measuring 15.0 x 13.1µm, range 12.5-17.1 x 12.4-14.0µm, n=9) was found in one bird (prevalence 1.1%). Two intestinal nematodes have been found: *Capillaria caudinflata* (prevalence 34.1%, mean intensity 37, range 1-340) was found in the small intestine and caeca and *Trichostrongylus tenuis* (prevalence 11.8%, mean intensity 3.4, range 1-9) was exclusively found in the caeca. Tissue parasite: *S. papillocerca* was not found. Ectoparasites: Two mallophagans were found; *Goniodes lagopi* (prevalence 75%) and *Lagopoecus affinis* (prevalence 63%). During the ringing activities the louse fly *Ornithomya chloropus* was noted on approximately every fourth ptarmigan and could be sampled from 14,3% of the individuals. Haematozoans:

So far, preliminary results on the examination of the blood smears have not revealed any parasites.

Conclusions: Parasites of the rock ptarmigan in Iceland have not been systematically surveyed before. Although relatively few birds have been examined already seven species have been found. *T. tenuis* and the *Eimeria* spp. are reported for the first time from Icelandic ptarmigans.

SPECIFIC FEATURES OF ANTI-SALMONELLA IMMUNITY DEVELOPED BY "TALOVAC 109 SE" AND "SG VACCINE NOBILIS" VACCINES

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Objective: Vaccination represents one of current measures to combat with salmonellosis, therefore vaccination of Hisex brown and Hisex white breed hens using "TALOVAC 109 SE" and "SG VACCINE NOBILIS" vaccines has been carried out in the Vievis Poultry Yard in 1996. The objective of our work was to determine effectiveness of the above vaccines in the development of immunity against *Salmonella enteritidis*.

Materials and Methods: Hisex brown and Hisex white breed hens vaccinated with inactivated "TALOVAC 109 SE" a product of German company "TAD" and live "SG VACCINE NOBILIS" by Netherlands company "INTERVET" have been used for an experiment. An antibody titer has been determined in the blood of the vaccinated and revaccinated hens using qualitative methods of blood drop agglutination with Kirzajev antigen and double diffusion into agar gel as well as quantitative immunoenzymatic method ELISA .

Results and Conclusions: Estimation of antibody titer has shown that revaccination of Hisex brown breed hens with "TALOVAC 109 SE" has not only increased antibody titer and stability against *Salmonella enteritidis*(after vaccination and revaccination average antibody titer in the first experimental group was S/N=0.52, S/N=0.122 and in the second group was S/N=0.64, S/N=0.166, respectively) but also developed immunity against other pathogenic bacteria of *Salmonella* genus (*S. typhimurium, S. pullorum, S. gallinarum).* It has also been determined that "TALOVAC 109 SE" vaccine developed higher level of immunity than "SG VACCINE NOBILIS", however both vaccines ensure immunity against *S. enteritidis* and *S. gallinarum.* Higher stability of the immune system response to vaccination has been stated in Hisex white breed hens in comparison with Hisex brown breed hens.

EVOLUTIONARY RELATIONSHIPS AMONG AVIAN AND MAMMALIAN BLOOD FLUKES (DIGENEA: SCHISTOSOMATIDAE)

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Objective: This study sought to use ribosomal and mitochondrial DNA sequence information to construct an hypothesis of phylogenetic relationships among the genera comprising the Schis-

tosomatidae. The Schistosomatidae parasitize the vascular systems of birds, mammals, and crocodilians. The family is comprised of 13 distinct genera, seven of which parasitize birds. The results of this study should demonstrate if the family is monophyletic, if avian and mammalian schistosomatid lineages arose and radiated independently of one another, and if the parasitism of pulmonate or prosobranch snails is the ancestral condition in this family.

Materials and Methods: Ethanol-preserved parasites were obtained from around the world. DNA was extracted from these parasites, and ribosomal and mitochondrial genes were amplified using the polymerase chain reaction. DNA sequences were obtained using automated sequencing technology. Sequences were aligned using ClustalW and analysed using PAUP*.

Results: The four avian, pulmonate snail-transmitted genera (*Bilharziella, Dendritobilharzia, Gigantobilharzia, Trichobilharzia*) form a monophyletic group. However, *Austrobilharzia* and *Ornithobilharzia*, avian schistosomatids transmitted by prosobranch snails, share closer evolutionary relationships to some mammalian schistosomatid parasites than to the other avian schistosomatids.

Conclusions: These data indicate that systematic schemes grouping schistosomatid parasites according to definitive host affinity need to be modified to correspond with the evolutionary relationships of the genera. It is apparent that host switching has occurred in the Schistosomatidae at both the intermediate and definitive host levels and that some mammalian parasite genera have arisen from ancestors parasitic in birds.

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ALLERGENIC ACAROFAUNA FROM NESTS OF SELECTED SPECIES OF SYNAN-THROPIC BIRDS IN POLAND

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Objective: The possible sources of allergenic mites in dwellings and stored products are nests of synanthropic birds, especially sparrows and swallows. The aim of this study was to investigate the possible occurrence of these mites (pyroglyphid dust mites, acarid and glycyphagid storage mites or others) in nests of domestic sparrows (*Passer domesticus*) [P D] and swallows (*Delichon urbica* [D U] and *Hirundo rustica* [H R]) from south part of Poland.

Materials and Methods: The study was carried out from January 1997 to March 1998. A total of 25 nests were examined, including 11 nests of P D, 7 nests of D U and 7 nests of H R. Majority of these nests was collected in Solarnia near Lubliniec, in Tychy and vicinity and in Laziska Gorne (all localities from Upper Silesia in Poland). The mites were extracted using the Berlese method and preserved in 70% ethanol. For identification the mites were mounted in Hoyer's medium on microscope slides.

Results: Twenty four of 25 nests contained mites (96%). A total of 10 007 mite specimens were isolated including 9 852 mites from the order Astigmata (98%). Among the astigmatid mites (13 species) the most abundant were *Hirstia passericola* [H P] (82.35% of the total count), *Glycyphagus domesticus* [G D] (9.61%), *Dermatophagoides evansi* (3.17%) and *Tyrophagus similis* (2.56%). So, H P have been found as numerically dominant, especially in the nests of D U (99.25%) and H R (93.17%). G D, the allergenic mite species, was found only in 2 nests of P D. G D was the dominant in a total count of mites from the nests of P D (48.3%). Other astigmatid species were distinctly less numerous and formed (altogether) only 0.76% of all mites.

Conclusions: Nests of both species of swallows are most frequently dominated by H P. The potential sources of some allergenic mites (as G D or *Tyrophagus* spp.) are the nests of domestic sparrows (P D).

NEW DATA ON THE KARYOTYPES OF GENUS *ICHTHYOCOTYLURUS* ODENING, 1969 (TREMATODA, STRIGEIDAE)

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Objective: In the course of karyological research of trematodes, the chromosome sets of *Ichthyocotylurus platycephalus* (Creplin, 1825) Odening 1969 and *I. variegatus* (Creplin, 1825) Odening 1969, a parasite of piscivorous birds, belonging to the family Laridae, Gaviidae, Podicipedidae, Phalacrocoracidae, was investigated. The aim of this study was also to determine the usefulness of karyological data as new characteristic together with traditional taxonomic methods in a comparative study of trematodes.

Materials and Methods: Naturally infected first intermediate hosts - the molluscs *Valvata piscinalis* (Prosobranchia) were collected in the lake Asveja in summer of 1994-1997. The study of chromosomes was carried out on somatic cells of parthenites using air-drying techniques.

Results: The diploid number of chromosomes in metaphase plates of both investigated species was found to have a mode of 20. Mitotic complement of *I. platycephalus* consisted of metacentric (pairs 1, 9, 10), submetacentric (pairs 6 - 8) and subtelocentric (pairs 2 - 5) chromosomes. The chromosome complement of *I. variegatus* was found consist of subtelocentric (pairs 1 - 5), submetacentric (pairs 6 - 8) and metacentric (pairs 9, 10) chromosomes. The mitotic cells of *I. variegatus* collected from 6 molluscs contained an additional 21st chromosome. The morphology of this chromosome was different in metaphase plates from various individuals. The small subtelocentric to submetacentric additional chromosome was found in chromosome sets of *I. variegatus* from four snails. The larger submetacentric additional chromosome, which most probably is B-chromosome, was found in metaphase plates of *I. variegatus* from two snails.

Conclusions: Karyotypes of *I. platycephalus* and *I. variegatus* display a typical strigeid pattern with 20 chromosomes. Comparative karyological analysis showed that principal morphological changes in karyotypes during the speciation in this group was caused by a smaller or larger pericentric inversions.

SOME PECULIARITIES OF THE DISTRIBUTION OF RHINONYSSID MITES (ACARI, GAMASINA, RHINONYSSIDAE) OF BIRDS

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The rhinonyssid mites is the most numerous and complicated in collecting group of gamasids (Acari, Parasitiformes, Mesostigmata) parasiting in the nasal cavities, tracheae and lungs of birds. More than 400 species of rhinonyssids are known in the world fauna. The distribution of these mites on the hosts is rather different. It depends from the many factors: species of bird, age, sex, locality, season, etc. The birds can have different number of rhinonyssids species. The possibility of exchange between birds of different species with rhinonyssids is rare with the exception of contacts between victim and prey or birds of different species in the places of feeding. The rhinonyssids from nasal cavities of anatid birds is the convenient group for investigation. It's possible to compare and analyse rhinonyssids from different species of ducks, geese and other representatives of the family. The analysis of material collected from nasal cavities of anatid birds in spring and autumn seasons of hunting (1960-1990) on the territory of Okskii State Biosphere
Reserve (Russia) gave the concrete information concerning the distribution of rhinonyssids from genus *Rhinonyssus* (Troues.). Some results based on the material collected could be given. In flocks the quantity of parasiting mites on juvenile ducks is more than on the old ones. There are specimens in a population, which serve as a reservoir of parasites (to 90 mites on the bird). The data on the interrelations connected with sexual, age, reproductive activity, list of species, specificity to bird-hosts in several regions of Russia (for example, in Ryazan and in Novosibirsk Oblasts) are given.

FRENKELIA, BUZZARDS AND RODENTS: MULTIPLE MECHANISMS OF PARASITE SURVIVAL STRATEGY

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Frenkelia spp. (Apicomplexa: Sarcocystidae) are dixenous coccidian parasites of buzzard (*Buteo buteo*) and its rodent prey. Sporocysts are excreted in buzzards' faeces (final host), while tissue cysts develop in the brain of rodents (intermediate hosts). The prevalence of *F. glareoli* and *F. microti* was studied in Czech Rep. Buzzard faeces were collected on nests with young, rodents (field vole *Microtus arvalis*, wood mice *Apodemus sylvaticus* and *A. flavicollis*, bank vole *Clethrionomys glareolus*) were snap-trapped. The total prevalence of sporocysts in buzzards was 72%. The prevalence increases with age of nestlings, 75% of samples being positive before fledging. The prevalence of *F. glareoli* in bank vole is 38%, of *F. microti* in field vole 5%. The main buzzard prey, however, is the field vole. The small number of bank vole in buzzard diet is therefore compensated by 10 fold higher prevalence of the parasite in the intermediate host. The prevalence also differs between habitats of rodents trapping, being the highest in ecotones. *Frenkelia* sporocysts probably cumulate there, because buzzard use ecotones as perching sites. This makes the bank vole more vulnerable to infection.

Diet composition significantly affects prevalence in buzzards. *Frenkelia* sp. sporocysts were found in faecal samples from 57% of nests in 1993, and 90% in 1994. The proportion of field vole in the diet was 24% and 52%, resp. Higher prevalences in rodents are also recorded in spring than in autumn, when the proportion of adult individuals in rodent population is the highest.

The prevalence of *F. microti* in field voles collected on nests and snap-trapped differed significantly (8% and 2% respectively.), suggesting that infection increases the risk of predation by the final host. Experiment with related coccidian *S. dispersa* confirmed that infected mice are more susceptible to predation by the final host, the long eared owl (*Asio otus*). Multiple mechanisms of parasite survival strategy therefore include 1. high environmental resistance of infective stages; 2. locally increased prevalence in intermediate host; 3. manipulation of the host behaviour increasing the risk of predation.

CONFORMITY OF PHENOLOGIES OF MALLARD *ANAS PLATYRHYNCHOS* L. AND INSECT VECTORS

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The study of breeding urban and wild-nesting Mallard *Anas platyrhynchos* populations has been carried out in Minsk, Belarus since 1989. In 1996, the investigations of mallard *Haemosporida* and vectors of the parasites began. The aim of this paper is to present the difference of vector's fauna and phenology at urban and wild nature territories and its relation with phenology of mallard.

Samples of Diptera were taken by means of an entomological sweep-net and light traps. The preimaginal stages of Culicidae and Simuliidae were taken at their habitats located near mallard's nesting places.

Collections of blood-sucking Diptera from urban areas are presented by 19 species of Culicidae, 21 - of Ceratopogonidae and 6 - of Simuliidae. At the territory of Belarus, 39 species of Culicidae, 28 - of Ceratopogonidae and 38 - of Simuliidae are known. Among them the mosquitoes *Culex pipiens pipiens* L., *Culiseta morsitans* Theob. and the blackflies *Simulium truncatum* Lundstr., *S. austeni* Edv. have been recorded as vectors of bird Haemosporida. At urbicoenoses, only *C. p. pipiens* was collected. Phenological indices of mallard life cycle are different at urban and nature areas. The urban nestlings hatch out three weeks later than the nestlings of wild-nesting mallards. The hatching and nestling period in wild nature is at the time of the most abundance of all groups of vectors. In urbicoenoses, the nestlings hatch out at the end of June, when abundance of Culicidae and Ceratopogonidae reduces about 1.5 times , Simuliidae - 20 times. At this time, the structure of vector's faunistic complex is changed, another species became more abundant than in May and in the beginning of June.

INVESTIGATING THE REGULATION OF PARASITIC NEMATODE FECUNDITY

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Objective: A primary characteristic of parasitic nematode life-histories is their extreme fecundity. Since the probability of each egg/larva produced actually infecting a new host is often very low, the high fecundity is necessary to ensure that infections persist and parasite fitness is maximised. However, large differences are often observed in the fecundity of the same nematode species infecting different host individuals. Here I investigate the causes of such variation.

Materials and Methods: The parasitic nematode *Heterakis gallinarum* was removed from one half of the viscera of 171 ring-necked pheasants *(Phasianus colchicus)*. The number of viable eggs contained within female worms was used as an index of nematode fecundity. An egg was assumed to be viable if the embryo developed through to the infective stage after being maintained for 21 days at 21 ^{O}C. Worm fecundity (on a per host basis) was analysed with respect to both worm count and worm length.

Results: *H. gallinarum* worm counts followed an aggregated distribution that was not significantly different from a negative binomial with an arithmetic mean of 25.64 and a positive exponent of 0.32 ($p = 0.25$). Upon analysis, a positive correlation between the log-transformed mean number of viable eggs per female worm and mean female worm length was observed ($p = 0.02$). Furthermore, at counts below 80 worms, female worm length increased with increasing worm count ($p < 0.001$) whilst, at counts above 80, female worm length decreased with increasing worm count ($p = 0.03$).

Conclusions: Influences on *H. gallinarum* fecundity appear to occur via effects on worm size. The non-linear relationship between worm count and worm length implies that variations in the host immune system may be the primary determinant of worm fecundity at low counts, whilst density-dependent competition among worms may be the primary determinant of worm fecundity at high counts.

RATE OF ANTIBODY TITER AFTER CHALLENGE BY VIRULENT *SALMONELLA ENTERITIDIS* CULTURE IN VACCINATED HENS

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Objective: Trial is devoted to evaluate influence of virulent *Salmonella enteritidis* culture on titers of specific antibodies in Hisex white (W) and Hisex brown (B) breed hens vaccinated with inactivated vaccine "TALOVAC 109 SE".

Materials and Methods: Trial was carried out on laying hens of W and B breeds (from 280 to 510 days of life at challenge moment). The birds were vaccinated twice with "TALOVAC 109 SE" and challenged orally by virulent *S. enteritidis* broth culture (0.2 ml/bird) on

14th day after second vaccination. Samples of blood were obtained on 35 day post challenge. Antibody titers were determined by using quantitative immunocapture assay ELISA.

Results and Conclusions: Figures of antibody titers (IDEXX ELISA S/N) in blood samples of treated hens showed high similarity (from 0.32 to 0.27 S/N). Only in one case S/N quantity found equal to 0.57. It corresponds to the lowest titer of specific antibodies. Laying of eggs hasn't been disturbed on post challenge time (hens were observed two months). According to our earlier trial single, samples with low titer of antibodies were found with 2.5% frequency on the contrary to high level in majority cases ascertained among twice vaccinated hens. Due to experiences in Bavaria, where nearly 600.000 broiler breeders were vaccinated in last two years, vaccination program reduced *S .enteritidis* isolation rate from 40% - before start of the vaccination schedule - to 2.5%. Complete eradication of *S. enteritidis* can not be achieved by vaccination and probiotics treatment only. One of the reasons leading to failure of current measures to combat with salmonellas may be constant presence of some percentage of immunosuppressed birds in breeders flocks. Moreover, hens with such weak immunity system create the main source of *S. enteritidis* shedding.

PREVALENCE OF COCCIDIA OF GENUS *CARYOSPORA* IN CAPTIVE BIRDS OF PREY IN THE CZECH REPUBLIC

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Objective: The purpose of this study was to describe the spectrum of coccidia of genus *Caryospora* in birds of prey in the Czech Republic.

Materials and Methods: Since September 1996 to March 1998 the faecal samples of 397 birds of prey were examined for parasites using faecal flotation method. The examined birds came from raptor rehabilitation centers, Zoos and private raptor keepers. Revealed coccidia were allowed to sporulate in 2.5% (w/v) potassium dichromate solution and oocysts were measured and determined using light and NIC microscopy.

Results: The coprological examinations revealed four species of genus *Caryospora* in hosts of order Falconiformes. In the faecal samples of 4 of 47 (8.51%) examined *Falco cherrug*, 3 of 26 (11.54%) *F. peregrinus* and 11 of 47 (23.40%) *F. tinnunculus* oocysts of *Caryospora kutzeri* were found. Oocysts of *Caryospora neofalconis* were found in 1 of 47 (2.13%) of *F. cherrug*, 4 of 26 (15.38%) of *F. peregrinus* and 3 of 47 (6.38%) of *F. tinnunculus*. 1 of 10 examined *Aquila chrysaetos* and 1 of 13 examined *Circus aeruginosus* were found to be passing oocysts of not yet described species. The sporulated oocysts of

Caryospora sp. 1 from *Circus aeruginosus* widely oval 24.5 × 21.8 µm (23.0–25.0 × 21.0–24.0 µm) with 2.0 µm thick wall. Polar granule, oocyst residuum and micropyle absent. The sporocysts spherical to subspherical, 16.2 × 15.6 µm (15.0–17.0 × 15.0–17.0 µm). Stieda and substieda bodies were absent. The oocysts of *Caryospora* sp. 2 from *Aquila chrysaetos* subspherical 43.0 × 37.5 µm (40.0–49.0 × 34.0–39.0 µm) with 2.2 µm thick wall. Polar granule, oocyst residuum and micropyle were absent. The sporocysts spherical to subspherical, 23.8 × 23.3 µm (23.0–25.0 × 22.0–25.0 µm). Stieda and substieda bodies also were absent.

Conclusions: While the new species statute of *Caryospora* sp. 1 is apparent, the size of *Caryospora* sp. 2 is almost identical to *C. megafalconis,* which occurs in hosts of family Falconidae. Its status should be an object of future study.

BLOOD PARASITES AND HAEMATOPHAGOUS INSECTS OF RAPTORS (FALCONIFORMES) IN THE CZECH REPUBLIC

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Raptors are known as hosts of 4 genera of blood protozoans: *Plasmodium, Leucocytozoon, Haemoproteus* and *Trypanosoma,* which are transmitted by mosquitoes (*Plasmodium*), blackflies (*Leucocytozoon*) and biting midges (*Haemoproteus*). The vector of trypanosomes (blackfly, mosquito or hippoboscid fly) is ambiguous.

In 1996 and 1997, we investigated the occurrence of blood parasites of raptors. Blood was collected from nestlings and adults of common buzzard (*Buteo buteo,* n=102), kestrel (*Falco tinnunculus,* n=68) and sparrowhawk (*Accipiter nisus,* n=324). Blood films were Giemsa-stained, cultivation was done on blood agar.

High prevalences of *Leucocytozoon, Trypanosoma* and *Haemoproteus* were found in adult buzzards and sparrowhawks. All these parasites were found in young buzzards and sparrowhawks, too, but the prevalence was markedly lower. Trypanosomes occurred in young and adult sparrowhawks and buzzards. No parasites were found in the blood of nestling kestrels. *Plasmodium* was not found at all.

In 1996, 1997 and 1998 haematophagous insects feeding on nesting birds were collected using the sticky bands, which were exposed twice for 6 – 8 days and blood-sucking insects were determined. In total, sticky bands were installed on 18 buzzard, 17 sparrowhawk and 12 kestrel nests.

In total, we captured 4 species of blackfly (the most common being *Eusimulium securiforme*), 12 species of biting midges (their respective representation depending on the observed locality and host species), 2 species of mosquito, and frequently the hippoboscid fly *Ornithomyia avicularia.*

Our results show, that an important part of populations of three raptor species in three different localities are infected with blood parasites. Vectors of different blood parasites in respective hosts are being sought for.

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FIRST DETERMINATION OF *EHRLICHIA* INFECTED TICKS AMONG THE PRIMARY VECTORS OF THE TICK-BORNE ENCEPHALITIS AND BORRELIOSIS IN THE RUSSIAN BALTIC REGION

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Abstract

This is the first communication of *Ehrlichia* spp. detected in *Ixodes persulcatus* Schulze and *Ixodes ricinus* (L.) ticks collected in the Russian territory. We tested a small number of ticks for the presence of *Ehrlichia* and *Borrelia* under a darkfield microscope (DF). One of 10 *I. persulcatus* was *Ehrlichia* spp. and *Borrelia garinii* positive. One *I. ricinus* out of 12 investigated by DF contained not only spirochetes, but also *Ehrlichia* spp.

The north beach of the Finnish Gulf (Morskaja, Lisy Nos) is an area of recreation for the inhabitants of St. Petersburg. In this area *I. persulcatus*, the primary vector of tick-borne encephalitis (TBE) and borreliosis, is abundant, and subsequently there is focus of both diseases (Antykova *et al.*, 1998).

Until now, no information about the presence of rickettsia-like diseases such as granulocytic ehrlichiosis is available from the region surrounding St. Petersburg or Kaliningrad. However, recently dogs from St. Petersburg region were found to show clinical signs similar to the symptoms described for severe ehrlichiosis (O. Arestov, personal communication).

In the USA (Ahkee & Ramirez, 1996; Goodman *et al.,* 1996; Barlough *et al.,* 1997) clinically and serologically confirmed cases of human ehrlichiosis have been described frequently, and in Europe some of cases have been suspected according to the serological data (Petrovec *et al.*, 1997; Dumler *et al.*, 1997).

Investigation of patients have provided evidence for mixed infections with tick-borne pathogens such as *Ehrlichia* spp., *Borrelia burgdorferi* sensu lato in addition to *Babesia microti* (Mitchell *et al.*, 1996). Infection of *Ixodes* ticks with multiple pathogens seems to be typical, e.g. Pancholi *et al.* (1995) found 2 out of

68 *I. scapularis* ticks infected with the human granulocytic ehrlichiosis agent (HGE) and *Borrelia burgdorferi* sensu stricto.

We investigated *I. persulcatus* and *I. ricinus* (L.) tick populations from areas in the vicinity of St. Petersburg and Kaliningrad for mixed infections with TBE, HGE and *B. burgdorferi* s.l. During the 1997 season 579 ticks were collected by flagging and then investigated using the DF technique. All ticks were examined by a direct IFA method to detect TBE antigens. DF positive specimens were fixed in 70% ethanol and then investigated using a PCR method to detect *Borrelia* genospecies (Rijpkema *et al.*, 1996).

The Kaliningrad region was also known as a focus of TBE and borreliosis (Zlobin *et al.*, 1996; Rejtchuk *et al.*, 1989) with *I. ricinus* as the primary vector for these pathogens. Within the Spring and Summer peaks of *I. ricinus* activity more than a total of 900 larvae, nymphs and adults were collected and investigated using the same methods.

Both tick populations are allopatric. In both regions mentioned, the presence of the TBE virus and of two species of *Borrelia* was demonstrated (Alekseev *et al.*, 1998). Double and even triple infections of both vector ticks were common, but such mixed infections occurred most often in *I. persulcatus* ticks. Two out of three *I. persulcatus* ticks which were infected with TBE also contained *Borrelia* spirochetes. One tick contained the TBE antigen and *Borrelia garinii*, and the one contained TBE, *B. garinii* and *Borrelia afzelii*. *Ehrlichia* species have not until recently been detected in European *I. ricinus* ticks (Cinco *et al.*, 1997, 1998; Stedingk *et al.*, 1997), and the presence of *Ehrlichia* species in *I. persulcatus* is not known in Europe.

We tested a small number of ticks for the presence of *Ehrlichia* among DF *Borrelia* positive *I. persulcatus* and *I. ricinus* ticks collected in areas of the Russian Baltic region (see above). One of 10 *I. persulcatus* was positive in a PCR based, reverse line blot hybridisation assay (Schouls *et al.*, 1998, in press). This specimen was also infected with *B. garinii.* One *I. ricinus* tick out of 12 investigated contained not only spirochetes detected by the DF method, but *Ehrlichia* spp. as well.

Although we found only two ticks positive for *Ehrlichia*, these data suggest that infections with multiple pathogens are not only present in the American *I. scapularis*, but do also occur in Eastern European, i.e. - *I. ricinus*, and in Euro-Asian *I. persulcatus.* Ticks from the Baltic regions may harbour at least three different pathogenic genera: the TBE virus, three *Borrelia* species and *Ehrlichia* species.

The determination of this new pathogen circulating in Russian territories is of great importance from epidemiological and clinical points of view emphasizing the necessity of differential diagnosis between different forms of infection. Magnarelli *et al.* (1995) stated that very often cases of serologically confirmed Lyme borreliosis are not investigated for *Babesia* or *Ehrlichia* antibodies. They concluded - and we agree with them - that multiple tick-associated illnesses have to be suspected in endemic zones, and thus tick-bitten patients should undergo a more extensive laboratory examination.

Acknowledgements

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PARASITES OF ATLANTIC SALMON *(SALMO SALAR)* AND BROWN TROUT *(SALMO TRUTTA)* FROM THE RIVER AKERSELVA, OSLO, NORWAY

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Abstract

Parr of Atlantic salmon and brown trout from the River Akerselva, Oslo, Norway, were examined for parasites. A total of fifteen parasite species were found. Of these were 5 ciliates, 1 myxosporidian, 2 monogeneans, 3 trematodes and 4 nematodes.

Introduction

The parasite fauna of Norwegian salmonids is fairy well known. There are numerous works dealing with individual parasite species (Huitfeldt-Kaas, 1927; Vik, 1954, 1959a,b, 1962, 1964; Halvorsen, 1970; Halvorsen & MacDonald, 1972; Lien & Borgstrøm, 1973). Included here are also many works on *Gyrodactylus salaris* (see references in Mo, 1994). However, only few works present data on the total parasite fauna of salmonids (Kennedy, 1977,1978; Bristow, 1991 and Bristow & Berland ,1991a,b). The aim of the present study was to further increase the knowledge of the freshwater parasite fauna of Atlantic salmon *Salmo salar* L. and brown trout *Salmo trutta* L. in Norway, by examining parr of these species from different seasons in the River Akerselva, Oslo.

Materials and methods

The fish were caught August 28, 1997 (water temperature: 22 °C), November 3, 1997 (4 °C) and May 22 1998 (12 °C) by electro-fishing in the River Akerselva, Oslo. The fish were kept alive (species separated) in river water in the laboratory until examination. They were killed by a sharp blow to the head. All external and internal organs were examined for parasites by the aid of dissecting- and phase contrast light microscopes. If possible, the number of each parasite species was determined, and this is presented as intensity range in Table 1. Ecological terms follow Bush *et al.* (1997).

The species determinations are based upon: Bykhovskaya-Pavlovskaya *et al.* (1962) (trematodes), Lom & Dykova (1992) (protozoans, myxosporidians), Malmberg (1970) (*Gyrodactylus*), and Moravec (1994) (nematodes).

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Table 1. List of parasites found on *Salmo salar* and *Salmo trutta* from the River Akerselva.

No. inf = number infected, Int. = intensity range (? = int. not recorded). Abbreviations: BC = body cavity, CV = corpus vitreum, F = fins GA = gill arches, GF = gill filaments, I = intestine, L = lens, LI = liver, S = skin, ST = stomach,

Season month (water temperature)		Summer August (22 °C)				Autumn November (3 °C)				Spring May (12 °C)			
Host species (number of specimens examined)		Salmon(10)		Trout(7)		Salmon(10)		Trout(10)		Salmon(4)		Trout(8)	
Weight (range, in g.)		13-55		9-72		10-41		14-167		12-32		10-29	
Length (range, in mm)		106-162		99-187		96-156		116-244		98-141		105-134	
Parasite species	Site	No. inf	Int.	No. inf	Int.	No. inf	Int.	No. inf	Int.	No. inf	Int.	No. inf	Int.
PROTOZOA													
Epistylis lwoffi Fauré-Fremiet, 1943	S,F,GA							4	?			1	?
Apiosoma sp.	S	1	?	1	?	1	?	1	?			5	?
Riboschyphidia sp.	S					5	?	6	?			2	?
Trichodina sp.	S,GF			1	?	2	?	1	?			1	?
Chilodonella piscicola (Zacharias, 1894)	GF									1	?		
MYXOZOA													
Chloromyxum truttae Léger, 1906	LI	1	?										
MONOGENEA													
Gyrodactylus derjavini Mikhailov, 1975	S, F	1	4	1	1	6	1-10	9	3-25	3	3-12	8	3-70
Gyrodactylus magnificus Malmberg, 1957	S, F											1	1
TREMATODA													
Crepidostomum metoecus (Braun, 1900)	I					2	8-25	2	1-2			4	2-8
Diplostomum sp.	L, CV	9	10-20	6	10-40	10	6-35	9	20-50	4	5-9	7	20-80
Ichthyocotylurus sp.	BC, PC	1	2			1	1					2	1-3
NEMATODA													
Cystidicoloides ephemeridarum (Linstow,1872)	ST	1	1	1	1	1	1	1	2			1	1
Pseudocapillaria salvelini (Polyansky, 1952)	I							1	1				
Rhabdocona oncorhynchi (Fujita, 1921)	I	4	1-4			7	1-30	5	2-35	4	4-40	7	2-30
Raphidascaris acus (Bloch, 1779)	I					1	1					5	1-3

Results and Discussion

The results are presented in Table 1 and discussed below:

Five ciliate species were found on the external surfaces of the fish. *Chilodonella piscicola* was found only on the salmon, and only trout harboured *Epistylis lwoffi*; a colonial ciliate recognised by the horse-shoe shaped macronucleus of the zooids. *Epistylis* sp. (probably *E. lwoffi*) has been found on several occasions in Norway before, but has not been determined to species level. For ciliates in general we found lower prevalences in the summer sample. High water temperatures and low water level normally stress fish and favour ciliate reproduction. The present results do not reflect these facts. The reason for this is unknown.

Gyrodactylus derjavini is commonly found on salmon and brown trout in rivers draining to the Oslo fjord. In our study it was present in all samples of both salmon and trout with a marked decrease in both prevalence and intensity in the summer sample. According to Mo (1997), this is a probable result of temperature induced immunity. One individual of *G. magnificus* was found on a fin of a spring sampled trout. The minnow *Phoxinus phoxinus* is the type host of *G. magnificus*, which has never previously been found on trout in Norway. However, it is suspected that the monogenean could have been transferred via the net used when electro-fishing instead of an natural host-switch. This was shown to be possible for other *Gyrodactylus* species under experimental conditions by Mo (1987).

The most common parasite in the present survey was *Diplostomum* sp. The metacercariae of this fluke were found in the lens and corpus vitreum in 92 % of the fish (n= 49). The intensity was normally high (range: 5-80). Owen *et al.* (1992) found that low level infection (4-7 metacercariae per eye) significantly reduces the vision and thereby the prey capture ability of sticklebacks *Gasterosteus aculeatus.* McKeown & Irwin (1996) showed that *Diplostomum* spp. indirectly caused mortality in roach *Rutilus rutilus*, due to increased susceptibility to predation by bird and fish. This is supported by various authors (Crowden & Broom, 1980; Field & Irwin, 1994). In light of these investigations, *Diplostomum* could have a significant negative effect on the populations of salmon and trout in the River Akerselva.

Four species of intestinal nematodes were found in the fish. The most common species was *Rhabdocona oncorhynchi.* This finding was presented in a separate communication by Sterud *et al.*(1998) and represented then the first record of this species from brown trout in Europe. Adult males and females of *Rhaphidascaris acus* were found in the intestine of both salmon and trout. To the best of our knowledge, this nematode is not previously known from salmonids in Norway. Brown trout is regarded as a common final host for *R. acus* under European conditions, while Atlantic salmon is not on the list of final hosts (see Moravec, 1994). The nematode was commonly found in the spring sample (5 of 8 trout infected). An occurrence only in the spring is in agreement with previous European findings (Moravec, 1994). One adult female of *Pseudocapillaria salvelini* was found in an autumn sampled trout. Although this is a holoarctic species commonly found in other salmonids than its type host *Salvelinus alpinus*, there are no published records of this species from Norwegian trout.

Cystidicoloides ephemeridarum was found in the stomach of both salmon and trout. *C. ephemeridarum* has never been found in salmon in Norway before, but according to Moravec (1994), Atlantic salmon is one of many salmonids which can serve as host for this nematode.

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SOCIETY NEWS

SCANDINAVIAN SOCIETY FOR PARASITOLOGY

Minutes from the Board telephone meeting 06. October, 1998:

Present: Tellervo Valtonen, Jorun Tharaldsen, Ingela Krantz, Karl, Skirnisson, Tor Atle Mo, Katarina Gustafsson and Maria Vang Johansen

Agenda for the meeting:

0. Comments to the minutes from the last meeting.
1. Latest news from ICOPA in Japan (including sorting out the problems - Federation correspondence) and news from the Polish jubilee meeting.
2. Question of collecting the fees and acquiring new members. (Tor-Atle and the local treasures from each country should tell about the local situations).
3 New members, acceptance of applicants.
4. The next meeting in Iceland. (Karl will inform).
5. Latest news on the WAAVP in Copenhagen (MVJ will brief).
6. Other issues.

Re 0) The minutes from October 29, 1997 were accepted without comments.

Re 1) Tellervo attended the ICOPA meeting in Japan, where she sorted out the problems with Professor van Knapen, World Federation for Parasitology, and paid our membership fee and exchanged new addresses.

Re 2) Norway, Finland, Iceland and Denmark have sent out payment forms to their members. Sweden is still waiting to get the forms from the giro office. Until now, the number of people who has paid is:

8 non-Scandinavians;
25 in Norway, (18 missing);
9 in Finland, (? missing);
18 in Denmark (19 missing);
5 in Iceland, (all have paid).
Ingela informed that Sweden has about 70 members.

It was agreed that all local treasures should send an updated membership list to Tor as soon as possible and keep him informed about changes. It was further suggested that we change to Euro accounts, which will be possible from next year. This needs to be further discussed. All local treasures could further inform that no members had complained about the paying procedure, but it was agreed that we from now on shall send out payment forms every year.

Re 3) Five new members from Finland and one from Denmark were approved. Ph.D. students are not regarded as students, hence they have to pay full membership fee. It was agreed to make an active move towards getting new members to SSP. Everyone should advocate for the society and the meeting next year.

Re 4) Prior to the meeting Karl had sent out information about the Iceland meeting. So far 40 people have responded to the first announcement. The Second Announcement will be sent out within the next month to all members. New members, although not formally accepted by the Board, will receive the announcement as well.
It was further agreed that the announcement should be sent to the Russian, the Polish, and the Baltic Societies. Parasitology Today as well as the European and World Federation for Parasitology should also be informed.

Re 5) Maria had nothing to report.

Re 6) Jorun asked for inputs to the Bulletin, which she has not gotten from any of the members. Advertisements of meetings, Ph.D. defences, awards, employments as well as scientific inputs are highly wanted. The next number of the Bulletin will be sent out shortly and one more will come before Christmas. So please, help Jorun with information.

Due to trouble sending mails, Maria will send out a new revised e-mail address list. Please remember to inform the secretary when addresses are changed.

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07.10.98 Maria Vang Johansen

News from Denmark

Professor **Peter Nansen**, Danish Centre for Experimental Parasitology, was in September 1998 elected Honorary Member of the Polish Society for Parasitology at the society's 50 years anniversary.

Charlotte M. Christensen, Danish Centre for Experimental Parasitology, obtained her Doctor of Science degree in June 1998 at the Royal Veterinary and Agricultural University, Denmark.

Danish Centre for Experimental Parasitology has been evaluated by an international panel, and granted another five years budget 1998-2003.

Ph.D. **Stig Milan Thamsborg** has been awarded a 5-years research professorship at the Royal Veterinary and Agricultural University in the area organic husbandry systems.

Ph.D. **Michael Larsen**, Danish Centre for Experimental Parasitology, has been granted a 2-years senior research fellowship from the Lundbeck Foundation - to study nematode-killing microfungi.

A group of researchers (headed by Peter Nansen) from Danish Centre for Experimental Parasitology has been granted an extension (1998-2001) of the ongoing Ruminant Helminth Research Project. The project is supported by Danida and includes Kenya, Tanzania, Zambia and Zimbabwe. The coordinator is Ph.D. Lee Willingham.

Danish Centre for Experimental Parasitology (DCEP) took the initiative to an international workshop: "The epidemiology and host-parasite relationships of *Schistosoma japonicum*", September 8-10, 1998, Jiangsu Institute of Parasitic Diseases, Wuxi, Peaples Republic of China (PRC). Sponsors were: CEP, Ministry of Health (PRC), SIDA, WHO/TDR, FAO. Totally 62 participants from 11 countries. Workshop coordinator: Dr. Lee Willingham.

Danish Centre for Experimental Parasitology arranged an international workshop on "Mysteries of Ascaris: What they are, how they behave and what to do about them. A focus on Ascaris in pig and man" October 8-11, 1998, Copenhagen. Totally 52 participants from 18 countries. Workshop coordinators Allan Roepstorff and Lis Eriksen.

GUIDELINES FOR CONTRIBUTORS

All contributions should be submitted as word-processed manuscripts on floppy disk, accompanied by two exactly matching print-outs of good reading-quality. The preferred storage medium is a 3½ inch disk in MS-DOS or Windows compatible format. The text should be written in Word or WordPerfect or other word processing programs convertible to these. **With a Macintosh computer, save the file in the MS-DOS compatible option.** Please indicate the word processor (and version) used to generate the file, the type of computer, the operating system, and the formatted capacity of the diskette.

The articles/communications should normally not exceed 4 printed pages, including tables, figures, and references, and may contain a maximum of 2000 words if there are no figures or tables. The first page should show the title of the article, and the name(s) of the author(s). The authors' addresses should be given, and the complete correspondence address with telephone and telefax number (if available). The text should follow, without subheadings, but a short summary, maximum 100 words, may be included.

The text should be typed unjustified (unaligned right margins), without hyphenation (except for compound words), and at 1 ½ line spacing. Do not type page numbers. Label the hard copies by hand at the bottom of the page. Please ensure that the digit 1 and the letter 'l' have been used properly, likewise with the digit 0 and the letter 'O'. Do not use decorative formatting, such as boldface and centred headings, or underlining of titles or subheads.

Authors are obliged to follow the rules governing biological nomenclatures, as laid down in e.g. the *International Code of Zoological Nomenclature.* Disease names should follow the principles of *Standardized Nomenclature of Parasitic Diseases* (SNOPAD).

Figure legends must be included on the diskette, but the **figures will be handled conventionally.** They should be marked on the back with the title of the article and name of the (first) author.

Line drawings should be provided as good quality hard copies suitable for reproduction as submitted.

Photographs must be provided as glossy prints, and be of sufficiently high quality to allow reproduction on standard (not glossy) paper. Colour plates will not be printed.

References in the text shold be stated by giving in brackets the name of the author and the year of publication, e.g. (Thornhill, 1987) or (Austin & Austin, 1987). If there are more than two authors, only the first name plus *et al.* is given (Lund-Larsen *et al,* 1977). The reference list should be in alphabetical order, and follow the style set forth in *Uniform Requirements to Manuscripts Submitted to Biomedical Journals,* Br Med J

1988; 296: 401-5. References to journals should contain names and initials of the authors, article title, the abbreviated name of the journal, year of publication, volume, and first and last page numbers of the paper. Journals should be abbreviated according to the "List of journals indexed in *Index Medicus*". Authors without access to this list may type the full name of the journal, and the Editor will take care of the abbreviations. If there are more than six authors, list only the first three and add *'et al'*. Personal communications and unpublished data should not be used as references, but may be inserted in the text (within parenthesis marks).

Examples of correct forms of references are given below:

Standard journal article:

Anonymous. Some facts on small animal practice. Vet Rec 1987; 120: 73

Horsberg TE, Berge GN, Høy T et al. Diklorvos som avlusningsmiddel for fisk: klinisk utprøving og toksisitetstesting. Nor Vet Tidsskr 1987; 99: 611-5

Lund-Larsen TR, Sundby A, Kruse V, Velle W. Relation between growth rate, serum somatomedin and plasma testosterone in young bulls. J Anim Sci 1977; 44: 189-94

Books and other monographs:

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