


**Bulletin
of the
SCANDINAVIAN SOCIETY
FOR PARASITOLOGY**



 **WITH PROCEEDINGS OF THE SYMPOSIUM ON ECOLOGICAL
PARASITOLOGY ON THE TURN OF MILLENIUM, ST. PETERSBURG,
RUSSIA, 1-7 JULY, 2000**

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BULLETIN OF THE SCANDINAVIAN SOCIETY FOR PARASITOLOGY

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.

PROCEEDINGS

RAAMATUKOGU
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of the symposium on

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arranged on behalf of the

Russian Parasitological Society

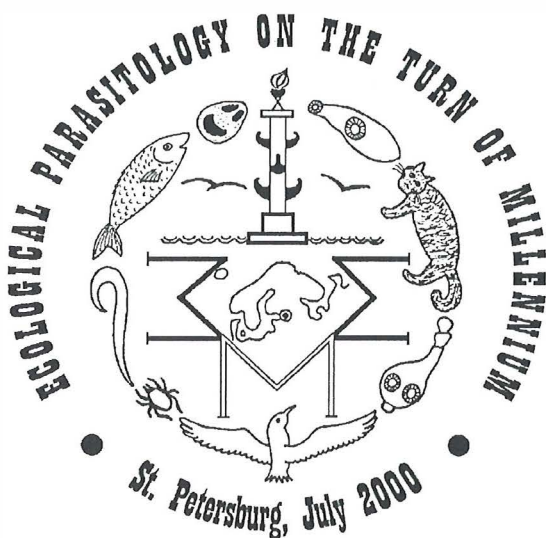
and the

Scandinavian Society for Parasitology

in

St. Petersburg, Russia

1-7 July, 2000



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PREFACE

In 1994 the Scandinavian Society for Parasitology (SSP) arranged for the first time a special symposium on *Parasites of Biological and Economical Significance in the Aquatic Environment* in Heimaey, Iceland (see the SSP Bulletin 4.2). Based on the same idea another special symposium was arranged on behalf of the SSP in Stykkishólmur, Iceland in 1996 that dealt with *Parasites and Ecology of Marine and Coastal Birds* (SSP Bulletin 6.2). In 1998 the Baltic Society for Parasitology and the SSP arranged a joint symposium on *Ecology of Bird-Parasite Interactions* in Vilnius, Lithuania (SSP Bulletin 8.2) and this issue is a result of a recently organized joint symposium of the Russian Parasitological Society and the SSP in St. Petersburg, Russia on *Ecological Parasitology on the Turn of Millennium*. These four meetings as well as the *Baltic-Scandinavian Symposium on Parasitic Zoonoses and Ecology of Parasites* held in 1994 in Vilnius, Lithuania (SSP Bulletin 5.1) have brought parasitologists in this regions together and promoted a very valuable exchange of information and initiated various collaboration among Scandinavian, Baltic and Russian parasitologists. The Bulletin of the SSP has been an important forum to publish invited papers and submitted abstracts which have been presented by hundreds of parasitologists during the above mentioned meetings. Several very valuable review articles, based on invited lectures given at the meetings, have been prepared and published in the Bulletin. There is no doubt that the organisation of the special meetings has increased the attention and the scientific value of the journal.

Due to various reasons St. Petersburg was chosen to be the venue of a joint symposium of the Russian Parasitological Society and the SSP on ecological parasitology. First to mention is the fact that in the 20's and 30's Professor Valentin A. Dogiel (1882-1955) founded in the city the Russian school of ecological parasitology. His books on ecological parasitology and books on the subject written by his Russian followers were translated to English and subsequently also stimulated the development of ecological parasitology in other countries of the world. Also, a considerable number of parasitologists is working on parasites at different institutions in St. Petersburg, e.g. the Zoological Institute, the St. Petersburg State University and the Institute of Lake and River Fishery (GosNIORKh). Many of them have continued Dogiel's tradition on ecological parasitology. Furthermore, close relationships exists between parasitologists working in St. Petersburg and colleagues in the states of the former USSR, especially, however, of those in NW Russia and in the Baltic countries. For them, as well as for western parasitologists, it was considered to be easy to come to St. Petersburg. During the "Cold War" the western and eastern branches of ecological parasitology developed more or less independently. Now, as the circumstances have considerably changed, and a free travel has been made possible, time had

come for the scientists of these countries to meet to present and discuss research data, exchange ideas and develop collaboration.

Altogether 111 scientists from 25 countries took part in the meeting. Eleven plenary lecturers and 49 submitted oral presentations were given and altogether 73 posters were shown. Papers or abstracts based on plenary lectures and abstracts of the submitted presentations are printed in this issue. As the readers will see the presentations mainly covered various aspects of modern ecological parasitology, e.g. patterns of parasite communities, strategies of parasite life-cycles and life-histories, parasite manipulations with host behaviour, parasites and wildlife management and vector's ecology.

Two workshops were organised during the symposium, on *"Ecological-parasitological problems of NW Europe"* and *"Parasites of marine and coastal birds in Arctic and subarctic regions"*.

On behalf of the Local and Scientific Organising Committees we would like to express our sincere thanks to the invited speakers, to the participants and to all other persons who contributed to the great success of the meeting. Last but not least we are very grateful to the sponsors listed below who kindly supported the symposium.

September 30, 2000

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INVITED LECTURES

VECTOR (TICK) AS ECOLOGICAL NICHE OF DIFFERENT PARASITIC ORGANISMS

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The main purpose of our communication is to test Academician Eugeny Pavlovsky's (1934) postulate that any living organism represents some kind of "parasitocosmos". We humans are able to live because, under normal circumstances, the "microcosm" of our microflora is the basis of our normal metabolism. Nevertheless the same commensals or foreign flora become deadly dangerous when this balance is disturbed. The appearance of AIDS served as a trigger, stimulating the discovery of a legion of so-called opportunistic infections. These may consist of our own previously commensal microflora, or might be representatives of exotic agents such as flea-borne microsporidia.

In the past, imagining ourselves to be the "kings of nature", we hardly permitted the thought that the same processes are common and typical of all other organisms on the lower steps of the "ladder" of life forms. In the study of parasitic systems most investigators have typically neglected the interaction between components of the "parasitocosmos" inside host

organisms. Different types of interactions, however, serve as important links in the chain of complicated parasitic systems, including vector-borne disease systems. As we have stated previously (Alekseev, 1993), mixed infections of vectors in natural foci of diseases is most probably the rule rather than the exception. We agree with the basic statement of P.A. Petristscheva (1972), that between different pathogens transmitted by the same vector there exists a very complicated interface, which determines the successful survival, development and transmission of one or another parasitic organism to the vertebrate host.

There exists, however, an opposite opinion: based on observations that different pathogens are able to coexist simultaneously in the same individual ixodid tick, some authors portray the tick as a kind of a «cabinet», containing different «shelves» (i.e. ecological niches) on which different pathogens live and multiply practically independ-

ent of each other. This concept ignores the type of pathogen, the time and stage at which one or another pathogen infests the invertebrate host (vector) and ignores the host reaction to the invasion. According to our definition of biological vector specificity (Alekseev, 1989), any pathogen that is specific is able to multiply and enlarge its biomass to be transmitted to another host. Only at the end of these processes might a vector be considered as a «filled cabinet». In nature, however, simultaneous infections of a single vector is a very rare phenomenon: symbionts (e.g. *Wolbachia*) and some pathogens (e.g. tick-borne encephalitis virus) may be transmitted transovarially, while others, particularly bacteria (spirochetes, rickettsiae, piroplasmidae) infect the tick chiefly *via* an infected blood meal; helminths, for example, are acquired exclusively with the blood meal. The manner of penetration by these parasites and their interaction inside the vector are very important factors in their survival and multiplication. When simultaneously infected by *Leishmania major* and *Leishmania gymnodactyli*, *Phlebotomus papatasi* sand-flies died (Alekseev *et al.*, 1975). Trematode super-invasion of snails, which were previously naturally infected by another trematode, may kill the host. The trematode-infected host subjected to super-invasion either fully or partially suppressed the development of the newcomer maritae. All such tested pairs of parasites belonged to different families (Ataev, 2000). In sand flies successfully infected by two species of *Leishmania*, the first-comer had an advantage in development in the host gut (Safjanova *et al.*, 1976). *Ixodes* ticks are not an exception, being host to many different groups of symbiotic and pathogenic (for vertebrate hosts) microorgan-

isms or parasites. It was shown previously (Alekseev, 1996; Alekseev *et al.*, 1996) that when *Ixodes persulcatus* ticks already naturally infected by *Borrelia burgdorferi sensu lato* were superinfected with TBE virus, infection was much less successful than in previously uninfected ticks.

In our study we are considering *I. persulcatus* ticks as an ecological niche for different groups of pathogens. While studying the population of taiga tick in the vicinity of the megapolis of St. Petersburg, we discovered that this population is not homogenous but represents two sub-populations. We called the larger group “normal”, and the other one “anomalous” because of anomalies in their exoskeleton structure, apparently a result of anthropogenic pressure (Alekseev, 1996). The responses of both sub-populations to pathogens and to important abiotic factors (Alekseev & Dubinina, 2000) were different. This permitted us to analyse the *I. persulcatus* population not as one, but as two different ecological niches. Vector response to *Borrelia* and *Ehrlichia* species was quite different, depending on the group to which the host belonged.

Responses of uninfected and infected ticks to a temperature gradient (Alekseev & Dubinina, 2000), and to humidity and gravity were used as markers of the two sub-populations' characteristics. All these markers, as well as measurements of tick activity parameters using the authors' own «ticks-drome» (Alekseev, 1996; Alekseev *et al.*, 2000, in press) were used to confirm the existence of two sub-populations. The same methods were

used to reveal differences in the interaction of the pathogens within the tick-host interface. Negative hydro- and geo-taxes determined the activity of ticks moving up vegetation stems. In the normal population, similar numbers of uninfected and infected ticks showed both taxes, whereas in the anomalous population, more infected than uninfected ticks showed negative taxes. There was a greater total number of active ticks among anomalous infected ticks. This was especially clearly demonstrated in males, because the anatomical anomalies were detected more precisely in this sex. Infection by any pathogen decreased activity parameters (speed, height and activity index) in both groups of ticks, but the relative decrease in anomalous specimens was less than in normal ones.

It was established that infected specimens appeared from the litter mainly when there was a positive temperature gradient (temperature of surface minus temperature in the litter). The threshold gradient at which ticks emerged from the litter is here called the TSG. Our earlier report of a difference between TSG values of uninfected and infected ticks (Alekseev & Dubinina, 2000) was based on this phenomenon. The decrease in the number of anomalous ticks under a negative TSG was twice as large as that of normal ones. Using the PCR method to detect infection, we compared the behaviour of mono-, dual- and triple-infected specimens, and showed that the reaction to abiotic factors of such infected normal and anomalous ticks was some-

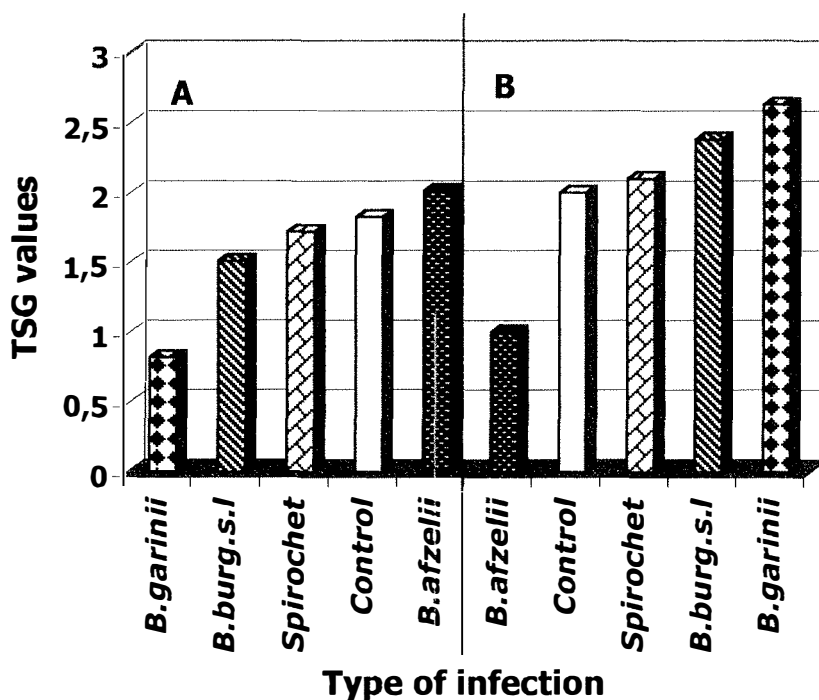


Fig. 1. Temperature gradient (TSG) values, at which normal (A) and anomalous (B) infected ticks appeared from the litter.

times quite opposite. *Borrelia garinii* infected normal ticks showed a TSG of 0.82°C compared with 2.63°C for similarly infected anomalous ticks. The opposite reaction was established among *Borrelia afzelii* infected specimens: *B. afzelii* infected anomalous specimens had a TSG of 1°C compared with 2.01°C for normal specimens (Fig. 1). Most of the ticks with anomalies infected by two pathogens simultaneously (whatever the type of infection) had lower TSG values that did normal ticks. Only dual infection by a mixture of *B. afzelii* and *B. garinii*, both highly pathogenic for humans, increased the TSG of both types of ticks.

Activity indices were also dependent on the type of infection, with observed synergistic or antagonistic effects of different pathogens co-inhabiting the same host. The more intensively infected were *I. persulcatus* ticks, the more often were *Borrelia* found in their salivary glands (Moskvitina *et al.*, 1995). Furthermore, active multiplication of any pathogen enhances its quality as a parasite and increases its transmission probability (Mackinnon & Read, 1999). We found a higher prevalence of high infection intensity (*Borrelia* No per 250 darkfields) in anomalous ticks than in normal ones. Also, amongst ticks more intensively infected by *Borrelia*, anomalous specimens were the most active ones. Dual infection of *B. afzelii* and *B. garinii* enhanced activity of both groups of ticks, but more so in anomalous ticks than in normal ones. *Borrelia-Ehrlichia* co-inhabitants had a synergistic effect, causing a decrease in TSG and an increase in infected tick activity, most marked amongst anomalous ticks. All these data stress the importance of monitoring not only the type of infection, but also of the

structure of tick sub-populations, which serve as an ecological niche for different pathogens.

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References

- Alekseev AN. Composition of invertebrate host "parasitocosmos" and its importance for transmission of transmissible infection agents. *Parasitol Rev* (Leningrad: Izdatel'stvo «Nauka») 1989; 36: 5-20 (in Russian)
- Alekseev AN. Tick-borne pathogen system and its emergent qualities. St.Petersburg: Zoological Institute RAS, Inc. 1993 (In Russian)
- Alekseev AN. 1996. Tick pathogen interactions: Behaviour of infected and uninfected ticks (Ixodidae). In *Acarology IX*. R. Mitchell, D.J. Horn, G.R. Needham, W.C. Welbourn (eds.) Columbus, Ohio 1996; 1: 113-5
- Alekseev AN, Burenkova LA, Vasilyeva IS, Dubinina HV, Chunikhin SP. The functioning of mixed tick-borne infection foci in Russia. *Med. parazitol.* (Moscow) 1996; 4: 9-16 (In Russian)
- Alekseev AN, Dubinina HV. Abiotic parameters and diel and seasonal activity of *Borrelia*-infected and uninfected *Ixodes persulcatus* (Acarina, Ixodidae). *J Med Entomol* 2000; 37: 9-15

Alekseev AN, Jensen PM, Dubinina HV, Smirnova LA, Makrouchina NA, Zharkov SD. Peculiarities of behaviour of taiga (*Ixodes persulcatus*) and sheep (*Ixodes ricinus*) ticks (Acarina, Ixodidae) determined by different methods. Folia Parasitol 2000; 47: 00-00 (In Press)

Alekseev AN, Safjanova VM, Karapetian AB. On the viability of sand flies (Diptera, Phychodidae, Phlebotominae) at the infection with promastigotes of the different species of *Leishmania*. Parazitologia 1975; 9: 271-7 (In Russian)

Ataev GL. Development of the Trematoda parthenites. Diss. Dr. Sci. St. Petersburg 2000 (In Russian)

Mackinnon MJ, Read AF. Genetic relationships between parasite virulence and transmission in the rodent malaria *Plasmodium chaubaudi*. Evolution 1999; 53: 689-703

Moskvitina GG, Korenberg EI, Spielman A, Schchyogoleva TV. On frequencies of generalised infection in unfed adult ticks of the genus *Ixodes* in Russian and American foci of the borrelioses. Parazitologia 1995; 29: 353-9 (In Russian)

Safjanova VM, Alekseev AN, Karapetjan AB. The fate of promastigotes of *Leishmania tropica major* and *L. gymnodactyli* in the organism of *Phlebotomus papatasi* at the mixed infection. Parazitologia 1976; 10: 78-83 (In Russian)

Pavlovsky EN. Host organism as a parasite habitat. Nature 1934; 1: 80-91 (In Russian)

Petristscheva PA. 1972. Biozenotical bands of bloodsucking arthropods with vertebrates and disease agents. Main results and perspectives of development of the theory of the natural focality of the human diseases. Moscow 1972: 108-23 (In Russian)

SELECTIVE PRESSURES AND PARASITE STRATEGIES

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"[Host-parasite relationships] are extremely interesting also from the point of view of theoretical considerations" (V. A. Dogiel, 1947)

Sewall Wright's adaptive surface

Sewall Wright (1932) described the relationships between gene combinations and fitness as a landscape with peaks and valleys. The landscape was represented as a two-dimensional figure (Fig. 1). In spite of Wright writing that this "diagrammatic representation of the field of gene combinations in two dimensions instead of many thousands" was a "very inadequate representation" of reality, Wright's proposition of adaptive peaks had an immense success: "Sometimes in science a simple phrase or diagram appears to be so cogent an encapsulation of an important truth that it takes on almost mythological proportions" (Lewin, 1988).

A population can be represented on Wright's landscape as a more or less tightly clustered cloud of points. Each point sym-

bolizes an individual. Natural selection tends to gather genotypes towards summits because individuals close to a summit have a reproductive success better than individuals situated on slopes or valleys. Conversely, mutation tends to disperse individuals away from the peak.

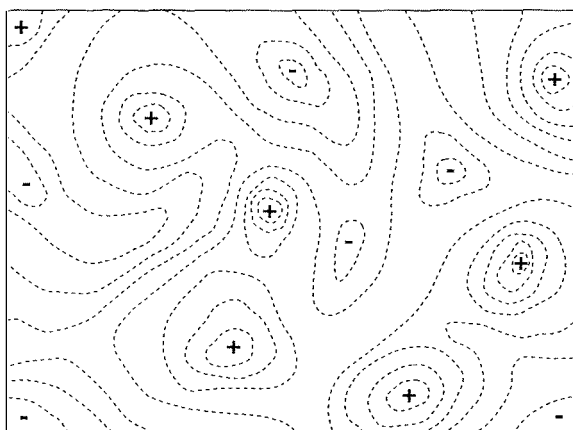


Fig. 1. The original figure of an adaptive landscape as symbolized by S. Wright (1932). Dotted lines are lines of equal fitness.

Wright's diagram gives a picture of "how a species' fitness varies as a result of modifications in its genetic make-up" (Lewin, 1988). Wright used his representation to illustrate how a population can move from one peak to another (the "shifting balance" model). Wright links evolution to adaptive peaks in the following terms: "The problem of evolution as I see it is that of a mechanism by which the species may continually find its way from lower to higher peaks in such a field. In order that this may occur, there must be some trial and error mechanism on a grand scale by which the species may explore the region surrounding the small portion of the field which it occupies".

Encounter and compatibility filters

The notion of adaptive landscape can be applied to parasite species without particular alterations.

However, the fitness of free living species depends only on their own gene combinations. On the contrary, the fitness of parasite species depends both on its genes and on the host's genes. A parasite must be adapted not just to an environment, but to a *living* environment (Pavlovski's and Dogiel's "micro-environment").

I have suggested (Combes, 1995, 1997) that, in a parasite-host system, natural selection acts at two different levels.

At a first level (which corresponds to "pre-infective" events), selection favours gene combinations which improve:

a) in the *parasite* genomes, the probability of *meeting* the host;

b) in the *host* genomes, the probability of *avoiding* infective stages of the parasites.

This is what I called the "encounter arms race". It implies principally behavioural adaptations and counter-adaptations.

Then, at a second level (which corresponds to "post-infective" events), natural selection favours gene combinations which improve:

c) in the *host* genomes, the probability of *killing* the parasite;

d) in the *parasite* genomes, the probability of *surviving* in the hostile environment created by the host.

This is what I called the "compatibility arms race". It implies principally defence and evasion mechanisms.

Selective pressures in parasite-host systems could thus be symbolized by two filters, an *encounter filter* and a

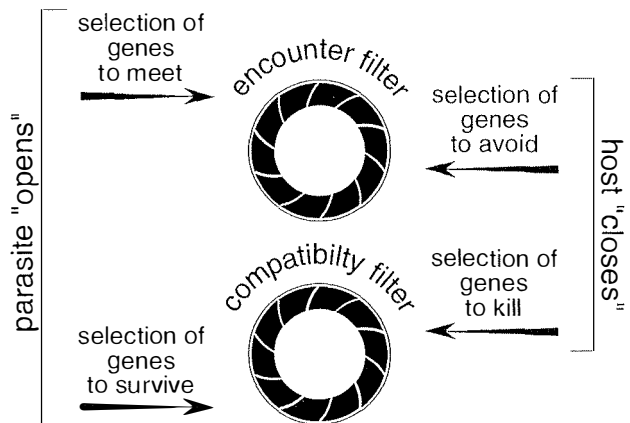


Fig. 2. Encounter and compatibility filters (from Combes, 1997, modified). Note that filters are *phenotypes* coded by *both* parasite and host genes.

compatibility filter, which are more or less opened, depending on the success of the selection in the genomes of the two partners (see Combes, 1995). Each filter is a "*crossed phenotype*", in the sense that it depends on genes both of the parasite and the host (Fig. 2).

All possible degrees of opening or closing of the two filters are possible regardless of the level of species, populations, or individuals addressed. Because abundance of parasites is, as a rule, positively correlated with virulence (defined as the parasite-mediated loss of fitness of the host), these degrees of opening or closing are themselves correlated with evolution of virulence through time.

Parasites in the landscape

Is it now possible to combine in some way Wright's adaptive landscape with the crossed phenotypes of parasite-host systems?

Because the fitness of a parasite population depends in part on genetic characteristics of its host species, I propose to design an adaptive landscape (Fig. 3) in which peaks co-ordinates are:

- host genes involved in the encounter filter (x);
- host genes involved in the compatibility filter (y); and
- parasite reproductive success (z).

The difference with Wright's contour map is that the gene combinations belong to the host whereas the fitness is that of the parasite. At this step of the reasoning, parasite genes are not taken into account. Each dot on the surface is an individual host, not an individual parasite but a "host-dot" *can be invaded* by a "parasite-dot".

Let us imagine an individual parasite confronting a potential individual host A with symbolic co-ordinates e_A , c_A and a potential host B with symbolic co-ordina

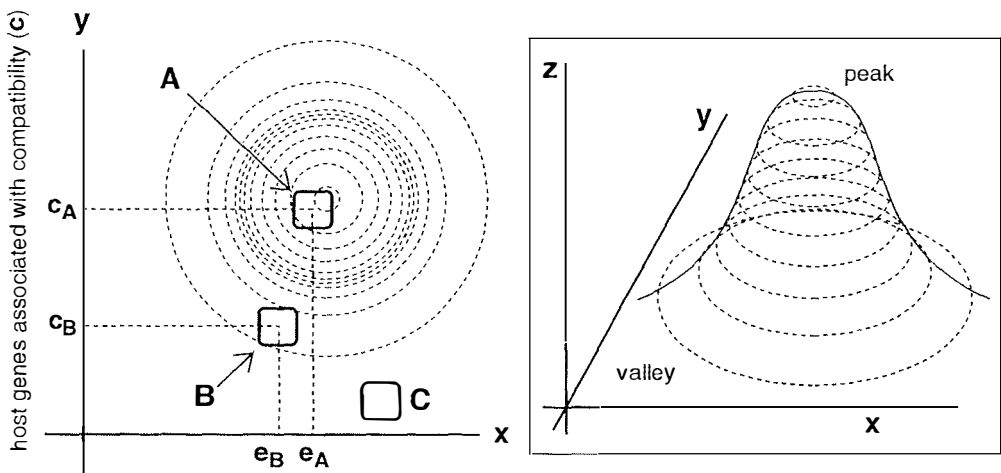


Fig. 3. A peak of parasite high fitness (the peak is supposed to have a round shape, to simplify). A is an individual host close to the summit, B is another individual, close to the bottom (supposedly having genes conferring low compatibility), C is another individual in a valley (unsuitable for the parasite). At right, 3-D view of a peak.

tes e_B , c_B (e and c mean encounter and compatibility, respectively). Because A is closer to the summit than B, the probability of having its fitness reduced by the parasite is greater for host A than for host B. This means that there exists an "inversed landscape" if we consider host fitness: where there is a peak of parasite fitness, there is a valley of host fitness.

This scheme allows one to discuss various evolutive aspects of parasite-host relationships.

1) If hosts produce mutations which disperse individuals away from the peak, it is those individuals which are away from the summit which have in average the best fitness because they have a better chance to escape parasitism (and thus transmit their genes). This means that selective pressures arising from parasites result in host populations "moving the peaks", either by changing behaviour (moving along x in Fig. 3) or by improving immune defence (moving along y), or both.

2) Such changes in the adaptive landscape which is offered to parasites modify the pressures exerted on them. It can thus be expected that counter-strategies will be selected in the parasite gene pool. These continuous selections of measures and counter-measures are nothing else than a Red Queen process (Van Valen, 1973). Here the Red Queen is symbolized by parasites provoking shifts of host peaks and hosts provoking shifts of parasite peaks. It is clear that where there is a peak of parasite fitness, there is a valley of host fitness, and reciprocally.

3) It is possible to speculate under what conditions strategies associated with encounter or strategies associated

with compatibility are likely to be the main targets of natural selection ("hide or fight", Hochberg, 1998). Because of the high costs which are usually associated with behavioural changes in most free-living animals, it can be expected that natural selection often invests in closing the compatibility filter ("fight") rather than in closing the encounter filter ("hide").

4) The model describes how a parasite species can move from one adaptive peak to another. Since adaptive peaks are mobile in the landscape, it can happen that two host species have (at a certain moment of evolution) neighbouring co-ordinates. If, at the same time, mutations in parasites make certain individuals wandering around their usual peak (let us remember Wright's expression "trial and error mechanism"), they may exploit a new peak, i. e. a new host species. Transfer implies only sufficient overlapping of *both* encounter and compatibility co-ordinates (Fig. 4). Parasites "explore" potential host species in the same way free-living species explore the surrounding region in Wright's landscape. Large host-spectra mean that several host species constitute a single adaptive peak for a parasite (one may imagine a more complicated representation associating several peaks of different altitudes if not all the host species provide the same fitness to the parasite).

5) The model can be useful to understand why speciation often occurs when a parasite exploits several host species, either after transfers or after host speciation. *Alloxenic speciation* (Euzet & Combes, 1980) occurs when adaptive peaks are no longer overlapping. The isolating mechanism can be associated

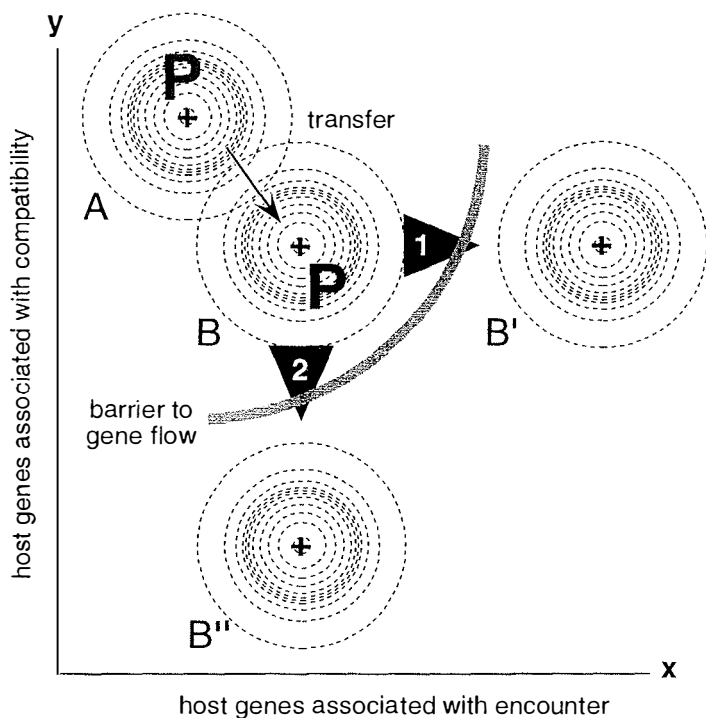


Fig. 4. Overlapping peaks allowing transfer of parasite **P** from host species **A** to host species **B**. After transfer, displacement of peaks may provoke isolation of parasite gene pools. It is supposed that host **B** moved to position **B'** because of selection of genes associated with encounter (arrow 1), or to position **B''** because of selection of genes associated with compatibility (arrow 2). Any intermediate position is possible. Pressures other than those arising from the parasite-host system can "move the peaks".

with the encounter filter or with the compatibility filter. These processes have been described by Combes & Théron (2000) as "polymorphism of habitat encounter" and "polymorphism of habitat compatibility". Similar reasoning consists of considering that the adaptive peak is defined at the microhabitat scale instead of the host species scale and leads to the concept of *synxenic speciation* (Euzet & Combes, 1980) with homologous isolating mechanisms.

Discussion

Various criticisms have been addressed to Wright's adaptive landscape (see Provine, 1986), the main one being that **x** and **y**-axes are discrete entities (gene combinations) and not continuous variables, in such a way that the adaptive surface does not exist in mathematical terms. Wright defended himself by saying that "an intelligible representation depends on some enormous simplification" and by insisting on the symbolic character of the adaptive landscape (see Lewis, 1988).

The representation of host species as adaptive peaks for parasites is even more symbolic because it uses gene combinations of the host and seems to neglect gene combinations of the parasite. However, as shown above, visualizing adaptive peaks in this way allows one to investigate several aspects of the evolution of parasite-host systems. If one wish to represent all the gene combinations involved in encounter and compatibility of a parasite-host system, it is not forbidden to consider that **x** axis symbolizes all genes controlling encounter, whatever they belong to the parasite

or the host, and similarly for *y* axis and genes controlling compatibility. In this case, two adaptive surfaces should be designed on a single 3-axis system, one for the parasite, one for the host. Because parasite and host compete for the same resource, peaks should never coincide. If, in a given system, peaks coincide, this means that the system is *mutualistic*, not parasitic.

References

- Combes C, Théron A. Metazoan parasites and resource heterogeneity: constraints and benefits. *Int J Parasitol* 2000; 30: 299-304
- Combes C. Interactions Durables. Ecologie et Evolution du Parasitisme. Masson, Paris, 1995.
- Combes C. Fitness of Parasites: pathology and selection. *Int J Parasitol* 1997; 27: 1-10
- Euzet L, Combes C. Les problèmes de l'espèce chez les animaux parasites. *Mém. Soc Zool France* 1980; 40: 239-85
- Lewin R. The uncertain perils of an invisible landscape. *Science* 1988; 240: 1405-06
- Provine WP. Sewall Wright and Evolutionary Biology. Univ Chicago Press, Chicago, 1986
- Van Valen L. A new evolutionary law. *Evolution Theory* 1973; 1: 1-30
- Wright S. The roles of mutation, inbreeding, crossbreeding, and selection in evolution. *Proc VIth Intern Congress Genetics* 1932; 1: 356-66

ECOLOGY AND GENETICS OF DAPHNIA-MICROPARASITE INTERACTIONS: WHICH FACTORS DETERMINE PARASITE DISTRIBUTION?

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There is hardly any multicellular organism that is not parasitized during some stage of its life. But not every host population harbours every potential parasite species and within a population not every host is parasitized with the same parasites. Most host populations coexist with only a small set of their potential parasites and most host individuals carry only a small subset of the parasites in a population. A number of models have been suggested to explain this diversity. These models are based on epidemiological factors (e.g. density dependent transmission, population size, number of host species), biological factors (host quality and host genotype,

competition among parasites) and spatial and temporal structure of the host (meta)-population.

I present the results of a number of studies which were designed to understand which factors govern the presence/absence patterns as well as the diversity of parasites in experimental and natural populations of the planctonic crustacean *Daphnia magna*. I will focus on three examples. I. A study of presence/absence patterns of parasites in rock pool *Daphnia* populations. II. Testing models using experimental epidemiology. III. The impact of genetic factors in determining parasite success.

AN ECOLOGICAL APPROACH TO THE ANALYSIS OF TREMATODE LIFE-CYCLE EVOLUTION

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Trematode life-cycles are amazingly complex and diverse. They are characterized by changes of generations (parthenogenetic and hermaphroditic) and animal hosts (intermediates and final). Each generation must develop from an immature state to a mature form. Each phase in a life-cycle must be capable of carrying out its particular function. Free living larvae must be required to penetrate a host, parasitic larvae must survive in the body of an intermediate host, adults should be capable of reproduction. To ensure that these tasks may be completed successfully various adaptations (morphological and behavioural) have been developed in the course of evolution. These adaptations are specific and depend on the life-cycle phase and ecological conditions of the environment. Therefore, it is impossible to discuss evolution of life-cycles without considering the ecological conditions that influence these life-cycles. This is the essence of the ecological approach which we use in our studies.

Trematodes are distributed from the Arctic to the Antarctic and their life-cycles are completed in different ecosystems (fresh water, terrestrial, marine littoral, pelagic, benthic, etc). What is the reason of their obvious success? Are there any universal features of the life-cycle structure promoting their successful transmission in practically all ecosystems? Is it possible that they have evolved some specific adaptations which provide life-cycles suitable for specific ecological systems? To answer these questions, we should consider initial steps of trematode evolution.

Formation of life-cycle

It is generally accepted that early trematodes (protrematodes) evolved in coastal zones and marine prosobranchs became their first (primary) host (Ginetzinskaja, 1968, English translation - 1988; Pearson, 1972; Cable, 1965, 1974; Gibson, 1987; Galaktionov, Dobrovolskij, 1998). The first two-host life-cycle arose between the triassic and jurassic

periods and it was associated with the wide distribution of Teleostei. These events could only have taken place in a restricted area that was characterized by a high diversity and density of animals.

The emergence of second intermediate hosts and, consequently, of three-host life-cycles, became a turning point in the conquest of new environments by trematodes. Of crucial importance is the fact that distribution of infection passed from a small short-living larva (cercaria) with limited locomotion ability to a second intermediate host, a much bigger animal occupying a much larger living space. These were new opportunities for the transmission of life-cycles, enabling their further development in depths of water inhabited by different organisms. It is obvious that the three-host systems became the more universal form of trematode life-cycle and permitted spread of these parasites into ecosystems of different types.

Lecithodendriidae *sensu lata* (a successful group of higher trematodes included in the Plagiorchiida branch) is a good example of a three-host scheme. The aquatic larvae of invertebrates completing their development on land were incorporated as second intermediate hosts into the prolecithodendriid's life-cycles. As a result, three groups of insect-eating animals (evolutionary unrelated) took the place of their previous final hosts. The new hosts were amphibians (Anura), insectivorous birds and bats. In every group of hosts specific species and genera of trematodes emerged, and sometimes divergence reached the level of the family. So, due to their second intermediate hosts, lecithodendriids left the boundaries of

aquatic ecosystems. Such "trans-ecosystem transfer", no doubt, proved the basis for biological spread and establishment by trematodes and promoted their expansion into new ecosystems, sometimes very different from their original site of origin.

Patterns of Strigeidida and Plagiorchiida transmission

It should be stressed that although the three-host scheme of life-cycles is predominant, it is not absolute. The evolution of life-cycle phases and complete life-cycles are different in different trematode groups. This is well illustrated by the most specialized trematodes which are found in the higher orders of Strigeidida and Plagiorchiida. In these organisms the three-host scheme is predominant. However, some specific features of strigeidids life-cycles, such as embryonation of eggs in water, free-swimming miracidia, long and complex development of metacercariae, long maturation of adults, relatively slow egg production etc., practically prevent life-cycle completion in ecosystems with frequent and sharp changes in ecological conditions (for example, marine littoral zone). Eggs and miracidia are especially vulnerable as their functions are carried out in the environment. The strategy of slow egg production does not provide a high density of eggs in the environment and this is also unfavourable. At the same time these specific features of Strigeidida life-cycles (unfavourable under littoral conditions) are very effective in fresh water ecosystems in which Strigeidida evolved and prospered.

The evolution of Plagiorchiida life-cycles took a different direction. Mirac-

idia only hatch from eggs in the intestine of a molluscan host. Parthenogenetic generations are characterized by extremely high productivity, formation of definitive organ systems takes place in the metacercariae, and therefore adult maturation in the definitive host occurs quickly and adults rapidly produce large numbers of eggs. This direction of evolution has resulted in life-cycles that are more universal than those of strigeidids. Two of the most specialized Plagiorchiida groups are the microphallids and lecithodendriids. The microphallids are able to inhabit ecosystems with very variable conditions such as littoral and terrestrial environments and Lecithodendriidae prosper in fresh water ecosystems in which Strigeidida life-cycles are also common.

Life-cycles in marine littoral and terrestrial ecosystems

Transmission of trematodes in littoral and terrestrial ecosystems became possible only after some adaptations arose that permitted the trematodes to be more or less independent from the environment. Of those, probably "passive" infection of molluscs is the most important. This arose in trematodes that completed their life-cycles in water and eventually became widespread. In these cases the miracidia do not leave the eggs when they are free in environment. Instead they hatch only after they have been ingested by the molluscan host.

A situation with the second free-living larva (cercaria) is more complicated. On one hand, it is very important for transmission and provides for penetration into the second intermediate host. On the other hand a free-swimming

cercaria is subjected to unfavourable environmental conditions. Dicrocoelids, which have relatively recently successfully inhabited terrestrial habitats, have still retain the structure of their life-cycle. They have solved the problem of cercariae distribution in a manner which protects them from the environment. *Dicrocoelium dendriticum* cercariae, which still present tails, enter the mollusc mantle cavity and form so called "slug balls", or mucoid globules there. These are excreted into environment and eaten by ants (the second intermediate hosts).

Representatives of the genera *Corrigia* and *Euritrema* are more specialized in this respect. Not cercariae, but thick-walled daughter sporocysts containing larvae with rudimentary tails, leave molluscs and pass into the environment. In all three examples the process of infection of the second intermediate hosts has changed. It has now become passive as they are ingested by the host. This is similar to the situation already described for miracidia.

Another terrestrial trematode, Brachylaimidae, adapted to the conditions of dry land independently from Dicrocoeliidae. It chose a different approach. Isolation of the cercariae from the environment was achieved by the fact that in most brachylaimids cercariae are not released into the environment at all. The life-cycle has secondarily become two-host one in the genera *Leucochloridium*, *Hasstilesia* etc, as the molluscs have combined the functions of both first and second intermediate hosts.

The emergence of two-host life-cycles that has become the main trend in the evolution of trematodes adapted to

ecosystems with extreme environmental conditions. Two-host life-cycles are widely distributed within another trematode group which has successfully adapted to the littoral zone of northern seas. This group is the Microphallidae which demonstrates a range of "transitory" forms ranged from those with free-living cercariae to those in the "*pygmaeus*" group. Metacercaria morphogenesis takes place within daughter sporocysts in this group (Deblock, 1977; Galaktionov, 1996).

The life-cycle of microphallids in the "*pygmaeus*" group is undoubtedly highly adaptive to ecosystems with extreme conditions. These trematodes are clearly predominant in littoral molluscs on the coasts of the northern seas (Norwegian, Barents and White Seas) (Galaktionov, Bustnes, 1999). A representative of this group, *Microphallus pseudopygmaeus*, is the only species of seabird trematodes that completes its life-cycle in the high Arctic shore ecosystems of Franz Josef Land (Galaktionov, 1996). In boreal regions trematodes with three-host life-cycles are predominant in littoral ecosystems. Probably, under "milder" ecological conditions the possibility of metacercariae become widely distributed because of the activity of the second intermediate host outweighs the advantages of complete independence from the environment achieved by the two-host life-cycle.

Life-cycles in pelagic ecosystems

Ability to exploit on the offshore shelf and pelagic regions of oceans is impossible without specific adaptations and changes in life-cycle structure. This is determined by the enormously of

environment. This results in a drastic decrease in density of aquatic animals, and consequently in less probability of successful infection. Biological adaptations in these conditions are obviously directed towards maximal longevity of invasive larvae in the environment. This has been achieved in a number of ways including the passive suspension in seawater. Hemiuroids that have developed complex tails prove an excellent example of this (Gibson, Bray, 1979; Køie, 1990).

It is our opinion that the increase in spatial scale of ocean systems required a new strategy in a life-cycle transmission. Dispersion abilities of cercariae and second intermediate hosts (mainly invertebrates) became insufficiently to ensure location and infection of final hosts such as pelagic carnivores fishes. The adoption of an additional host (a third intermediate host) became necessary. Initially this host main functions were transport and protection of the parasite. On one hand, it guaranteed the prolongation of juvenile parasite stages and, on the other, it provided transport between the site of parasite dispersion and the location of final hosts. This gave rise to four-host cycles. They were originally facultative and then became obligatory.

Four host life-cycles are characteristic for at least some didimozoids. Young specimens of these trematodes (at the initial stages of adult morphogenesis) have been recorded in the intestines of a number of small fishes. This has led to the possible conclusion by Nikolaeva (1965) and Pearson (1972) that juvenile Didimozoidae are "transported" from crustaceans to large pelagic carnivores such as tuna and sierra in the intestines

of small fishes. This mode of transport is a feature of all species in this taxon inhabiting pelagic waters.

Although the authenticity of four-host life-cycles in Didimozoidae may still be in question, they are obligatory in some Hemiuridae. In these cases planktonic crustaceans act as hosts for mesocercariae (an intermediate form between cercaria and metacercaria). The metacercarial stage has been transferred to fishes, thereby permitting the use of these large and more long ranged carnivores as final hosts. The introduction of a mesocercaria provides for additional morphogenetic changes to take place in their development.

Four-host cycles have also arisen independently in some freshwater trematodes, such as *Strigea* and *Alaria*. Initially this was probably associated with their invasion and establishment in large freshwater basins. Adoption of new hosts (which is common in trematodes) promoted incorporation of large carnivores into the life-cycles. Many of these hosts such as foxes, dogs and wolves, were only peripherally connected with the fresh water basins that were essential for the evolution of these parasites.

Concluding remarks

The data presented has demonstrated that complex life-cycles have enabled parasites to utilize new groups of hosts and expand into ecosystems of different types. The new opportunities gained, probably outbalanced the inevitable difficulties connected with the extension of host chains and transmission of infection. This has occurred in spite of the fact that completion of a simple life-cycle (host-free-living larva -

host) appears to be much more probable than completion of a life-cycle involving several host animals (even two of them).

The purely quantitative losses associated with complex life-cycles are compensated by the acquisition of very specialized adaptations (morphological, physiological, behavioural, etc.) developed by the life-cycle phases in the course of the evolution. The already mentioned advantages of the incorporation of intermediate hosts, and the fact that intermediate hosts are usually included in the trophic chain of the final hosts is of special importance. Complex life-cycles provide for adaptations that ensure successful transmission in all types of ecosystems. In terms of biological progress, complex life-cycles have been favoured and they have provided for the universal success of parasites. This is why complex life-cycles are so frequently encountered among parasites and have resulted in their widespread distribution in the biosphere.

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References

- Cable RM. "Thereby hangs a tail". J Parasitol 1965; 51: 2-12
- Cable RM. Phylogeny and taxonomy of trematodes with reference to marine species. In: Vernberg WB, ed. Synbiosis in the sea. Columbia, 1974: 173-93
- Deblock S. De l'abregement du cycle évolutif chez les trematodes digenes microphallides. Libro homenaje al Dr Eduardo Caballero y

Caballero. Instituto de Biología, publicaciones especiales. Mexico, 1977; 4: 151-60

Galaktionov KV. Life-cycle and distribution of seabird helminths in Arctic and sub-Arctic regions. Bull Scand Soc Parasitol 1996; 6: 31-49

Galaktionov KV, Bustnes JO. Distribution patterns of marine bird digenean larvae in periwinkles along the southern Barents Sea coast. Dis Aquat Org 1999; 37: 221-30

Galaktionov KV, Dobrovolskiy AA. The origin and evolution of trematode life-cycles. St. Petersburg: Izdatelstvo Nauka, 1998 (In Russian)

Gibson DI. Questions in digenean systematics and evolution. Parasitology 1987; 95: 429-60

Gibson DI, Bray RA. The Hemiuroidea: terminology, systematics and evolution. Bull Brit Mus (Natur Hist) 1979; Zool ser 36: 35-146

Ginetsinskaya TA. Trematodes, their life-cycles, biology and evolution. New Delhi, 1988

Køie M. On the morphology and life history of *Hemiurus luehei* Odhner, 1905 (Digenea: Hemiuridae). J Helminthol 1990; 64: 193-202

Nikolaeva VM. On the developmental cycle of trematodes in the family Didymozoidae (Monticelli, 1888) Poche, 1907 Zool Szurn 1965; 44: 1317-27 (In Russian)

Pearson JC. A phylogeny of life-cycle patterns of the Digenea. Adv Parasitol 1972; 10: 153-89

PHYLOGENY, HISTORY AND BIODIVERSITY: UNDERSTANDING FAUNAL STRUCTURE AND BIOGEOGRAPHY IN THE MARINE REALM

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"The past is the key to the present, where historical reconstruction involving parasites contributes to a predictive framework for discovering the interaction of biotic communities, environment and climate." Hoberg (1997)

Abstract

Helminth faunas in pinnipeds and seabirds have been assembled across widely disparate temporal and spatial scales. Structure in these systems is revealed by the branching order of phylogenies for parasites and hosts that allows us to examine the history of diversification for host-parasite assemblages and to identify the range of determinants that have influenced ecological and biogeographic patterns. Defined across a spatial continuum, faunas at their broadest extent may have distributions that are bipolar and global in scale or may be geographically delimited within regional zones. Geographic scale may be linked to the relative age for initial association of parasite and host taxa, vagility of the assemblage, and the duration for their history of coevolution.

Relatively archaic and widespread distributions for host-parasite assemblages appear indicated by some campulid digeneans, including species of *Orthoplanchmus*, various diphyllbothriid cestodes, some anisakine nematodes in phocids and otariids and acanthocephalans in cetaceans and pinnipeds. In contrast, cestodes of the genus *Anophryocephalus*, and some species of anisakine nematodes appear to have common regional histories for diversification in pinnipeds across northern seas during the past 3-5 million years. These histories remain compatible with new calibrations for the initial opening of Bering Strait and communication between the North Pacific and North Atlantic prior to the Pliocene/Pleistocene boundary. Generalities developed in the *Arctic*

Refugium Hypothesis to describe the history for this regional fauna continue to have substantial explanatory power and the significance of climatological determinants, and environmental perturbation for faunal diversification is emphasized. Definitive hosts in these systems are postulated as the primary drivers of isolation and diversification for parasites. Phylogenetic studies among tetrabothriid tapeworms, campulid digeneans, and ascaridoid nematodes have revealed complex histories involving coevolution and extensive colonization that describes a tapestry to elucidate general-level determinants for diversification in marine faunas. Many parasite groups, however, remain poorly studied, and have yet to be evaluated based on phylogenetic methods. Phylogenetic studies of parasites and hosts provide critical context for understanding patterns in biodiversity, faunal structure and both contemporary and historical biogeography.

Phylogeny, history and biodiversity

Biodiversity can be assessed across a number of functional hierarchies in a continuum linking populations, species, ecosystems and communities at local, regional and global scales. Established within a phylogenetic context, biodiversity results from an intricate interaction of history, ecology and geography as the determinants of organismal evolution and distribution. A foundation for understanding patterns and processes in the structure of biotic associations at any level emanates from phylogenetic and historical reconstruction, and this is particularly evident in studies of complex host-parasite systems (Brooks and

McLennan, 1991, 1993; Hoberg, 1996, 1997; Brooks and Hoberg, 2000).

Parasite faunas in avian and mammalian hosts in the marine realm have received minimal attention with respect to studies of cospeciation and historical biogeography (Hoberg, 1997). Elucidating the patterns and history for biodiversity, and the determinants of continuity and structure for such complex assemblages requires detailed information for phylogeny of both hosts and parasites. Some components of the parasite faunas in pinnipeds and seabirds have been examined in detail based on phylogenetic methods (e.g., Hoberg, 1986, 1992, 1995; Hoberg *et al.*, 1997a). Complete assessment of these systems, however, had until recently been limited by the availability of well resolved phylogenies for particular mammalian or avian host groups (e.g., for pinnipeds, Arnason *et al.*, 1995; Berta and Wyss, 1994; Berta and Sumich, 1999; for alcids, Friesen *et al.*, 1996a).

Helminth faunas in pinnipeds and seabirds have been assembled across widely disparate temporal and spatial scales. Further, host and geographic ranges of parasites are historically constrained by genealogical and ecological associations (e.g., Brooks and McLennan, 1993). Structure in these systems, revealed by the branching order of phylogenies for parasites and hosts, allows us to examine the history of diversification for host-parasite assemblages. Alternative hypotheses for history involving varying degrees of coevolution or colonization are the cornerstone for elucidating origin, temporal continuity and biogeography. Consequently, parasites serve as models to articulate a

comprehensive understanding of the history and structure of the biosphere (Hoberg, 1997; Brooks and Hoberg, 2000).

Coevolution, encompassing both cospeciation and coadaptation, is consistent with association by descent and a protracted history for components of an assemblage (e.g., Brooks and McLennan, 1991, 1993; Hoberg *et al.*, 1997a). A coevolutionary history is corroborated through examination and interpretation of host-parasite associations which demonstrate: (1.) consistency and congruence in host-parasite phylogenies or area relationships; (2.) a high degree of cospeciation or coadaptation; (3.) recognition of numerical or phylogenetic relicts; and (4.) often widespread geographic distributions that in the case of marine systems may be global or bipolar in extent. Additionally, general congruence in biogeographic patterns among complex host-parasite assemblages are characteristic of faunas that have been influenced by coincidental physical and biotic processes as determinants of distribution (Hoberg, 1986, 1992, 1997). In such instances, geographic scale may be linked to the relative age for initial association of parasite and host taxa, vagility of the assemblage, and the duration for their history of coevolution.

Components of a biota that have been structured by colonization contrast with coevolutionary systems and demonstrate: (1.) incongruent and inconsistent phylogenies for parasites and hosts; (2.) similarities in host trophic ecology; (3.) faunas that are geographically or regionally delimited; (4.) parasite faunas in which diversification is temporally circumscribed in the context of the origin

and duration of the host group; (5.) faunas of low diversity that are depauperate in contrast to relictual; and (6.) associations of variable temporal duration and varying degrees of cospeciation/coadaptation depending on time frame for colonization of host clade. In a context of coevolution or colonization, the temporal duration of an assemblage is elucidated by interpretation of data encompassing: (1.) host-parasite distributions; (2.) historical biogeography of hosts; (3.) regional history; and (4.) physical geology (Brooks, 1985; Brooks and McLennan, 1991; Hoberg, 1986, 1992, 1995, 1997; Hoberg and Adams, 1992).

These alternatives set a hypothesis-driven framework and a series of predictions and expectations for identification of the range of complex determinants of genealogical and ecological diversity and faunal structure. Represented is a powerful tool to explore the history of marine and other biotas. We apply this foundation and focus on the helminth faunas characteristic in pinnipeds and within a context defined by: (1.) phylogeny and history for hosts (2.) phylogenetic data for parasites; and (3.) patterns of host association. Specifically we explore the overlying generalities and contrasting patterns for faunal structure (e.g., "archaic" and widespread, versus "recent" and regional), host distribution and historical biogeography while articulating hypotheses for the driving mechanisms that influence diversity in marine systems.

A brief history for pinniped hosts:

Pinnipeds are a monophyletic group of marine mammals with origins in

Boreal-SubArctic seas of the North Pacific 25 million years ago (MYA) (Berta and Wyss, 1994; Berta and Sumich, 1999). Among the contemporary fauna, 3 extant families are recognized including Otariidae (Berta and Deméré, 1986), Odobenidae (Berta and Wyss, 1994; Deméré, 1994; Arnason *et al.*, 1995) and Phocidae (Ray, 1976; Repenning *et al.*, 1979; Arnason *et al.*, 1995; Bininda-Emonds and Russell, 1996; Stanley *et al.*, 1996; Berta and Sumich, 1999). The history for extant higher taxa extends to the middle Miocene, 14-16 MYA, with centers of diversification for otariids and odobenids in the North Pacific basin and for phocids in the North Atlantic. Phocids and otariids are secondarily found in the Southern Hemisphere and a minimum of 3 independent invasions into the Southern Ocean that influenced the contemporary fauna are recognized since the Miocene/Pliocene transition, 5-6 MYA (e.g., Repenning *et al.*, 1979).

Phylogeny and historical biogeography for pinnipeds establishes the spatial and temporal limits on the distribution of the phylogenetically disparate elements of the helminth parasite faunas in otariids, odobenids and phocids. Differences in specific phylogenetic hypotheses for the pinnipeds do not substantially alter the following hypotheses articulated for the evolution of host-parasite associations, faunal history, distribution and structure.

“Archaic” associations- the global and bipolar patterns

Geographically widespread faunas encompassing global or antitropical distributions are indicative of early

associations with specific host groups. Geographic scale may be linked to age, duration and vagility of the assemblage; patterns may also be influenced by colonization events. Typically bipolar distributions have been demonstrated across all groups of helminths in pinnipeds including acanthocephalans such as *Corynosoma* (e.g., Golvan, 1959; Zdzitowiecki, 1986), anisakine nematodes such as *Contracaecum* and *Pseudoterranova* (Deliamure, 1955; Fagerholm and Gibson, 1987; Bullini *et al.*, 1994, 1997; Paggi and Bullini, 1994; Arduino *et al.*, 1995), diphyllbothriid tapeworms including *Diphyllbothrium* spp. (Deliamure, 1955; Iurakhno, 1991; Wojciechowska and Zdzitowiecki, 1995), and the campulid digeneans (Deliamure, 1955; Adams and Rausch, 1989). Although broad scale patterns are apparent, few taxa have been examined phylogenetically, a requisite first step in developing hypotheses for the history of this fauna.

History for some Diphyllbothriidae (Eucestoda):

Diphyllbothriids are among the basal groups of tapeworms and their occurrence in mammalian hosts from marine systems may be consistent initially with a history of colonization and secondary coevolution (e.g., Bray *et al.*, 1999; Hoberg *et al.*, 2000). It has yet to be completely resolved whether or not those taxa typical in cetaceans and pinnipeds, respectively represent subclades within the diphyllbothriids, or if there has been an extensive history for host-switching (Iurakhno, 1991).

Diphyllbothriids are broadly distributed among northern and southern pin-

nipeds. Elements of the fauna in otariids, monachines and phocines appear to be distinct (Markowski, 1952a, 1952b; Wojciechowska and Zdzitowiecki, 1995), suggesting extended and divergent evolutionary trajectories for these lineages of tapeworms. Patterns of distribution compatible with a protracted coevolutionary history in pinnipeds, are evidenced by such genera as *Glandicephalus*, *Baylisia*, and *Baylisiella* in *Mirounga* and the lobodontines. Moderate generic-level diversity for diphylobothriids is observed in the Lobodontini and the distinctive nature of the circumantarctic fauna would have been established since ≤ 5 -6 MYA.

In contrast, *Diphylobothrium* has a bipolar distribution in northern and southern hemisphere Phocidae and Otariidae, probably having become established independently through separate invasions of the Southern Hemisphere by Phocidae (5-6 MYA), "Arctocephalinae" (5MYA) and Otariinae (3MYA) (Repenning *et al.*, 1979; Berta and Sumich, 1999). Relationships among the species distributed in the Southern Hemisphere and Antarctica are currently unknown and it is uncertain if the fauna is phylogenetically partitioned among phocids, otariids and cetaceans; putative relationships

among the genera endemic to Antarctica and other diphylobothriids are also unresolved. Interestingly, such species as *D. pacificum* may have extensive ranges in both northern and southern otariids including *Eumetopias*, *Otaria* and *Arctocephalus*; alternatively a complex of poorly differentiated species could also be represented (R.L. Rausch, Pers. Comm., 2000). A clear understanding of the history of this diverse assemblage of hosts and parasites is hindered by the absence of phylogenetic studies among

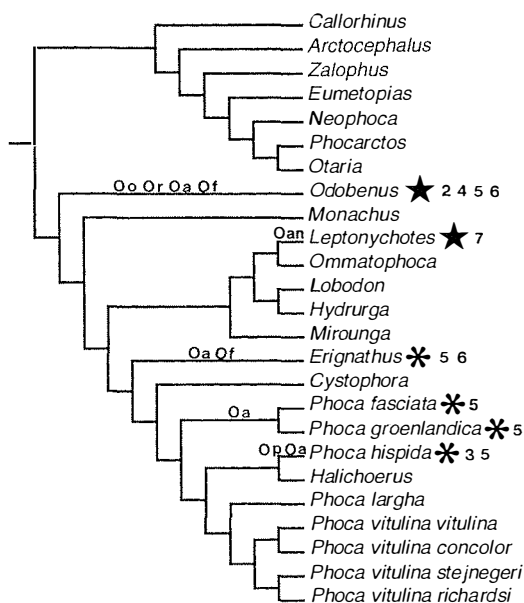


Fig. 1. Phylogeny of the Pinnipedia showing distribution and history for species of *Orthosplanchmus*. Relictual distributions (stars) are indicated for *O. oculatus* (Oo), *O. rossicus* (Or), *O. arcticus* (Oa) and *O. fraterculus* (Of) in odobenids and for *O. antarcticus* (Oan) in *Leptonychotes weddelli*. Colonization (asterisks) explains associations for *O. pygmaeus* (Op) and other species among phocines; distributions in *Enhydra lutra* and *Eschrichtius gibbosus* are not shown. Numbers show the sequence of speciation among species of *Orthosplanchmus*. Phylogeny for the pinnipeds is modified from Arnason *et al.* (1995), Berta and Wyss (1994) and Berta and Sumich (1999); further alternative hypotheses are presented in Bininda-Emonds and Russell (1996)

the genera and species of the Diphyllbothriidae.

History for some Campulidae (Digenea):

Digeneans of the family Campulidae are primarily parasites in odontocete cetaceans (Delamure, 1955) and appear to be a group that originated by coloniza-

tion of toothed-whales from marine fishes (Fernández *et al.* 1998a, 1998b). Further instances of host-switching by campulids from odontocetes to pinnipeds are represented by *Zalophotrema* in sea lions (Fernández *et al.*, 1998a) and *Orthosplanchnus* in odobenids (Figs. 1 and 2).

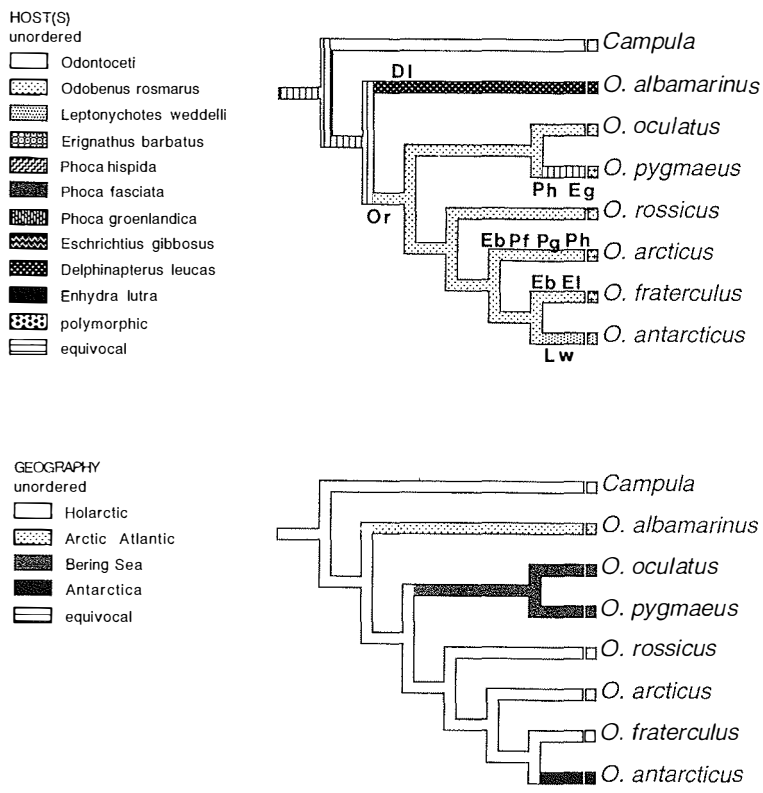


Fig. 2. Phylogeny for species of *Orthosplanchnus* showing host associations and biogeographic history (see Appendix 1). Host and geographic distribution were mapped and optimized on this tree using MacClade 3.05 (Maddison and Maddison, 1992). Fig. 2a. Host associations indicate a basal relationship with odobenids subsequent to colonization from odontocetes. *Orthosplanchnus* exhibits a relictual distribution in *Odobenus rosmarus* (Or) and *Leptonychotes weddelli* (Lw); other associations in phocines, *Erignathus barbatus* (Eb), *Phoca hispida* (Ph), *P. fasciata* (Pf), and *P. groenlandica* (Pg), and other marine mammals, *Enhydra lutra* (El) and *Eschrichtius gibbosus* (Eg) are attributed to colonization. Fig. 2b. Biogeographic history for *Orthosplanchnus* is largely confined to northern seas, with evidence of vicariance, or a single invasion into the Southern Ocean represented by *O. antarcticus*

Comparative studies based on the phylogeny of *Orthosplanchnus* suggest that species of this genus coevolved with odobenids and monachines. Distributions for contemporary species of *Orthosplanchnus* are relictual, indicated by basal associations for 4 species in *Odobenus rosmarus* and the highly derived position for *O. antarcticus* in *Leptonychotes* (Fig. 2a). Secondarily, sequential colonization from odobenids to phocids and other marine mammals accounts for contemporary distributions of *O. pygmaeus*, *O. arcticus* and *O. fraterculus*. Temporal limits and historical biogeography for odobenines and monachines, however, suggests an alternative (Repenning *et al.*, 1979; Berta and Sumich, 1999). Colonization of the latter group from walruses could be postulated during a period of faunal interchange in the Central American Seaway, adjacent to the Pacific/Caribbean (5-8 MYA), prior to establishment of the monachines and diversification of the Lobodontini in the Southern Hemisphere. In either situation, all associations with phocids and other marine mammals could represent colonization, both temporally deep, consistent with distribution in weddell seals, and relatively recent to contemporary, consistent with distributions in sea otter, gray whales, and northern phocines.

Relictual distributions revealed through phylogenetic studies of campulids and *Orthosplanchnus* in pinnipeds demonstrate that the history does not parallel *Anophryocephalus* and *Alcataenia* in the Holarctic (Figs. 2a and 2b). Prior assumptions about host associations and the history for *Orthosplanchnus* were posed outside of the context provided by phylogeny for either species

of hosts or parasites (e.g., Deliamure, 1955; Adams and Rausch, 1989; Fernández *et al.*, 1998a). It was generally accepted that *Orthosplanchnus* spp. were primarily associated with phocine seals from northern seas in the Pleistocene and that the occurrence in walruses reflected recent colonization; the distribution for *O. antarcticus* was thus seen as enigmatic. Critical examination of relationships with pinniped hosts and *Orthosplanchnus* (Figs. 1 and 2) indicates associations with odobenids and lobodontines that extend at a minimum to near the Miocene-Pliocene transition, > 5MYA.

Regional Holarctic faunas- the Berinian connection

Regionally or geographically delimited faunas are often associated with specific host-groups and definable temporal limits for assemblages that are linked to a history of host-switching by parasites. These explain a certain range of patterns in biogeography and host associations for helminths in northern phocines and alcid seabirds. Synchronic and congruent patterns for speciation and historical biogeography have been postulated for phylogenetically disparate tetrabothriid and dilepidid tapeworms and some anisakine nematodes in marine birds or pinnipeds across high latitudes of the Holarctic (Hoberg, 1986, 1992, 1995; Hoberg and Adams, 1992; Hoberg *et al.*, 1997a; Bullini *et al.* 1994, 1997; Mattiucci *et al.*, 1998; Paggi *et al.*, 2000).

History for tapeworms in pinnipeds:

Acquisition of *Anophryocephalus* by pinnipeds from odontocetes (about 2.5-3

MYA) occurred subsequent to major segregation of northern and southern ocean faunas ≤ 5 MYA (Repenning *et al.*, 1979; Arnason *et al.*, 1995; Berta and Sumich, 1999), accounting for absence of these cestodes in true seals of the

antarctic and arctocephalines and otariines in the Southern Hemisphere (Hoberg and Adams, 1992). Colonization of phocines by *Anophryocephalus* occurred after cladogenesis of the phocid subfamilies and subsequent to the establishment of monachines in the Southern Hemisphere (Fig. 3).

Basal species of *Anophryocephalus* (*A. anophrys*, *A. inuitorum*, and *A. arcticensis*), except *A. skrjabini*, are associated with the high latitude seas of the Atlantic or with the Arctic basin; all are specifically linked to a history of cospeciation or coadaptation in ringed seals, *Phoca hispida* (Figs. 3 and 4). An association between *Anophryocephalus*, phocines and *P. hispida* extends no deeper than 2.5-3.0 MYA in the Atlantic and Arctic basin, consistent with the origin of this phocine (Arnason *et al.*, 1995) and host and geographic distributions for these cestodes (Hoberg and Adams, 1992, Hoberg, 1992, 1995). Patterns of distribution for 2 of these species, *A. skrjabini* and *A. arcticensis* in other phocines are compatible largely with a history of colonization.

Assuming that the basal species are historically linked to the Arctic basin, then 2 independent invasions of the North Pacific are postulated (Figs. 3 and 4); compare to Hoberg (1992, 1995) and Hoberg and Adams (1992). *Anophryocephalus* would have been widespread in the region, entering the North Pacific from the Arctic coincidental with 2 sequential openings of Bering Strait (concurrent with 2 interstadi-

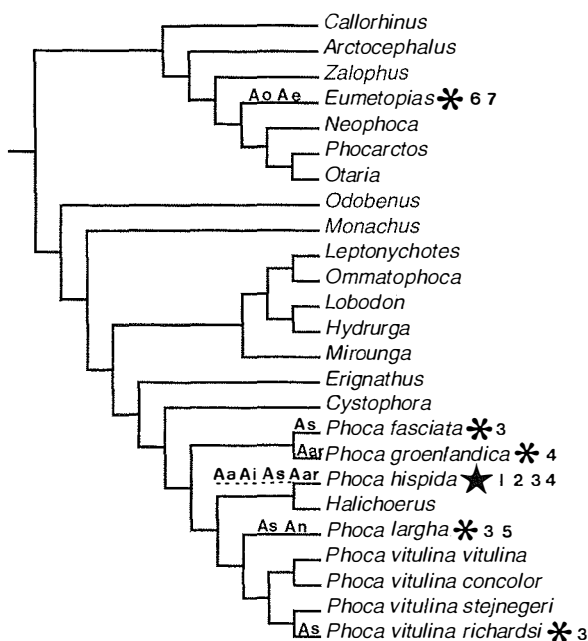


Fig. 3. Phylogeny of the Pinnipedia showing distribution and history for *Anophryocephalus* spp. A basal association (star) is recognized between *Phoca hispida* and 4 species, *A. anophrys* (Aa), *A. inuitorum* (Ai), *A. skrjabini* (As), and *A. arcticensis* (Aar). Colonization (asterisks) is consistent with distributions of species in other phocines including *A. nunivakensis* (An) in which speciation is associated with the host-switch. Species in *Eumetopias*, *A. eumetopii* (Ae) and *A. ochotensis* (Ao), resulted from colonization of this otariid from phocines and subsequent cospeciation. Numbers show the sequence of speciation among species of *Anophryocephalus*. Phylogeny for the pinnipeds is modified from Arnason *et al.* (1995), Berta and Wyss (1994) and Berta and Sumich (1999); further alternative hypotheses are presented in Bininda-Emonds and Russell (1996).

als) in the Pleistocene. Although Bering Strait was open at least by the Miocene/Pliocene transition (Marincovich and Gladenkov, 1999), it may not have become significant for phocid biogeography until later in the Pliocene. Range extension for hosts and parasites into the Bering Sea, followed by emergence of Beringia and closure of Bering Strait during glacial maxima resulted in

intense periods of isolation leading to speciation for *Anophryocephalus*. Thus, the first invasion resulted in *A. skrjabini* and the second led to *A. nunivakensis*, *A. eumetopii* and *A. ochotensis* (Fig. 4). The geographic distribution of *A. skrjabini* in *P. hispida* includes the Arctic basin adjacent to Bering Strait (Hoberg and Adams, 1992), and rather than a secondary dispersal from the North Pacific,

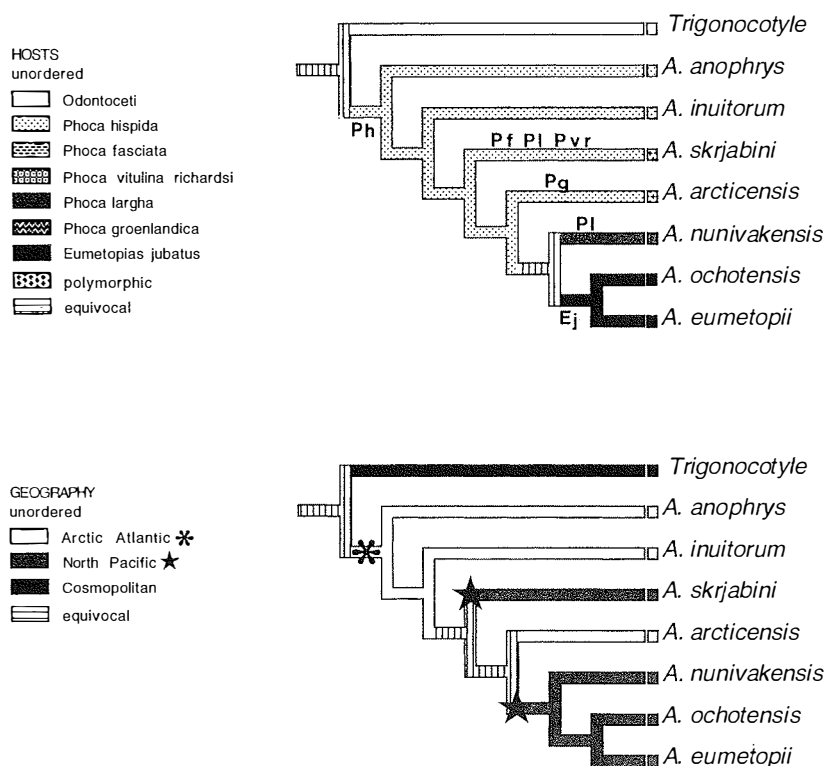


Fig. 4. Phylogeny for *Anophryocephalus* spp. showing host associations for pinnipeds and historical biogeography across the Holarctic region. The phylogenetic tree for *Anophryocephalus* is based on the hypothesis presented by Hoberg (1995). Host and geographic distribution were mapped and optimized on this tree using MacClade 3.05 (Maddison and Maddison, 1992). Fig. 4a. Host associations are compatible with origin of *Anophryocephalus* by colonization from odontocetes (see also Hoberg and Adams, 1992). Basal species are associated with a history of cospeciation in *Phoca hispida* (Ph). Occurrence of *A. skrjabini* in *P. fasciata* (Pf), *P. largha* (Pl) and *P. vitulina richardsi* (Pvr) may be consistent with colonization. Species in *Eumetopias jubatus* (Ej) developed by cospeciation following colonization. Fig. 4b. Biogeographic patterns are consistent with a history linked to the Arctic-Atlantic basin (asterisk), and 2 independent invasions of the North Pacific basin (stars) in the Pleistocene coinciding with sequential openings of Bering Strait

this may represent a relictual distribution for this species in its typical host. A limited distribution for *A. arcticensis* in the eastern Canadian Arctic is consistent with speciation by peripheral isolation of this widespread ancestral population of parasites in ringed seals and colonization of *P. groenlandica*. Overall the patterns of distribution and diversification for *Anophryocephalus* are consistent with models for rapid speciation (Hoberg, 1995).

It is apparent that *A. skrjabini* and *A. munivakensis* are linked to 2 successive marine transgressions and independent openings of Bering Strait during the Pleistocene (Fig. 4a, and 4b). Remarkably, these parasites are exquisite indicators of environmental conditions and faunal continuity in peripheral seas of Beringia during the Quaternary and can reveal considerable insights about the biogeographic history for phocines in the region (Hoberg, 1995). Given the hypothesis for the timing of arrival of ringed seals in the North Pacific basin, conceivably the dating for these subsequent isolation events might be further narrowed. Along with other species of *Anophryocephalus*, these cestodes are direct indicators of (1.) complex biogeographic events; and (2.) cryptic histories of isolation at the intraspecific level for their phocine hosts (Hoberg, 1995).

Anophryocephalus eumetopii and *A. ochotensis* developed in *Eumetopias jubatus* following colonization in the North Pacific ≤ 2 MYA (see Hoberg and Adams, 1992, Hoberg, 1992). The association of *Anophryocephalus* and *Eumetopias* was established subsequent to the divergence of the Otariinae and "Arctocephalinae", after divergence of the

lineage leading to *Eumetopias* from *Neophoca* + *Phocarcetos* and *Otaria*, and thus followed the invasion of otariines into the Southern Hemisphere about 3MYA (Fig. 3) (see Repenning *et al.*, 1979; Berta and Deméré, 1986; Berta and Sumich, 1999).

Biogeographic and historical studies of *Anophryocephalus* in northern pinipeds and *Alcataenia* in Alcidae have revealed a recent history for these assemblages and a pattern of diversification driven by climatological events since the Pliocene (Hoberg and Adams, 1992; Hoberg 1986, 1992, 1995). These unrelated faunas originated by host-switching and were largely structured by sequential colonization during periods of extreme climatic variation and habitat perturbation that characterized the past 2.5-3.0 MY.

History for some anisakines in pinipeds:

Diversification among certain anisakines appears to have paralleled, at least in part, the history for *Alcataenia* and *Anophryocephalus* across the Holarctic (Paggi and Bullini, 1994; Bullini *et al.* 1994, 1997; Hoberg, 1995). Diversification within *Contracaecum osculatum* in the boreal and arctic zones of the Atlantic occurred within the past 3.0 MY; striking host associations in *Erignathus*, *P. groenlandica*, and *Halichoerus* are evident. Differentiation within *Pseudoterranova decipiens* occurred primarily among phocines over the past 3.5 MY in the Atlantic, Arctic, and North Pacific (Bullini *et al.*, 1994). The presence of 4 cryptic species among the *Pseudoterranova decipiens* - complex in phocines and *Eumetopias* may

indicate a history of colonization in the North Pacific ≤ 2 MYA (Bullini *et al.*, 1994, 1997; Mattiucci *et al.*, 1998; Paggi *et al.*, 2000) in parallel to *Anophryoccephalus* spp. in seals and Steller's Sea Lion. Additionally, speciation within *Phocascaris* resulting in *P. phocae* in harp and gray seals and *P. cystophorae* in hooded and gray seals is related to isolation and divergence in the North Atlantic about .5MYA (Paggi and Bullini, 1994).

In these instances, differentiation among a complex of morpho and sibling species is postulated to have been driven by isolation in Pleistocene refugia, and via segregation in specific pinniped hosts (Paggi *et al.* 1991; Nascetti *et al.* 1993; Orecchia *et al.*, 1993; Bullini *et al.*, 1994, 1997; Paggi and Bullini, 1994). A further generality for anisakines in pinnipeds appears to be a history of peripatric speciation with isolation and speciation strictly linked to geographic isolation of the definitive hosts, highlighting the importance of small effective population size on diversification of anisakines within the northern fauna (Arduino *et al.* 1995).

Arctic Refugium Hypothesis:

Radiation of hosts and parasites in Subarctic to Arctic refugia during the late Pliocene into the Quaternary appears as a general conceptual model where refugial effects, isolation and habitat fragmentation have been significant determinants for faunal diversity (Hoberg, 1986, 1992). The *Arctic Refugium Hypothesis* (ARH) was formally presented and named in 1992, and represents a synoptic outline for speciation processes, and historical biogeography in

marine systems across high latitudes of the Holarctic spanning the late Tertiary and Quaternary (Hoberg, 1986, 1992, 1995, 1996, 1997; Hoberg and Adams, 1992). The development of the ARH resulted from empirical and phylogenetic studies of two highly disparate assemblages of parasites and homeothermic hosts. This interdisciplinary hypothesis has become a focal point for discussions within parasitology (Brooks and McLennan, 1993), and conceptually has become an integral cornerstone of historical biogeographic studies of seabirds in the North Pacific and Okhotsk Sea (Siegel-Causey, 1991; Friesen *et al.*, 1996b; D. Siegel-Causey, Pers. Comm., 2000) and pinnipeds (Berta and Sumich, 1999).

The ARH is a synthesis integrating phylogeny, ecology, and geological history in a macroevolutionary framework addressing the apparent congruent and synchronic histories for marine host-parasite assemblages across the Holarctic. Demonstrated is the power of phylogenetic approaches in elucidating large scale geographic and historical patterns in the structure and continuity of biotas (Hoberg 1995, 1997):

"Speciation of hosts and parasites coincided with partitioning of the North Pacific basin (and high latitudes of the Holarctic Region) into refugial zones during glacial maxima coinciding with periods of maximum eustatic reduction in sea level. Range contraction, vicariance, isolation and speciation occurred during stadials. Range expansion, from refugial centers and colonization occurred during interstadials. These alternating sequences of climatic extremes constituted the driving mechanism of diversification rather than extinction

among disparate taxa in marine environments at high boreal latitudes of the Holarctic Region during the late Pliocene and Pleistocene epochs....." (Hoberg, 1992, p. 614).

Additional salient points were outlined (see Hoberg, 1992; Hoberg and Adams, 1992), and have since been expanded in detail (Hoberg, 1995). The central points of the hypothesis include: (1.) general replicated patterns for speciation of phylogenetically disparate hosts and parasites- indicative of common causality; (2.) small effective populations of hosts and parasites; (3.) cyclical climatic variation with eustatic reduction in sea level; (4.) habitat disruption, and vicariance of host-parasite populations; (5.) range restriction in ephemeral and marginal refugia and micro-refugia during stadials leading to cospeciation and coadaptation; (6.) range expansion during interstadials leading to colonization (host switching); and (7.) a specific time frame during the late Pliocene and Pleistocene. The *ARH* serves as a model or paradigm for speciation processes and historical biogeography across the Holarctic since the Pliocene (Hoberg 1995) and has received substantial corroboration through studies of anisakine nematodes (e.g., Paggi *et al.*, 1991; Nascetti *et al.*, 1993; Orrechia *et al.*, 1994; Bullini *et al.*, 1994, 1997). As a valid generality, the *ARH* has been reinforced by recent studies on phylogeny and biogeography of marine birds including alcids (Friesen *et al.*, 1996a,b), and shags (e.g., Siegel-Causey, 1991).

The critical significance of the Beringian nexus as a physical determinant of marine biogeography during the Pliocene and Pleistocene continues to be high-

lighted. Recent hypotheses for an earlier opening of Bering Strait now suggest a potentially longer period of marine exchange, prior to inception of periodic and cyclical isolation events (eustatic transgression/ regression cycles) that characterized the late Pliocene and Pleistocene (Sher, 1999; Marincovich and Gladenkov, 1999). Although Bering Strait was open possibly for the first time near the Miocene- Pliocene transition 4.8-5.5 MYA, the impact of this connection between the Arctic and Pacific basins on the biogeographic history for pinnipeds has yet to be elucidated (e.g., Repenning *et al.*, 1979; Berta and Sumich, 1999). The chronology for some parasite-host assemblages across Holarctic seas could have a longer temporal duration, but such would have been dependent on the specific environmental conditions and biotic provinces that characterized the Arctic basin in the late Miocene.

Host switching and diversification in marine systems

A dominant and recurring theme or general trend in diversification of the helminth faunas in marine homeotherms including cetaceans, pinnipeds and sea-birds has been colonization (Hoberg, 1986, 1996, 1997; Hoberg *et al.*, 1997a; Hoberg *et al.*, 1999a; Brooks and Hoberg, 2000). Few taxa of helminths are indicators of historical coevolutionary linkages, or association by descent, between marine and terrestrial faunas (Deliamure, 1955). The concept of "hostal radiation" (e.g., Iurakhno, 1991) has defined ecologically linked switches among phylogenetically unrelated hosts; e.g., among marine mammals, and

among marine mammals and avian hosts. Instances of colonization of poikilotherms from a homeotherm-source, however, have not been identified.

Host-switching has occurred on varying temporal scales extending from the Mesozoic to Quaternary and Recent. For example, the Tetrabothriidae is an apparently archaic group, with origins in the Mesozoic. Ancestral hosts may be represented by now extinct non-avian archosaurs in marine systems, with colonization of basal avian and later mammalian hosts (Spasskii, 1993; Hoberg *et al.*, 1997b; Hoberg *et al.* 1999a, 1999b); such an hypothesis contrasts with previous concepts for the origin of tetrabothriids via colonization of homeotherms by tetraphyllidean cestodes of chondrichthians. Early colonization of avian groups and diversification of *Tetrabothrius* may be indicated by patterns of putative basal cospeciation with marine bird assemblages (e.g., Hoberg, 1996). Marine mammals were acquired independently as hosts for tetrabothriids in the middle to late Tertiary with colonization of cetaceans from seabirds and pinnipeds from odontocetes (Hoberg and Adams, 1992).

Campulids are also a relatively old group with origins extending at a minimum to the middle Miocene (≥ 10 -15 MYA), following radiation of odontocetes including delphinids and phocoenids (Fordyce and Barnes, 1994). Radiation of campulids occurred subsequent to host switching from marine fishes to cetaceans (see Fernández *et al.* 1998a, 1998b) and secondarily among odontocetes and pinnipeds. Diversification of *Orthosplanchnus* involved both coevolution among odobenids and colonization

among phocines, whales and sea otters. Thus, the history of a group may involve an extended association with its hosts, but also may be structured by both coevolution and ecological associations that drive colonization.

Hoberg and Adams (1992) discussed the issues surrounding host switching in faunas typical of marine homeotherms. Colonization is a stochastic process dependent on predictable guild associations over extended evolutionary time frames and may result in faunal diversification within new host-groups, coadaptation, or parasite extinction. Broad diversification of a parasite group via historical colonization indicates substantial ecological similarity among definitive hosts of an assemblage. The duration, predictability and geographic extent of an ecological association within the context of specific food-webs or trophic linkages defines the potential for successful colonization. It is also apparent that not all associations, even those where host-specificity is particularly pronounced, involve deep temporal roots. Examples of such assemblages that have largely been structured by colonization in already long established vertebrate taxa include campulids and *Anophryocephalus* in pinnipeds and *Alcataenia* in the Alcidae (Hoberg 1992; Hoberg *et al.*, 1997a).

Definitive hosts as drivers of isolation and diversification

An additional generality has been the observation of the important role for definitive hosts as drivers in parasite speciation. In marine systems, parasite populations appear to be strongly influenced by the distributions of relatively

vagile definitive hosts that disseminate infective stages for an array of intermediate hosts. Continuity for marine parasite assemblages is reinforced through dependence on predictable foraging zones by pinnipeds or seabirds, such as systems of oceanic fronts or insular eddies, that represent foci for transmission. In insular and pelagic marine systems, the putative role of intermediate hosts is neutral with respect to both gene flow and isolation (see Hoberg, 1992, 1995). Life history and transmission consequently are evolutionarily conservative and structured by guild dynamics such that selection may be for continuity in transmission rather than for associations with a specific group of definitive hosts.

These predictions are consistent with low levels of cospeciation, where rapid shifts by parasites define the potential for successful colonization that occurs among ecologically similar hosts across and within host-clades (Hoberg, 1986). The common factor in these associations is exploitation of a common prey resource in communities occupying limited biogeographic regions or zones. Faunas structured by colonization are regionally limited and often depauperate (Hoberg, 1986, 1992).

Speciation is allopatric and is driven by isolation of definitive hosts, whereas ecological continuity and predictability are determined by transmission dynamics linked to intermediate hosts (Hoberg, 1995). Speciation at least for cestodes in pinnipeds and seabirds appears to be driven by the limiting factor of the geographic ranges occupied by definitive hosts. Thus, isolation and speciation among diverse assemblages of marine

parasites could have proceeded independently from that of populations of intermediate hosts.

Phylogenetic context - building and interpreting the tapestry

Phylogenetic studies of parasites and hosts provide critical context for understanding patterns in biodiversity, faunal structure and both contemporary and historical biogeography.

The hierarchical order of the parasite phylogenies reveals historical relationships and constrains the range of possible explanations for faunal structure when examined within the context of host phylogeny. For example, in the case of *Orthosplanchmus* the relictual nature of the assemblage is indicated by basal associations of 4 species in *Odobenus*, but a derived placement for *O. antarcticus* in *Leptonychotes*. In this assemblage the branching order of the parasite phylogeny is largely congruent with its hosts; relictual associations and parasite extinction do not result in incongruence. Overall patterns are consistent with basal cospeciation and a now relictual distribution for species in *Odobenus* and *Leptonychotes*, but one of secondary colonization among other phocines and marine mammals; the associations are archaic, and antitropical in scale.

In contrast, the phylogenies of *Anoplocephalus* and pinnipeds are highly incongruent, consistent with an overall history of colonization following initial diversification of species in ringed seals. In these systems, diversification was relatively recent and driven by well defined patterns of environmental perturbation in the Pleistocene; associations are temporally circumscribed with re-

spect to the origin and duration of phocids, and regionally delimited.

Deliamure (1955) observed that resolution of the history and biodiversity of helminth faunas in marine mammals was dependent on accurate taxonomic concepts, and an understanding of phylogenetic relationships for both parasite and host taxa. Nearly 50 years later, we continue to have a paucity of phylogenetic studies for parasites in marine homeotherms (Hoberg, 1997), and only recently has there been substantial resolution for relationships among the primary host groups (Berta and Sumich, 1999).

Caveats aside, the power of integration for phylogenetic, biogeographic, ecological, and geological history that leads to formulation of synoptic hypotheses for faunal development over varying spatial and temporal scales is evident (e.g., Hoberg, 1997; Brooks and Hoberg, 2000). Parasites are exquisite phylogenetic and historical ecological indicators revealing substantial information about the marine biosphere (Hoberg, 1996, 1997; Brooks and Hoberg, 2000). Phylogenetic hypotheses for parasites are the foundation for estimation of the minimum age and duration of complex ecological assemblages. In marine systems, anisakine nematodes, cestodes, digeneans and acanthocephalans, all with complex life cycles, track broadly and predictably across trophic levels as representatives of biological structure. Patterns of association represent a continuum from relatively recent to archaic. Some associations are indicative of temporally deep structure of ecosystems and communities and serve to emphasize the importance of helminths in assess-

ments of historical ecology and biogeography. Parasite and host phylogenies constitute the tapestry for elucidating the interaction of coevolution, colonization and extinction on patterns of biodiversity, faunal structure and ecological continuity across deep temporal and broad geographic scales in marine environments (Brooks and Hoberg, 2000).

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References

- Adams A, Rausch RL. A revision of the genus *Orthosplanchnus* Odhner, 1905 with consideration of the genera *Odhneriella* Skriabin, 1915 and *Hadwenius* Price, 1932 (Digenea: Campulidae). Can J Zool 1989; 67: 1268-78
- Arduino P, Nascetti G, Cianchi R, Plötz J, Mattiucci S, D'Amelio S, Paggi L, Orecchia P, Bullini L. Isozyme variation and taxonomic rank of *Contracaecum radiatum* (v. Linstow, 1907) from the Antarctic Ocean (Nematoda, Ascaridoidea). Syst Parasitol 1995; 30: 1-9

- Arnason U, Bodin K, Gullberg A, Ledje C, Mouchaty S. A molecular view of pinniped relationships with particular emphasis on the true seals. *J Molecular Evol* 1995; 40: 78-85
- Berta A, Deméré TA. *Callorhinus gilmorei* n. sp. (Carnivora: Otariidae) from the San Diego Formation (Blancan) and its implications for otariid phylogeny. *Trans San Diego Soc Nat Hist* 1986; 111-26
- Berta A, Sumich JL. Marine mammals: Evolutionary biology. San Francisco: Academic Press, 1999
- Berta A, Wyss AR. Pinniped phylogeny. In: Berta A, and Deméré TA, eds. Contributions in marine mammal paleontology honoring Frank C. Whitmore Jr. *Proc San Diego Soc Nat Hist* 1994; 29: 33-56
- Bininda-Emonds ORP, Russell AP. A morphological perspective on the phylogenetic relationships of the extant phocid seals (Mammalia: Carnivora: Phocidae). *Bonner Zool Monogr* 1996; 1-256
- Bray R, Jones A, Hoberg EP. Observations on the phylogeny of the cestode order Pseudophyllidea Carus, 1863. *Syst Parasitol* 1999; 42: 13-20
- Brooks DR. Historical ecology: A new approach to studying the evolution of ecological associations. *Ann Missouri Bot Garden* 1985; 72: 660-80.
- Brooks DR, Hoberg EP. Triage for the biosphere: the need and rationale for taxonomic inventories and phylogenetic studies of parasites. *Comparative Parasitology* 2000; 67: 1-25.
- Brooks DR, McLennan DA. Phylogeny, ecology and behavior, a research program in comparative biology. Chicago, USA: University of Chicago Press, 1991
- Brooks DR, McLennan DA. Parascript parasites and the language of evolution. Washington DC: Smithsonian Institution Press, 1993
- Bullini L, Arduino P, Cianchi R, Nascetti G, D'Amelio S, Mattiucci S, Paggi L, Orecchia P. Genetic and ecological studies on nematode endoparasites of the genera *Contracaecum* and *Pseudoterranova* in the Antarctic and Arctic-Boreal regions. In: Proceedings 2nd Meeting, Antarctic Biology. Martello A, (ed). Padova, Italy: Universitare Patavine, 1994; 131-46
- Bullini L, Arduino P, Cianchi R, Nascetti G, D'Amelio S, Mattiucci S, Paggi L, Orecchia P., Plötz, J., Berland, B., Smith, J. W., Bratney, J. Genetic and ecological research on anisakid endoparasites of fish and marine mammals in the Antarctic and Arctic-Boreal regions. In: Antarctic communities: species, structure and survival. Battaglia B, Valencia J, Walton DWH, eds. Cambridge, UK: Cambridge University Press, 1997; 39-44
- Deméré T. The family Odobenidae: A phylogenetic analysis of fossil and living taxa. In: Berta A, and Deméré TA, eds. Contributions in marine mammal paleontology honoring Frank C. Whitmore Jr. *Proc San Diego Soc Nat Hist* 1994; 29: 99-123
- Deliamure SL. Helminthofauna of marine mammals (ecology and phylogeny). Moskva: Izdatel'stvo Akad Nauk SSSR, 1955. (English Translation, Israel Program for Scientific Translations, Jerusalem, 1968)
- Fagerholm H, Gibson DI. A redescription of the pinniped parasite *Contracaecum ogmorhini* (Nematoda: Ascaridoidea), with an assessment of its antiboreal circumpolar distribution. *Zool Scripta* 1987; 16: 19-24
- Fernández M, Aznar FJ, Latorre A, Raga JA. Molecular phylogeny of the families Campulidae and Nasitrematidae (Trematoda) based on mtDNA sequence comparison. *Int J Parasitol* 1998a; 28: 767-75
- Fernández M, Littlewood DTJ, Latorre A, Raga JA, Rollinson D. Phylogenetic relationships of the family Campulidae (Trematoda) based on 18S rRNA sequences. *Parasitology* 1998b; 117: 383-91

- Fordyce RE, Barnes LG. The evolutionary history of whales and dolphins. *Ann Rev Earth Planet Sci* 1994; 22: 419-55
- Friesen VL, Baker AJ, Piatt J. Phylogenetic relationships with the Alcidae (Charadriiformes: Aves) inferred from total molecular evidence. *Molec Biol Evol* 1996a; 13: 359-67
- Friesen VL, Montevecchi WA, Baker AJ, Barrett RT, Davidson WS. Population differentiation and evolution in the common guillemot *Uria aalge*. *Molec Ecol* 1996b; 5: 793-805
- Golvan YJ. Acanthocéphales du genre *Corynosoma* Lühe 1904 parasites de mammifères d'Alaska et de Midway. *Ann Parasit hum comp* 1959; 34: 287-321
- Hoberg EP. Evolution and historical biogeography of a parasite-host assemblage: *Alcataenia* spp. (Cyclophyllidae: Dilepididae) in Alcidae (Charadriiformes). *Can J Zool* 1986; 64: 2576-89
- Hoberg EP. Congruent and synchronic patterns in biogeography and speciation among seabirds, pinnipeds and cestodes. *J Parasitol* 1992; 78: 601-15
- Hoberg EP. Historical biogeography and modes of speciation across high latitude seas of the Holarctic: Concepts for host-parasite coevolution among Phocini (Phocidae) and Tetrabothriidae (Eucestoda). *Can J Zool* 1995; 73: 45-57
- Hoberg EP. Faunal diversity among avian parasite assemblages: the interaction of history, ecology, and biogeography in marine systems. *Bull Scand Soc Parasitol*, 1996; 65-89
- Hoberg EP. Phylogeny and historical reconstruction: Host-parasite systems as keystones in biogeography and ecology. In: Reaka-Kudla ML, Wilson DE, and Wilson EO, eds. *Biodiversity II: Understanding and protecting our biological resources*. Washington DC: Joseph Henry Press, 1997; 243-61
- Hoberg EP, Adams AM. Phylogeny, historical biogeography, and ecology of *Anoplycephalus* spp. (Eucestoda: Tetrabothriidae) among pinnipeds of the Holarctic during the late Tertiary and Pleistocene. *Can J Zool* 1992; 70: 703-19
- Hoberg EP, Brooks DR, Siegel-Causey D. Host-parasite cospeciation: History, principles and prospects. In: Clayton D, and Moore J, eds. *Host-parasite evolution: general principles and avian models*. Oxford, United Kingdom: Oxford University Press, 1997a; 212-35
- Hoberg EP, Gardner SL, Campbell RA. Systematics of the Eucestoda: Advances toward a new phylogenetic paradigm, and observations on the early diversification of tapeworms and vertebrates. *Syst Parasitol* 1999a; 42: 1-12
- Hoberg EP, Jones A, Bray R. Phylogenetic analysis among the families of the Cyclophyllidae (Eucestoda) based on comparative morphology, with new hypotheses for coevolution in vertebrates. *Syst Parasitol* 1999b; 42: 51-73
- Hoberg EP, Mariaux J, Justine J-L, Brooks DR, Weekes P. Phylogeny of the orders of the Eucestoda (Cercomeromorphae) based on comparative morphology: Historical perspectives and a new working hypothesis. *J Parasitol* 1997b; 83: 1128-47
- Hoberg EP, Mariaux J, Brooks DR. Phylogeny among the orders of the Eucestoda (Cercomeromorphae): Integrating morphology, molecules and total evidence. In: *Interrelationships of the Platyhelminthes*. Littlewood DTJ, Bray R., eds. London, UK: Taylor and Francis, 2000; In Press.
- Iurakhno MV. Osobennosti evoliutsii gel'mintov lastonogikh. In: *Evoliutsiya Parazitov. Materialy Pervogo Vsesoyuznogo Simpoziuma*. Tol'yatti, Russia: Institut Ekologii Volzhskogo Basseina AN SSR 1991; 124-27

- Maddison WP, Maddison DR. MacClade: Analysis of phylogeny and character evolution. Version 3.05. Sunderland, Mass., USA: Sinauer Associates, 1992
- Marincovich L, Jr, Gladenkov A Yu. Evidence for an early opening of the Bering Strait. *Nature* 1999; 397: 149-51
- Markowski S. The cestodes of seals from the Antarctic. *Bull British Mus (Nat Hist) Zool* 1952a; 1: 123-50.
- Markowski S. The cestodes of pinnipeds in the Arctic and other regions. *J Helminthol* 1952b; 26: 171-214
- Mattiucci S, Paggi L, Nascetti G, Ishikura H, Kikuchi K, Sato N, Cianchi R, Bullini L. Allozyme and morphological identification of *Anisakis*, *Contracaecum* and *Pseudoterranova* from Japanese waters (Nematoda, Ascaridoidea). *Syst Parasitol* 1998; 40: 81-92
- Nascetti G, Cianchi R, Mattiucci S, D'Amelio S, Orecchia P, Paggi L, Bratney J, Berland B, Smith JW, Bullini L. Three sibling species with *Contracaecum osculatatum* (Nematoda, Ascaridida, Ascaridoidea), from the Atlantic Arctic-Boreal region: reproductive isolation and host preferences. *Int J Parasitol* 1993; 23: 105-20
- Orecchia P, Mattiucci S, D'Amelio S, Paggi L, Plötz J, Cianchi R, Nascetti G, Arduino P, Bullini L. Two new members in the *Contracaecum osculatatum* complex (Nematoda, Ascaridoidea) from the Antarctic. *Int J Parasitol* 1994; 24: 367-77
- Paggi L, Bullini L. Molecular taxonomy in anisakines. *Bull Scand Soc Parasitol* 1994; 4: 25-39.
- Paggi L, Mattiucci S, Gibson DI, Berland B, Nascetti G, Cianchi R, Bullini L. *Pseudoterranova decipiens* species A and B (Nematoda, Ascaridoidea): nomenclatural designation, morphological diagnostic characters and genetic markers. *Syst Parasitol* 2000; 45: 185-197
- Paggi L, Nascetti G, Cianchi R, Orecchia P, Mattiucci S, D'Amelio S, Berland B, Bratney J, Smith JW, Bullini L. Genetic evidence for three species within *Pseudoterranova decipiens* (Nematoda: Ascaridida, Ascaridoidea) in the North Atlantic and Norwegian and Barents Seas. *Int J Parasitol* 1991; 21: 195-212
- Ray CE. Geography of phocid evolution. *Syst Zool* 1976; 25: 391-406
- Repenning CA, Ray CE, Grigorescu D. Pinniped biogeography. In: Gray J, and Boucot AJ, eds. *Historical biogeography, plate tectonics, and the changing environment*. Corvallis, USA: Oregon State University Press 1979; 357-69
- Sher A. Traffic lights at the Beringian crossroads. *Nature* 1999; 397: 103-4
- Siegel-Causey D. Systematics and biogeography of North Pacific shags, with a description of a new species. *Occ Papers Mus Nat Hist Univ Kansas* 1991; 140: 1-17
- Spasskii AA. On the participation of marine Mesozoic reptiles in the evolution of the suborder Tetrabothriata (Cestoda: Tetraphyllidea). *Tezisy Dokladov. XI Conference of the Ukrainian Society of Parasitologists*. Kiev, Ukraine, 1993; p. 154-155. (In Russian. English translation, V. Tkach)
- Stanley H, Casey S, Carnahan JM, Goodman S, Harwood J, Wayne RK. Worldwide patterns of mitochondrial DNA differentiation in the harbor seal (*Phoca vitulina*). *Mol Biol Evol* 1996; 13: 368-82
- Swofford D. Phylogenetic analysis using parsimony (PAUP). Version 3.1.1. Champaign, USA: Illinois Natural History Survey, 1993
- Wojciechowska A, Zdzitowiecki K. Cestodes of Antarctic seals. *Acta Parasitol Polon* 1995; 40: 125-31
- Zdzitowiecki K. Acanthocephala of the Antarctic. *Pol Polar Res* 1986; 7: 79-117

Appendix I. Phylogenetic analysis for *Orthosplanchnus* spp.

Phylogenetic analysis for *Orthosplanchnus* was conducted with PAUP 3.0 using an exhaustive search (Swofford, 1993). Character-coding was based primarily on taxonomic outgroup comparisons to *Campula* spp., shown to be among the basal members of the family Campulidae (Fernández *et al.*, 1998a; also Hoberg and Adams, unpublished data). Additionally, a functional outgroup, the basal species of *Orthosplanchnus*, was used to secondarily assess characters 11 and 20. A single most parsimonious tree (MPT) resulting from this analysis supported monophyly for the genus and was fully resolved (minimum length= 30 steps, 38 required; consistency index, CI, excluding uninformative characters= 0.778; homoplasy index, HI= 0.222)

Morphological characters for phylogenetic analysis of *Orthosplanchnus* spp.

1. **Cuticular Spination:** 0= complete; 1= confined to anterior.
2. **Body Length:** 0= elongate, ≥ 10 mm; 1= medium, ≈ 4 -7mm; minuscule, ≤ 2 mm.
3. **Oral Sucker, Diameter:** 0= mean $\approx 500\mu\text{m}$; 1= mean $\leq 350\mu\text{m}$; 2= mean $\leq 250\mu\text{m}$.
4. **Ventral Sucker, Diameter:** 0= mean $\geq 500\mu\text{m}$; 1= mean $\geq 350\mu\text{m}$; 2= mean $\leq 250\mu\text{m}$.
5. **OS:VS Ratio:** 0= $< 1:1$; 1= $1:1$; 2= $1:2$.
6. **Pharynx, Diameter:** 0= mean $> 500\mu\text{m}$; 1= mean $\approx 300\mu\text{m}$; 2= mean $\approx 200\mu\text{m}$; 3= mean $< 200\mu\text{m}$.
7. **Ovary, Diameter:** 0= mean $> 450\mu\text{m}$; 1= mean $\geq 250\mu\text{m}$; 2= mean $< 200\mu\text{m}$.
8. **Ovary, Form:** 0= ellipsoidal to elongate; 1= ovoid or subspherical.
9. **Testes, Form:** 0= dendritic, highly lobate; 1= elongate to ellipsoidal; 2= ovoid.
10. **Testes, Position:** 0= middle third of body; 1= third quarter of body.

11. **Egg, Length:** 0= mean $\approx 100\mu\text{m}$; 1= mean $\approx 80\mu\text{m}$. Coding for this character was based on functional outgroup criteria.
12. **Vitellaria, Extent:** 0= to near pharynx; 1= to acetabulum; 2= to near anterior edge of ovary.
13. **Vitellaria, Form:** 0= dendritic in anterior; 1= follicular.
14. **Cirrus, Spination:** 0= absent; 1= present.
15. **Metratrum, Spination:** 0= absent; 1= present.
16. **Habitat:** 0= intestine; 1= gall bladder.
17. **Eye-Spots:** 0= absent; 1= present.
18. **Ovary, Position:** 0= not overlapping anterior testis; 1= overlapping anterior testis.
19. **Testes, Position:** 0= tandem, not overlapping; 1= tandem, overlapping.
20. **Body, L:W Ratio:** 0= approximately 1:6-7; 1= elongate, 1:14; 2= approximately 1:2-3. Coding for this character is consistent with functional outgroup criteria.

Character Matrix for Phylogenetic Analysis of *Orthosplanchnus* spp.

Characters	1-20			
<i>Campula</i> spp.*	00000	00000	00000	00000
<i>O. arcticus</i>	01001	11110	00111	10100
<i>O. fraterculus</i>	01111	22110	11111	10000
<i>O. rossicus</i>	10001	11110	12111	10011
<i>O. pygmaeus</i>	12221	32121	10111	01102
<i>O. antarcticus</i>	01111	21110	11111	00001
<i>O. oculatus</i>	12221	32121	10111	01112
<i>O. albamarinus</i>	10002	10010	00000	00010

*Outgroup

PARASITE APPLICATION IN CONSERVATION AND PEST CONTROL

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Parasitic infections have an impact on the fitness of individuals and this can have consequences for the population of the host species. In natural populations of economic or conservation value then we may wish to reduce parasitic infections to increase yield or maintain biodiversity. Alternatively we may wish to use parasites to control pest species. This paper will examine some of methods that can be used and their efficacy in the manipulation of parasites in wild animal populations.

Direct and indirect means of applying anthelmintic to red grouse (*Lagopus lagopus*) to control *Trichostrongylus tenuis* will be examined. The control of parasites in a reservoir host species and the timing of application in relation to seasonal infection will also be examined. Parasites can also be used to control pest species. The ways entomopathogenic nematodes can be used to control insect pests will be considered.

FRESHWATER FISH PARASITES AND HABITAT CHANGE

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The rate of habitat change appears to be exceptionally rapid in freshwaters. Many contemporary changes are anthropochore in origin, so all too often several factors change more or less simultaneously. These changes must and do influence the biota, including the parasite fauna. The effects on parasites may be direct on the free living stages or on ectoparasites, or indirect via effects on fish or invertebrate hosts but the existence of a causal relationship between anthropochore habitat change and change in metazoan parasite communities in freshwater fish is undeniable (Kennedy, 1997a).

These anthropochore changes are essentially local in nature and generally affect a single catchment or water body. They are, however, superimposed on a background of regional changes which are natural and climatic. These may be discrete events such as floods and droughts or a continual change such as a rise in temperature. The two types of change may sometimes be linked as when a drought accentuates the effects of water abstraction, or floods negate the attempts at regulation, and when faced

with such multiple causality it can be very difficult to distinguish the determinant variables. Most studies relating fish parasite communities to habitat change have focused on the local, anthropochore changes and have been short term in nature. However, to address the effects of climatic induced habitat change it is necessary to employ long term data sets and these are sadly in short supply.

This present study employs long term data sets in order to investigate whether habitat changes caused by climatic events can be detected and recognised as such in the presence of anthropochore changes and then correlated with changes in helminth parasite communities in fish. The climatic variables selected are droughts and floods and temperature extremes, as these are generally monitored on both local and regional scales. If they do have an impact on parasite communities we can predict similar and simultaneous changes in discrete localities within a region. This hypothesis will be tested by examining the changes in parasite communities in the European eel *Anguilla anguilla* in three rivers and a lake in South Devon

over periods varying from 14 to 30 years. The data sets were originally collected for other purposes and two of them have been published (Kennedy, 1993, 1997b).

The Environment Agency has identified 1976, 1984 and 1989 as drought years in South Devon, in which minimum flows were reported from the River Exe as 36.5, 103.4 and 104.9 respectively in comparison to the normal of 165.4 (Ml/d). By contrast 1981, 1986 and 1988 were exceptionally wet years. The winters of 1978 and 1984/85 were also exceptionally cold in South Devon, to the extent that in 1985 some lakes froze over for the first time in 22 years. These climatic variations are natural but severe enough to be rated as exceptional. In addition, the last decade has seen some of the warmest years on record.

The R. Clyst is a small (25km) tributary of the R. Exe and joins the main river in the estuary. Its water quality is only class B (moderate), it does not harbour brown trout, *Salmo trutta*, and it is becoming enriched from farm drainage. It has been subject to a multiplicity of local changes including straightening, deepening, dredging and bank stabilization. Samples were taken over 20 years, from 1979 - 1998 (Kennedy, 1993). Up until 1982 the intestinal helminth community comprised three species, with *Acanthocephalus clavula* dominant over *Bothriocephalus claviceps* and *Paraquimperia tenerima*. The number of species dropped to 2 in 1983 and to 0 in 1984. By 1991 community richness had risen to 9 species and has subsequently fluctuated between 7 and 9 species. In addition to enrichment, the identity of the dominant species has changed to *P.*

tenerima and *A. clavula* has become very rare. Eel specialists including *Proteocephalus macrocephalus* and *Dero-prists inflata* have appeared in the community since 1991, as have non-specialists including *Neoechinorhynchus rutili* and *Raphidascaris acus*. The appearance of *D. inflata* may relate to river management, such that tidal influence may now be felt further upstream, but none of the other species appearances can be related to climatic or other particular events. The crash in community species richness co-incided with the drought year of 1984, but there was no discernable effect of the drought of 1989.

The R. Culm is also a tributary of the R. Exe and joins the main river above Exeter. It is 45km long, and until recently had water quality close to class C (fairly good) as a consequence of pollution from paper mills. The mills have now closed and the river has become grade B. Brown trout are present in the river and chub *Leuciscus cephalus* have been introduced into it. Samples have been taken over an 18 year period from 1981 - 1998. In 1981 *B. claviceps* was the only species present in the intestinal community and this species is still present. In 1986 species richness increased to three with the detection of *P. tenerima* and *Acanthocephalus lucii*. The introduction of chub was coincidental with the appearance of *Pomphorhynchus laevis* in the river and by 1997 this species dominated the intestinal community in eels. Species richness had increased to 8 by 1998 with the appearance of eel specialists such as *Acanthocephalus clavula* and *Spinitectus inermis* but *P. laevis* continues to dominate the com-

munity. The community here has never fallen to zero richness or even declined, but has steadily increased in richness over the period and this may be related to the recovery of the river from the effects of the mill pollution. There is no indication that any of the droughts or cold winters affected the community.

The R. Otter catchment is adjacent to that of the R. Exe. The river is 44 km long and flows directly to the sea. It is subject to borehole extraction and agricultural input, but the water quality is class A. The sampling programme has extended over 14 years, from 1985 - 1996 (Kennedy, 1997b). In 1985 only *B. claviceps* was present, and it is possible that the low species richness might also relate to the 1984 drought, but the community had increased to 8 species by 1987 and then declined to 1 in 1988 and 0 in 1989. This decline preceded the drought of 1990. Community richness then varied between 4 and 8 from 1991 to 1998. The only new species to appear after 1989 was the generalist *Sphaerostoma bramae* as all the other species had been reported in the river before this time. Both *P. laevis* and *S. inermis* were first recorded in the 1987, but both increased in abundance from 1991 onwards until *S. inermis* dominated the community from 1996-1998. The appearance of *P. laevis* is believed to be due to stocking of the river with brown trout, but none of the other changes can be clearly related to climatic or local habitat events.

Slapton Ley is a small, isolated coastal lake in South Devon. The lake has suffered from increasing eutrophication which switched into hyper-eutrophication as a consequence of the

drought of 1976. This enrichment also led to winter-kill of fish when the lake froze over during the winter of 1984/85 (Kennedy, 1996). These events have had a profound effect upon the fishery and the parasites of fish in the lake. The sampling programme here extends over 30 years, from 1971 to 2000. Because of its isolation, parasite communities of fish tend to be rather poor. The lake is one of the few localities from which the gill copepod *Ergasilus gibbus* has been recorded from eels in Britain. In 1971 and 1975, the only intestinal species recorded from eels was *Acanthocephalus lucii*. By 1985, this had been replaced by *A. clavula*. By 1987 *B. claviceps* and *P. tenerrima* were also reported in eels, although *A. clavula* dominated the community. Thereafter *A. clavula*, together with other species of acanthocephalans, gradually declined in the lake and eventually, around 1990, became locally extinct. From 1995 - 1999 the community comprised four species with, *P. tenerrima* dominating over *B. claviceps*, *P. macrocephalus* and *Pseudocapillaria* and *E. gibbus* is still present on the gills. Once again, none of these changes can be related to local habitat changes or to climatic changes although both have had major effects upon the parasite communities of other species of fish in the lake.

The expansion in range throughout Europe of *Anguillicola crassus* and *Pseudodactylogyrus anguillae* over the last two decades has extended into Devon and since 1995 both have been found in all four localities.

All four localities experienced the same regional climatic regime of droughts, floods and temperature changes. All four, however, were also

subject to local anthropochore changes, the nature and magnitude of which differed in each case. The R. Clyst was subject to management and flood relief changes, the R. Culm to pollution and recovery therefrom, the R. Otter to bore-hole abstraction and agricultural run off and Slapton Ley to eutrophication. At least two rivers were also subject to fish stocking from another catchment. In all four localities the helminth communities in eels showed changes over the period of study. The problem lies in relating the parasite changes to the habitat changes, and distinguishing regional and local influences.

If regional, climatic factors are important influences on helminth communities then the changes in the communities should be similar and synchronous. A number of such changes were in fact observed :

1. All four communities were invaded by *A. crassus* and *P. anguillae*. This, however was not related to local or regional factors as such: both species have been spreading throughout Britain over the last 15 years (Kennedy & Fitch, 1990) and it is not surprising that they reached the far west so late. *Daniconema anguillae* was also found in all four localities, but this is more likely to reflect improved detection rather than a colonisation event.

2. Over the last 20 years there has been a decline in the prevalence and abundance of *A. clavula* in the region, such that this once common species has become extinct in one locality and rare in three others.

3. A common suite of eel specialists comprising *B. claviceps*, *P. tenerrima* and *A. clavula* was present in each local-

ity in the early part of the study period. Changes in the proportions of these species occurred throughout the study period and *A. clavula* was often replaced by another, non-eel specialist acanthocephalan, but the other species were present throughout.

4. The identity of the dominant species changed: *P. tenerrima* increased in abundance in all localities and came to dominate 3 of them in the late 1990s.

5. In all four localities there was an overall increase in component community species richness over the period of study. This involved additions to the common suite due to acquisition of the specialist *Pseudocapillaria* in all four localities and to the non-eel specialists *N. rutili*, *R. acus* and *S. bramae* in the three rivers. In the rivers close to the estuary and subject to tidal influences, *D. inflata* appeared. In some cases, introduced species such as *P. laevis* and *S. inermis* increased species richness.

There were also different and asynchronous changes between the communities:

1. Eel parasite communities in the R. Culm and R. Otter were enriched by species introduced with stocked fish: *P. laevis* arriving with chub in the former river and trout in the latter. These anthropochore stockings were independent events.

2. The rare eel specialist *S. inermis* became common in the R. Otter and R. Culm, but not in the R. Clyst. It was first detected in the R. Otter in the same year as *P. laevis* but this must be coincidental as eels are the only host for the species and cannot serve as a definitive host for *P. laevis*, *S. inermis* did not appear in the R. Culm until 10 years

later, but the source of it in both rivers is unknown.

3. Community species richness declined to zero in the Rivers Clyst and Otter but there was no such decline in the R. Culm which was adjacent to the Clyst.

4. There was no synchrony in the times of zero species richness.

5. Species richness increased steadily in the R. Culm, perhaps in response to recovery of the river from pollution and a corresponding increase in invertebrate diversity.

6. The community also increased in richness in Slapton Ley over the period of eutrophication and through events such as winterkill that caused the disappearance of many parasite species from other species of fish (Kennedy, 1998). Whilst species of *Dactylogyrus* disappeared, *E. gibbus* was unaffected.

The overall conclusion must be that there is very little evidence that discrete, regional, climatic events such as droughts have any lasting effect upon helminth communities of eels. By contrast, these communities are strongly affected by local anthropochore events and especially introductions. It is possible to detect correlations between climate improvement and increasing species richness in all four localities: as with other suggestions on the effects of global warming, however, the evidence for causality is so far lacking.

Trematode life-cycles are amazingly complex and diverse. They are characterized by changes of generations (parthenogenetic and hermaphroditic) and animal hosts (intermediates and final). Each generation must develop from an imma-

ture state to a mature form. Each phase in a life-cycle must be capable of carrying out its particular function. Free living larvae must be required to penetrate a host, parasitic larvae must survive in the body of an intermediate host, adults should be capable of reproduction. To ensure that these tasks may be completed successfully various adaptations (morphological and behavioural) have been developed in the course of evolution. These adaptations are specific and depend on the life-cycle phase and ecological conditions of the environment. Therefore, it is impossible to discuss evolution of life-cycles without considering the ecological conditions that influence these life-cycles. This is the essence of the ecological approach which we use in our studies.

References

- Kennedy CR. The dynamics of intestinal helminth communities in eels *Anguilla anguilla* in a small stream: long term changes in richness and structure. *Parasitology* 1993; 107: 71-8
- Kennedy CR. Freshwater fish parasites and environmental quality: an overview and caution. *Parassitologia* 1997a; 39: 249-54
- Kennedy CR. Long term and seasonal changes in composition and richness of intestinal helminth communities in eels *Anguilla anguilla* of an isolated English river. *Folia Parasitologica* 1997b; 44: 267-73
- Kennedy CR. Aquatic birds as agents of parasite dispersal: a field test of the effectiveness of helminth colonization strategies. *Bull Scand Soc Parasit* 1998; 8: 23-8
- Kennedy CR, Fitch DJ. Colonization, larval survival and epidemiology of the nematode *Anguillicola crassus*, parasitic in the eel *Anguilla anguilla*, in Britain. *J Fish Biol* 1990; 36: 117-312

THE EVOLUTIONARY ECOLOGY OF PARASITE-INDUCED CHANGES IN HOST PHENOTYPE

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Since it was first convincingly illustrated by Holmes, Bethel (1972), the ability of many parasites to manipulate the phenotype of their host in order to facilitate their own transmission has become a paradigm in the area of host-parasite evolutionary ecology. After two decades during which examples had been accumulating, the focus of research in the past ten years has shifted toward the evolution and adaptive nature of the phenomenon (Moore, Gotelli, 1990; Poulin, 1994, 1995; Kuris, 1997; Brown, 1999) and its physiological basis (Hurd, 1990; Thompson, Kavaliers, 1994). More recent lines of research have highlighted different issues relating to host manipulation by parasites, and this essay will explore some of them. I will first draw attention to a rather disturbing historical trend in the quantification of parasite-induced changes in host phenotype, and then discuss the more general implications of altered host phenotypes for the evolution of hosts and parasites.

New ideas that provide simple, elegant explanations for widespread phe-

nomena often become rapidly and widely accepted by the scientific community. Following an initial enthusiasm for the new paradigm, there is typically a decrease in interest followed by a shift toward another explanation. This pattern is so common that Kuhn (1996) proposed that it was the normal way in which scientific progress and revolutions are achieved. The acceptance of host phenotype manipulation as an adaptive parasite strategy was no different. Recently, I used published estimates from the past 30 years of the magnitude of parasite-induced changes in host behaviour to test for a potential weakening of the manipulation paradigm (Poulin, 2000). I used data on the effects of helminths on the behaviour of their host, and quantified the effects of parasites as the difference between the mean behaviour of infected and control host groups, corrected for sample size and the pooled standard deviation of individual behavioural measures. I then tested the null hypothesis that the magnitude of the published effects of parasites has remained the same through the past 30

years. Using only data from studies of the effects of helminths on the behaviour of their definitive host (in which a change in host behaviour has no obvious effects on parasite fitness), this is indeed what I found: the magnitude of published estimates of parasite-induced changes does not vary over time. However, using data from studies looking at the effects of parasitic helminths on the behaviour of their intermediate host, the published estimates of parasite-induced changes in host behaviour decreased significantly over time (Poulin, 2000). All these studies were explicit tests of the adaptive host manipulation hypothesis. They all were on systems in which intermediate hosts must be ingested by the definitive host for parasite transmission to occur, and thus systems in which alterations in intermediate host behaviour can affect their susceptibility to predatory definitive hosts. Another analysis on an independent data set, in which the parasite-mediated increase in predation of definitive hosts on intermediate hosts was quantified instead of actual behavioural changes, showed the same pattern: the published estimates of increases in susceptibility to predation (measured as the increase in the probability of being eaten resulting from infection) decreased significantly over the past three decades (Poulin, 2000).

What does this all mean? Well, a publication bias may be the main factor responsible for the historical trend. Reviewers and editors may be more willing to publish weak results or exceptions to the paradigm years after its first popular acceptance than at the beginning. The existence of the host manipulation phenomenon is not in doubt.

However, the magnitude of the effects of parasites on host phenotype are usually more subtle and much less spectacular than in the first published examples that are still the most widely cited.

With this cautionary remark in mind, the time has come to examine other evolutionary aspects of the host manipulation phenomenon. Beyond its fitness benefits for the manipulating parasite, the alteration in host phenotype can have serious implications for the evolution of the host itself, as well as that of other parasite species sharing it with the manipulating species. Looking first at the host, it is clear that host manipulation by parasites can change the shape of the frequency distributions of various continuous phenotypic variables within the host population (Poulin, Thomas, 1999). Infection by a manipulating parasite can increase or decrease the mean value of a phenotypic trait and increase its variance in the overall host population. This will of course depend on the prevalence or abundance of the manipulating parasite. If the parasite is very common, the frequency distribution of host phenotypic traits may remain normal but be shifted toward higher or lower values; if the parasite is only moderately common, the distribution of host traits is likely to become skewed (Poulin, Thomas, 1999). The importance of this effect is that because of the parasite, the observed distribution of host traits in the population no longer reflects the distribution expected from host genotypes. This parasite-mediated uncoupling between host genotype and phenotype can disrupt selection acting on hosts. The strong background noise generated by parasites renders selection myopic, i.e. blind to the

genotype and only capable of seeing and acting on the presently expressed phenotypes. One possible consequence would be a slowing down of evolutionary (genetic) changes in specific host traits from generation to generation (Poulin, Thomas, 1999). There has been no attempt to date at quantifying these sorts of secondary evolutionary effects of parasite manipulation of host phenotypes.

In more extreme cases, manipulating parasites cause such a large shift in host phenotype that they split the population into two morphotypes, i.e. the frequency distribution of certain host phenotypic traits becomes truly bimodal. This is true of certain helminths that alter the colouration or morphology of their intermediate hosts to the point that a human observer can easily separate parasitized individuals from healthy ones simply by looking at them (e.g., Hindsbo, 1972; Plateaux 1972; LoBue, Bell, 1993). In other systems, manipulating parasites cause a shift in the spatial distribution of their hosts, such that parasitized individuals are segregated in space from healthy conspecifics. For example, a microphallid trematode causes its amphipod intermediate hosts to move toward the water surface whereas unparasitized amphipods stay at the bottom of their lagoon habitats (Helluy, 1984). This marked spatial segregation causes parasitized amphipods to mate assortatively with one another, whereas uninfected amphipods tend to mate only with other uninfected conspecifics (Thomas *et al.*, 1995). The evolutionary effects of spatial segregation and reduced gene flow between parasitized and healthy individuals in a host population as a consequence of manipulation by a para-

site have received very little attention to date (Poulin, Thomas, 1999).

Finally, what are the ecological and evolutionary consequences of host manipulation by one parasite species for the other parasite species that utilise the same host population? In the case of larval helminths exploiting the same intermediate host population, there may be either shared interests or conflicts between the manipulating parasite and the other helminth species, depending on whether they also share the same definitive host. If we consider the intermediate host as a vehicle taking parasites toward their definitive hosts, then the manipulative parasite can be seen as the driver, since it influences the direction taken by the vehicle, i.e. the definitive host most likely to eat the intermediate host (Lafferty, 1999). Other parasites with the same definitive host as the manipulator can fortuitously benefit from the manipulation when they happen to share an intermediate host with a manipulator, or they can evolve the ability to seek manipulated hosts and 'hitch' a ride with manipulating parasites (Thomas *et al.*, 1998). If two manipulating species exploit the same intermediate and definitive host populations, they may evolve a tendency to seek one another if their effects are additive, or one may lose its manipulative ability and associate with the other one to obtain a cheap ride toward the definitive host (Lafferty *et al.*, 2000). However, if a parasite species shares an intermediate host population with a manipulator, but if they have different definitive hosts, then there is a potential for conflict between them. The unlucky passenger may evolve ways to avoid the manipulator in order not to be

taken into a dead end (i.e. the wrong definitive host). If both parasite species are capable of manipulating intermediate hosts but influence different phenotypic traits, there may be a struggle for control of the host, with one species ending up in the driver seat and the other interfering without success (see Lafferty *et al.*, 2000). All these situations are simplified; in reality, the outcome of these sympatric associations would depend on the prevalence of the two parasites, on their life history and developmental characteristics, etc.

The point of all the above scenarios is that the evolution of host selection mechanisms and transmission strategies in parasites with complex life cycles is not independent from the strategies used by other, sympatric parasite species when host manipulation is involved. The first prediction that can be made from the observation that a manipulator shares an intermediate host population with other species is that there should be positive or negative associations between parasite species among intermediate hosts, depending on what definitive hosts they use. Many recent studies (see Lafferty *et al.*, 2000 for examples) have indeed found such associations. The search for coevolved transmission strategies among sympatric parasites should reveal a wide array of different tactics illustrating the broader consequences of host manipulation.

Despite the historical decrease in the magnitude of the published estimates of its effect, the manipulation of host phenotype by parasites remains an important phenomenon. It is widespread in natural systems, having evolved *de novo* in many parasite taxa. This essay has fo-

cused on some of the evolutionary consequences of host manipulation for organisms other than the manipulating parasite itself. Host manipulation weakens the link between the genotype and the phenotype of the host, with possible effects on the speed of selection (Poulin, Thomas, 1999), and it modifies the host landscape in which other sympatric parasites evolve (Lafferty *et al.*, 2000). In addition, manipulative parasites can have indirect effects on other organisms, not part of the host-parasite complex (see Thomas *et al.*, 1999). These kinds of consequences of host manipulation, in addition to further insight into the adaptive nature of manipulation, should be the focus of future studies in this area.

References

- Brown SP. Cooperation and conflict in host-manipulating parasites. *Proc R Soc London B* 1999; 266: 1899-904
- Helluy S. Relations hôtes-parasites du trématode *Microphallus papillorobustus* (Rankin, 1940). III. Facteurs impliqués dans les modifications du comportement des *Gammarus* hôtes intermédiaires et tests de prédation. *Ann Parasitol Hum Comp* 1984; 59: 41-56
- Hindsbo O. Effects of *Polymorphus* (Acanthocephala) on colour and behaviour of *Gammarus lacustris*. *Nature* 1972; 238: 333
- Holmes JC, Bethel WM. Modification of intermediate host behaviour by parasites. In: Canning EU, Wright CA, eds. Behavioural aspects of parasite transmission. London: Academic Press, 1972: 123-49
- Hurd H. Physiological and behavioural interactions between parasites and invertebrate hosts. *Adv Parasitol* 1990; 29: 271-318
- Kuhn TS. The structure of scientific revolutions, 3rd edition. Chicago: University of Chicago Press, 1996

- Kuris AM. Host behavior modification: an evolutionary perspective. In: Beckage NE, ed. *Parasites and pathogens: effects on host hormones and behavior*. New York: Chapman & Hall, 1997: 293-315
- Lafferty KD. The evolution of trophic transmission. *Parasitol Today* 1999; 15: 111-15
- Lafferty KD, Thomas F, Poulin R. Evolution of host phenotype manipulation by parasites and its consequences. In: Poulin R, Morand S, Skorping A, eds. *Evolutionary biology of host-parasite relationships: theory meets reality*. Amsterdam: Elsevier Science, 2000; (in press)
- LoBue CP, Bell MA. Phenotypic manipulation by the cestode parasite *Schistocephalus solidus* of its intermediate host, *Gasterosteus aculeatus*, the threespine stickleback. *Am Nat* 1993; 142: 725-35
- Moore J, Gotelli NJ. A phylogenetic perspective on the evolution of altered host behaviours: a critical look at the manipulation hypothesis. In: Barnard CJ, Behnke JM, eds. *Parasitism and host behaviour*. London: Taylor & Francis, 1990: 193-233
- Plateaux L. Sur les modifications produites chez une fourmi par la présence d'un parasite cestode. *Ann Sci Nat Zool Biol Anim* 1972; 14: 203-20
- Poulin R. The evolution of parasite manipulation of host behaviour: a theoretical analysis. *Parasitology* 1994; 109: S109-S118
- Poulin R. 'Adaptive' changes in the behaviour of parasitized animals: a critical review. *Int J Parasitol* 1995; 25: 1371-83
- Poulin R. Manipulation of host behaviour by parasites: a weakening paradigm? *Proc R Soc London B* 2000; (in press)
- Poulin R, Thomas F. Phenotypic variability induced by parasites: extent and evolutionary implications. *Parasitol Today* 1999; 15: 28-32
- Thomas F, Renaud F, Derothe JM, Lambert A, de Meëus T, Cézilly F. Assortative pairing in *Gammarus insensibilis* (Amphipoda) infected by a trematode parasite. *Oecologia* 1995; 104: 259-64
- Thomas F, Renaud F, Poulin R. Exploitation of manipulators: 'hitch-hiking' as a parasite transmission strategy. *Anim Behav* 1998; 56: 199-206
- Thomas F, Poulin R, de Meëus T, Guégan J-F, Renaud F. Parasites and ecosystem engineering: what roles could they play? *Oikos* 1999; 84: 167-71
- Thompson SN, Kavaliers M. Physiological bases for parasite-induced alterations of host behaviour. *Parasitology* 1994; 109: S119-S138

INFRACOMMUNITIES: STRUCTURE AND COMPOSITION

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Parasite communities from single host individuals have one undoubted feature: the overwhelming majority of parasite infrapopulations cannot maintain their numbers by self-reproduction. These communities are rigorously defined spatially. The existence of an infracommunity is restricted to its individual host's lifetime. However, at this level parasites only interact or do not interact, compete or do not compete with each other, and either form or do not form guilds. As a result of these interactions isolationist or interactive communities are formed.

Holmes & Price (1986) suggested that the host organism is analogous to an "island" which is inhabited by parasites. A number of studies of communities of intestinal helminths have clearly shown that even component communities consist of few helminth species (5-10). But taking into account host numbers one can assume a great number of empty or partly populated "islands" (Simberloff, 1990). Frequency distributions of numbers of parasite species in 899 infracommunities revealed the fact that most of them consist

of 1-2 parasite species. Frequency distributions of parasite species are overdispersed ($\sigma^2/M = 2.23$) and can be fitted by Gamma or Poisson distributions. The same distribution type was found when infracommunities were grouped according to fish ecology or systematic position. This distribution is typical for the frequency distribution of numbers of a single parasite species in one host population. Parasite species frequency distributions vary in different component communities: from typically overdispersed to asymmetrical. This reflects different life conditions for different host populations. Thus, one of the important parameters of infracommunity - species number is stochastic.

For all host individuals a low probability of events occurring and approximately equal probabilities of a parasite being acquired (but not establishing) are the basis of overdispersed or aggregated distributions. Research into free-living communities often focuses on spatial segregation

(overdispersion) and on changing patterns of spatial use as evidence for interspecific interactions, particularly competition (Simberloff, 1990). Overdispersed species distribution seems not to be a feature at the infracommunity level or even to have no sense because of the impossibility of studying the same host individual several times. Nevertheless it is difficult to fit another type of distribution for an association each member of which is overdispersed. This phenomenon is based on a very low probability for parasites to complete their life cycle. If prevalence is the probabilistic estimation for the event (to complete life cycle), the next probabilistic estimation could be done for a cestode: $P = 0,0005 * 0,05 * 0,8 = 0,00002$, where the first number is prevalence of infection of a planktonic copepod, the second - prevalence of infection of the second intermediate host (fish) and the third number - prevalence of infection of the final host (predatory fish). Perhaps the probability of infecting a host increases from first intermediate to final host. Hence the probability of occurring in the same host individual comes to zero as we have to add another multiplier $1/N$ where N is the number of host specimens in the population. This very low probability is compensated for by high fecundity, reservoir parasitism etc. Such a property is typical of parasites with complicated life cycles that are less dependent on the external environment. It could be supposed that parasites with direct life cycles which have a greater probability of infecting the host will be found more often and in higher numbers than parasites with complex life cycles, which means that they will be dominant species in infracommunities. However, these species were dominant in only 25% of infracommunities

despite the fact that both parasite groups are nearly equally represented in the region (44% and 56%). Thus, parasites with direct life cycles which are more dependent on the external environment but with a greater probability of infecting the host are less often dominant in infracommunities than parasites with complex life cycles. This is one evidence of the interactive nature of infracommunities. On the other hand spatial segregation (overdispersion) is the result of interaction (ghost of competition in the past) when all problems within the community have been solved, whereas any disturbance of overdispersion is the sign of serious infracommunity reorganization when competition plays an important role. These periods can be short, for example during fish spawning, migration etc.

Simberloff (1990) stated that "host individuals may more closely approximate replicates of one other, than islands do". It could be supposed that a real island has a greater variety of biotopes than a host individual, but host population genotype variety, diversity and the extent of host reaction to "parasite-colonists" are more diverse or at least the same as on a real island. The main difference is that species colonizing a real island compete with each other while the parasite habitat (host organism) reacts actively to such a colonist's occurrence. The other difference is that the number of "hosts-islands" is much higher than the number of islands in any archipelago. It is well known that the number of species inhabiting an island depends on the size of the island. In parasitology the analo-

gous parameter could be host size. We use fish length as the measure of host size. No great correlation was found between fish length and species number or fish length and number of parasite individuals (Fig. 1). None of the infracommunity parameters (dominance index, evenness, Brillouin index) correlated with host size either when all infracommunities were included into analyses or when infracommunities without multicellular parasites ($S=0$) were excluded. This means that the host organism is not completely analogous to an island. The same fact was found when infracommunities were grouped according to fish ecology. When the systematic position of the host was included in the analysis the situation changed. Salmonidae s.l. show a weak significant correlation between S and $\ln N$ with fish length which became less when infracommunities with $S=0$ were excluded.

Cyprinidae show weak a significant correlation of S and N with fish length which increases slightly when infracommunities with $S=0$ are excluded. Among Salmonidae S was correlated with fish length in the case of graylings ($r=0,33$; $p=0,01$) when infracommunities with $S=0$ were included. A negative significant correlation was found between S , N and fish length in the case of round whitefish (*Prosopium cylindraceum*) ($r=-0,4678$, $p=0,003$; $r=-0,3488$, $p=0,032$). Such a correlation was not found among other salmonid species (*Salvelinus malma*, *Brachymystax lenok*, *Coregonus sardinella*). The picture is much more diverse among Cyprinidae. Species of the genus *Phoxinus* in a combined sample did not demonstrate significant correlations between S , N and fish length, while in the case of species of the related genus

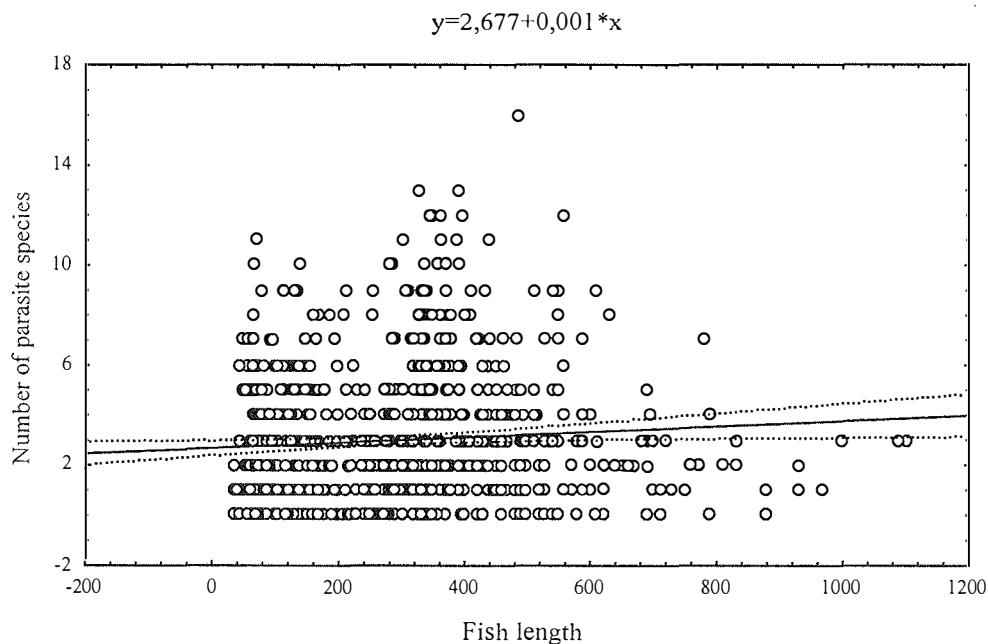


Fig. 1. Relationship between fish length and number of parasite species ($r=0,077$).

Oreoleuciscus such correlations were observed ($r=0,5058$, $p=0,0001$; $r=0,3534$, $p=0,0001$). Lake minnow (*Phoxinus phoxinus*) demonstrated a weak negative correlation between S and fish length only if infracommunities with $S=0$ were excluded ($r=-0,2512$, $p=0,045$). River minnow (*Ph. phoxinus*) demonstrated a weak positive correlation between N and fish length only if infracommunities with $S=0$ were excluded ($r=0,282$, $p=0,16$, $r=0,24$, $p=0,02$). The lacustrine form of the two species of west-mongolian minnows (*Oreoleuciscus potanini* and *O. pewzowi*) from Big Lake Valley demonstrated significant correlations between S, N and fish length. The third species of the genus *Oreoleuciscus* (*O. humilis*), which has lacustrine and riverine forms, demonstrated a significant negative correlation only between S and fish length ($r=-0,3591$, $p=0,015$). No significant correlations between these parameters were found among lacustrine forms of this species while its riverine form demonstrated a significant correlation between N and fish length only ($r=0,4529$, $p=0,012$).

Thus, two main parameters - number of species and number of parasite individuals - of the infracommunity show very diverse correlations with host size only when we take into account host phylogenetic relationships. The diversity of these correlations demonstrates the impossibility of making a direct analogy with free-living animal ecology. If we would like to make such an analogy in the case of "host-island" theory then every host species would consist of "populations-archipelagos which are situated in the same geographical zone". Only among "islands" of one and the same "archipel-

ago" could correlations be revealed. Host species of different sizes can harbour many parasite species, for example minnow and pike (Pugachev, 1997).

The numbers of parasites (N) in infracommunities varied greatly. 95% of infracommunities had less than 1000 parasites; 86% - less than 500; 76% - less than 200. Frequency distributions of parasite numbers were overdispersed as were numbers of parasite species. Numbers of species and numbers of parasite individuals are connected by a significant positive correlation, the value of which increased considerably when infracommunities with more than 500 parasite individuals (14% of infracommunities) or more than 200 (24% of infracommunities) were excluded from the sample. This correlation between S and N was revealed in the case of fish ecological groups, systematic groups (Salmonidae and Cyprinidae) and all fish species except burbot (*Lota lota*). The value of the significant correlation varied from 0.38 to 0.45 in the case of fish ecological groups and from 0.31 to 0.66 in the case of different fish species and was 0.35 for Salmonidae and 0.45 for Cyprinidae. The numbers of parasite individuals in infracommunities reached "saturation level" on the average when infracommunities consisted of 150 parasite individuals and 9-10 species (Fig. 2). This "saturation level" was revealed in all fish ecological and systematic groups. Thus, the number of parasite individuals in the infracommunity being a stochastic and overdispersely distributed value shows the tendency to achieve saturation on the

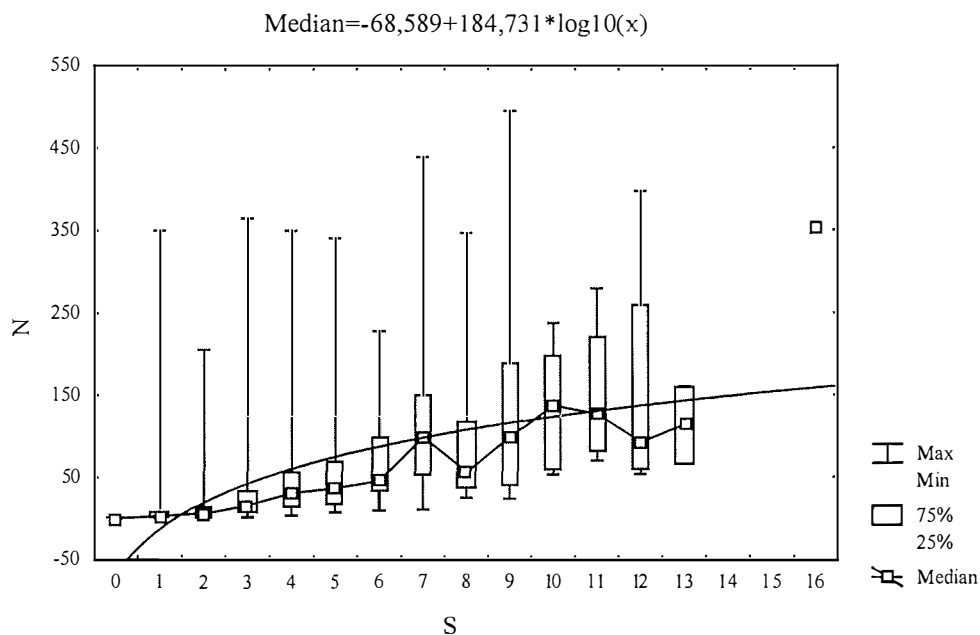


Fig. 2. Relationship between number of species (S) and numbers of parasites (N) within infracommunities (regression line by average values, $N < 500$)

average. This is possible evidence for recognizing an infracommunity as interactive, nonisolationist and saturated, which is the result of interactions between host organism and parasites as well as between parasites. Only if we suggest that a host organism is an indifferent habitat can we come to the conclusion that there are “empty niches” and unlimited food resources. Absence of parasites is not evidence of the existence of empty niches. Niches can be “closed” by host reactions or even be non-existent.

There are infracommunities which consist of a large number of parasite individuals and which could be defined as “oversaturated” (Fig.2). These oversaturated infracommunities mask the saturation. Infracommunities consist of parasite species with different life strategies. Some parasites cannot complete their life cycle

in a fish and are “interested in” the host’s death and its availability to a predator. The others are not. 55% of oversaturated infracommunities had dominant parasites of the first group. Thus, such parasite species exert an important influence on the fate of an infracommunity. A rapid increase in parasite numbers corresponds to their life strategy. These oversaturated infracommunities have to have short life spans. In these cases parasites from the second group have little chance of completing their life cycles.

An analysis of relationships between the main three parameters of infracommunities was carried out. As Brillouin index and evenness are connected by formula their correlation is not discussed. Dominance index was significantly negatively correlated with

number of parasite species (S), evenness and Brillouin indices but not with number of parasite individuals. These correlations were found for fish ecological groups, and for most species of Salmonidae and Cyprinidae. Evenness index was positively correlated with S but not with N. The same relationship is characteristic for Brillouin index also. Thus, three main parameters of infracommunities demonstrate the usual relationships. When the number of species in the infracommunity increases, evenness and Brillouin index increases but dominance decreases. This is further evidence of the interactive nature of parasite infracommunities. The character of such interaction, presence or absence of competition between or within species, presence or absence of competition between or within guilds, needs further investigations.

Fundamental infracommunity features are: existence is restricted to the lifetime of an individual host; spatial distinctness; high rates of emigration and immigration; co-existence of species with different life strategies; habitat (host organism) reacts actively to the parasite; parasite infrapopulations cannot maintain their numbers by self-reproduction. These features clearly distinguish parasite infracommunities from communities of free-living animals. In this respect a parasite infracommunity is a "subcommunity" or "hemicommunity".

Summary

1. Analysis of infracommunity structure for separate fish species did not reveal any clear tendencies for main infracommunity parameters. The infracommunity looks stochastic and unpredictable.

2. The reasons for stochasticity are large numbers of hosts and diversity of interactions within different host-parasite systems.

3. Analysis of all infracommunities has demonstrated saturation and even oversaturation for parasite numbers; functional dependence between parasite species number and number of individuals; dependence of S and N on host size when host phylogenetic relationships were considered; clear correlations between main infracommunity parameters.

4. Being stochastic by nature infracommunities are sufficiently predictable and interactive.

References

- Holmes JC, Price PW. Communities of parasites. In: Anderson DJ, Kikkawa J, eds. *Community Ecology: Patterns and Processes*. Oxford: Blackwell Scientific Publications, 1986: 187-213
- Pugachev ON. Comparative analysis parasite communities of pike and minnow. In: Alimov AF, ed. *Ecological monitoring of parasites*. St. Petersburg: Zoological Institute RAS, 1997; 83-5 (In Russian)
- Simberloff D. Free-living communities and alimentary tract helminths: hypothesis and pattern analyses. In: Esch G, Bush A, Aho J, eds. *Parasite communities: Patterns and Processes*. London: Chapman and Hall, 1990: 289-319

WHAT DETERMINES THE LONGEVITY OF MAMMALIAN NEMATODES?

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The life of a nematode within its final host can conveniently be divided into two phases: the prepatency or developmental period, and the period the worm produces eggs or larvae – usually termed the patency period. As shown in Fig. 1, after entering the final host some nematode species mature in less than a week while others take more than a year to reach the reproductive phase. Once they have started to reproduce, some species will continue reproduction for years, while others burn out after a few days. Much of this variation in longevity could be related to different habitats or different hosts, but even among nematode species sharing the same organ within a single host species we find a staggering range in longevity. In the human gut, for example, *Enterobius vermicularis* has a life-span of about 60 days, while *Necator americanus* may live for more than 4 years.

To any biologist interested in evolution such variation begs the question: Why do different species, even when infecting the

same host and the same organ, live their lives so differently? Since all species are the result of past selection we must assume that both short- and long-lived nematode species are optimally adapted, but why is it optimal for a hookworm to hang on to the gut mucosa and keep producing eggs for years, but not for pinworms? Answering such question for individual species is likely to require detailed information about their basic biology, but we may gain some general insights by searching for patterns in this diversity, and by using a theoretical framework developed by evolutionary biologists.

Life history evolution

The theory of life history evolution is based on the simple idea that life consists of compromises (Stearns, 1992). Ideally, the optimal organism would start reproduction immediately after birth and produce an unlimited number of offspring forever. The rea-

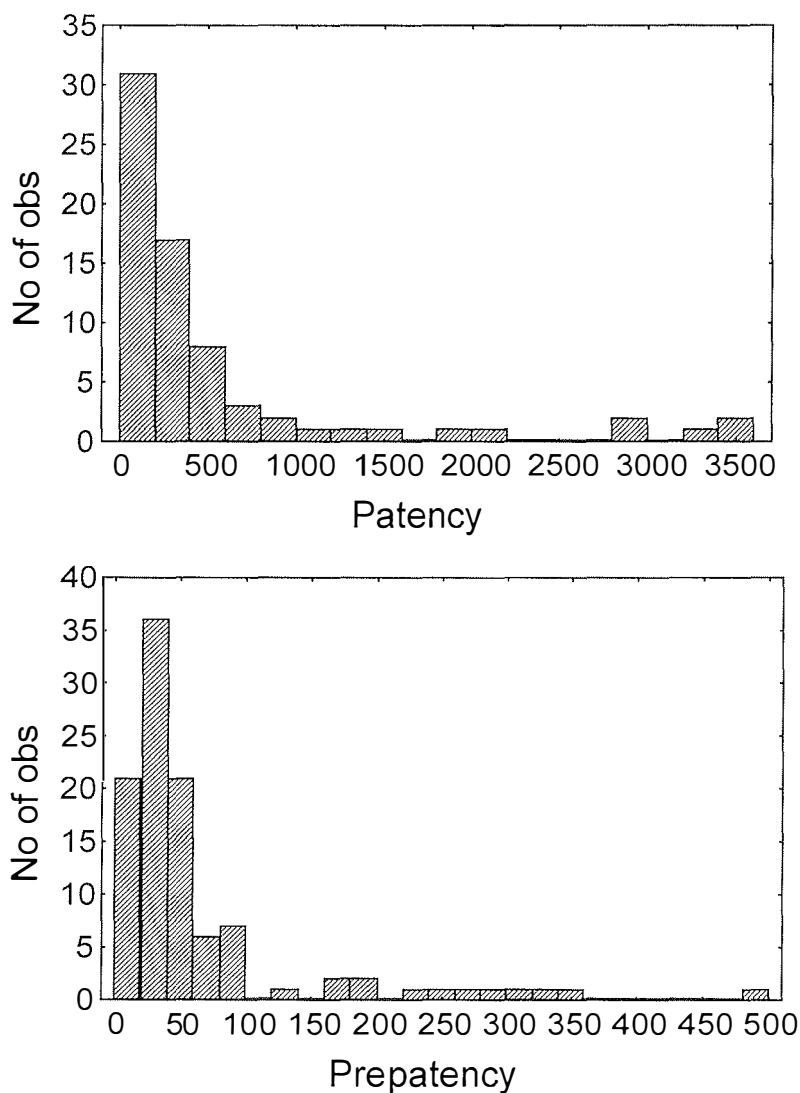


Fig. 1. Frequency distributions of prepatency and patency times of mammalian nematodes.

reason such "Darwinian demons" do not exist is because organisms are limited by energy and time. Spending more energy on reproduction leaves less for processes related to the maintenance of life, such as tissue repair. We would therefore expect long-lived organisms to have less available energy for reproduction per time than shorter-lived ones. In poikilothermic organisms there is usually an association between size and fecundity. Small indi-

viduals therefore are less fecund than larger ones. But reaching a certain size takes time. Higher fecundity must therefore be paid for by a longer developmental time.

The optimal way for an organism to mature and reproduce must depend on its ecological situation, or, more precisely, on the expected age- or stage-specific mortality. Many organisms,

including parasites, have distinct developmental stages in different habitats. In situations where juvenile mortality is low an individual could increase its fitness by prolonging its developmental time, increasing its body size and fecundity. If a change to bigger reproductive stages leads to higher adult mortality (for instance by increased predation or immune attack), we would also expect a shortening of adult life span. The opposite situation – high juvenile mortality – should select for a shorter developmental time. If this leads to lower adult mortality, fitness could be increased by prolonging the reproductive period. Although this theory claims to be general, it has mainly been applied and tested on relatively few taxa of free-living organisms.

Are trade-offs between life history traits different in parasites?

Is there anything about the parasitic mode of life that shape their life histories differently from free-living animals? Certainly many cestodes appear to come close to Darwinian demons with their enormous fecundity combined with a reproductive lifespan that may equal that of its host. Parasites are repeatedly referred to as extravagant reproducers with a significant higher egg-output than their freeliving relatives (e.g. Kennedy, 1975; Calow, 1983; Whittington, 1998), and Jennings & Calow (1975) suggested that parasites were more fecund because the host provides them with a stable environment and virtually unlimited food resources. However, the only study that has addressed this problem using many different species, and controlling for common ancestry, found no differences in reproductive capacity between parasitic and free living flatworms when body size was

controlled for (Trouve *et al.*, 1998). Certainly, the large variation in fecundity observed among different parasite species indicates that egg-production is traded off against some other traits related to fitness.

COMPARATIVE STUDIES IN NEMATODES OF MAMMALS

In nematodes the most important factor limiting the number of eggs a worm can produce appears to be its body size (Skorping *et al.*, 1991). Among intestinal nematodes of mammals the typically impressive daily output of hundreds of thousands of eggs per female only occurs among the larger species, such as *Ascaris* spp. The slope of the relationship between prepatency and body size is significantly higher than 1 indicating that the fecundity gain per time increases the longer the nematode stays in the prereproductive growth phase. Additionally, bigger nematodes tend to have a longer reproductive period (Fig. 2). Spending a long time in the prepatency phase therefore seems to give a nematode a twofold advantage – it becomes more fecund and will produce eggs for a longer time. Why then, are not all nematodes big, fecund and long-lived?

The cost of becoming big is a long developmental time (Fig. 2). This will increase generation time and also the risk of dying before ever reaching maturity. Apparently, this disadvantage is a strong constraint on how long a nematode can afford to keep growing – the majority of nematode species are relatively small (Poulin, Morand, 1997).

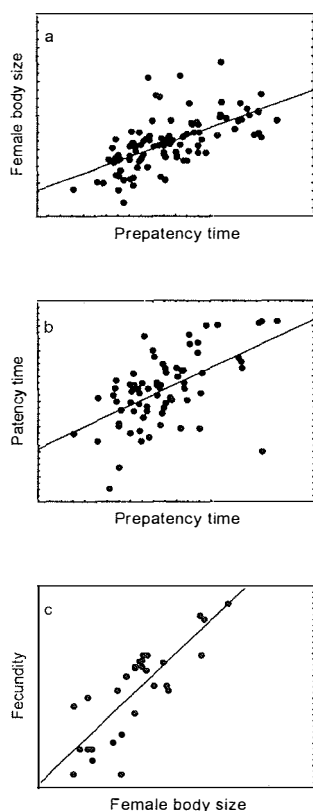


Fig. 2. Three important associations between mammalian nematode life history traits. Worms that take longer time to develop tend to be bigger (a), and have longer reproductive periods (b). Bigger worms also have higher fecundity (c). (After Skorping, Read & Keymer 1991)

One way a nematode can reduce the cost of having a big size, is to increase the rate of development. However, speeding up growth rate might increase the instantaneous death rate if more resources are allocated to growth rather than to processes related to avoiding immune defences. We have many reasons for assuming that immune defences differ both qualitatively and quantitatively in different parts of the vertebrate body (Read,

Skorping, 1995), suggesting growth rates might depend on the habitat for development. Indeed, comparing nematode species developing in the gastrointestinal system with species having a juvenile phase in other tissues, the latter group was found to have a highly significant larger size and higher growth rate (Read, Skorping, 1995).

If we assume that within a habitat there is a fixed optimal growth rate that can be attained, it has been hypothesised that the average mortality rate during development is a major determinant of how long a nematode can risk to stay in the developmental phase in order to increase growth (and fecundity). Gemmill *et al* (1999) developed a simple model assuming the optimal time of development for an intestinal nematode to be proportional to the inverse of juvenile mortality rate. The growth rate was estimated from the slope of the relationship between prepatency and body size, and juvenile mortality rate from experimental measures of prepatent period for a range of species, assuming a constant death rate. Although these assumptions are overly simple, the model fitted remarkably well with observed data.

THE ROLE OF HOSTS

Several authors have found a positive relationship between host and parasite body size (Harvey, Keymer, 1991; Morand *et al*, 1996; Sorci *et al*, 1997). Is this relationship mainly caused by lower mortality rates in bigger hosts, or because a larger host can provide more energy? Harvey, Keymer (1991), examining pinworms in primate hosts, found that host life

expectancy explained more of the variation in parasite size than host body size, a pattern which has been confirmed for a larger dataset on pinworms by Sorci *et al* (1997). We have argued elsewhere that variations in host longevity is unlikely to have much selective effect on maturation times of nematodes in mammals, because most nematodes species live within much shorter time scales than their hosts (Read *et al*, 2000). To a pinworm, developing within a couple of weeks, it cannot matter much whether the host lives for 5 or 15 years. By looking at all nematode species within mammals for which we have been able to find data (533 species), host body size explains much more of the variation in parasite body size (and therefore prepatency times) than host life expectancy (Skorping, Read in prep.). Nematodes therefore do become larger and have longer maturation times in bigger hosts, but this can not be explained by the fact that larger hosts have lower mortality rates.

EVOLUTIONARY EFFECTS OF ANTHELMINTICS

Nematodes in mammals are among the most important targets of the drug industry. If an anthelmintic increases the juvenile mortality rate, we would expect selection for faster, smaller, less fecund – and probably less virulent nematodes – according to the model developed by Gemmill *et al* (1999). Apparently, modern drug use should therefore have positive evolutionary consequences, in the sense that they will select for parasites that produce less disease. However, the selective effects of modern chemotherapy are not always this simple (Skorping, Read, 1998). Tissue-migrating nematodes in their larval phase

appear to be less susceptible to anthelmintics, than in their adult, intestinal phase. Continuous exposure to such stage-specific anthelmintics should therefore select for worms spending more time in the larval phase, and less time in the reproductive stage. This could lead to an increase in worm body size. Much of the pathology caused by this group of worms is associated with the tissue phase, so prolonging this stage is likely to lead to more virulent worms. In order to predict the long term consequences of chemotherapy, a better understanding of parasite life-history evolution is therefore crucial.

Parasite communities from single host individuals have one undoubted feature: the overwhelming majority of parasite infrapopulations cannot maintain their numbers by self-reproduction. These communities are rigorously defined spatially. The existence of an infracommunity is restricted to its individual host's lifetime. However, at this level parasites only interact or do not interact, compete or do not compete with each other, and either form or do not form guilds. As a result of these interactions isolationist or interactive communities are formed.

References

- Calow P. Pattern and paradox in parasite reproduction. *Parasitology* 1983; 86: 197-207
- Gemmill AW, Skorping A, Read AF. Optimal timing of first reproduction in parasitic nematodes. *J Evol Biol* 1999; 12: 1148-56
- Harvey PH, Keymer AE. Comparing life histories using phylogenies. *Phil Trans (Royal Society of London) B* 1991; 332: 31-9

Jennings JB, Calow P. The relationship between high fecundity and the evolution of entoparasitism. *Oecologia* 1975; 21: 109-15

Kennedy CR. Ecological animal parasitology. Oxford London Edinburgh Melbourne: Blackwell, 1975

Morand S, Legendre P, Gardner SL, Hugot JP. Body size evolution of oxyurid (Nematoda) parasites: the role of hosts. *Oecologia* 1996; 107: 274-82

Poulin R, Morand S. Parasite body size distributions: interpreting patterns of skewness. *Int J Parasitol* 1997; 27: 959-64

Read AF, Skorping A. The evolution of tissue migration by parasitic nematode larvae. *Parasitology* 1995; 111: 359-71

Read AF, Gemmill AW, Skorping A. Evolution of nematode life histories: theory meets reality? In Poulin R, Morand S, Skorping A, eds. *Evolutionary biology of host-parasite relationships: Theory meets reality*. Amsterdam: Elsevier, 2000: 237-46

Skorping A, Read AF, Keymer AE. Life history covariation in intestinal nematodes of mammals. *Oikos* 1991; 60: 365-72

Skorping A, Read AF. Drugs and parasites: global experiments in life history evolution. *Ecology Letters* 1998; 1: 10-2

Sorci G, Morand S, Hugot JP. Host-parasite coevolution: comparative evidence for covariation of life history traits in primates and oxyurid parasites. *Proc R Soc Lond.* 1997; 264: 285-9

Stearns SC. The evolution of life histories. Oxford: Oxford University Press 1992

Trouvé S, Sasal P, Jourdane J, Renaud F, Morand S. The evolution of life-history traits in parasitic and free-living platyhelminthes: a new perspective. *Oecologia* 1998; 115: 370-8

Whittington I. Reproduction and host-location among the parasitic platyhelminthes. *Int J for Parasitol* 1997; 27: 705-14

GETTING TO THE CORE OF THE PARASITE COMMUNITITES: SEPARATING REALITY FROM NOISE

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Introduction

There has been a wide-ranging debate on the factors determining species richness and predictability of parasite communities. Analyses of patterns and processes of parasite communities have often been made from published lists of host-parasite records without a thorough knowledge of each of the systems included and the methods involved in collecting the data. Recently, the effects of e.g. unequal sampling effort and the influence of host phylogeny on the analyses have been discussed (Gregory, Blackburn, 1991; Guegan, Kennedy, 1996; Poulin, 1995, 1997a,b). However, there are other possible confounding factors which may have an effect on the exchange patterns of parasites between hosts and thus the structure and predictability of the component communities of parasites. Factors that have not been previously addressed in this connection are the effect of ecological elements within each study area and the significance of the rare parasite species having scattered occurrences. On the other hand, it is known that scattered occurrences are not important in the

maintenance of the parasite population (Holmes *et al.*, 1977), and thus their role in the exchange patterns of parasites between hosts may be questioned. Applying equal sampling effort is important when comparing component communities of hosts in different areas. However, in the analysis of component communities of sympatric hosts within one area, the real relative abundance of hosts, which affect the sampling effort, are an important factor in determining the population densities of parasites and thus the exchange between hosts (Leong, Holmes, 1981). In this work we show how area specific ecological elements and scattered occurrences of parasites may mask or obscure the real patterns in exchange or sharing of parasites between 31 sympatric fish species.

Material, methods and study area

Our study system is located in the Bothnian Bay, the northeastern part of the Baltic Sea, the largest brackish

water area in the world. The Bothnian Bay is a unique open system which comprises components of both marine and freshwater origin on all trophic levels side by side. Most of the fish species occurring in the area are of freshwater origin, but the fish hosts also receive parasites from the marine part of the Baltic Sea. This has occurred via the marine fish species that have migrated into the area and established resident populations or via accidental visitors from the southern Baltic Sea. Our data comprises metazoan parasite records (excluding monogeneans) of 31 fish species, of which the common ones were collected during two years as monthly or bimonthly samples from the catches of commercial fishermen and additional samples were taken of the less common species. The relative proportions fish species studied were a good reflection of the actual fish species composition in the area. Newly caught fish were studied for metazoan parasites (excluding monogeneans) using standardized parasitological methods. Parasites that occurred in a host species with prevalence below 5% were considered as a scattered occurrence in that particular host. Scattered occurrences may be significant in the maintenance of a parasite population, however, if they accumulate in the food web either as larval stages from intermediate hosts to definitive hosts or as adult stages from a prey fish to a predatory fish (post-cyclic transmission). We based our evaluation of the accumulation of these scattered occurrences to predatory fishes within the fish community both on published data on the life-cycles of the parasites and their ability to undergo post-cyclic transmission and partly on detailed dietary analysis of the fish species studied (E.T.Valtonen, unpubl.).

Results and conclusions

Altogether, 63 parasite species were found in the 31 fish species studied from the Bothnian Bay (Valtonen, Pulkkinen, Julkunen, Poulin, unpubl.). The number of parasite species found in one fish varied from the minimum of 0 parasites in *Ammotides tobianus* to the maximum of 26 species in *Lota lota*. The host range of one parasite species varied from those found in only one host species, to generalist species, that were found from up to 25 fish species. Majority of the parasite species had only 1 to 4 hosts. 31% of the parasite species occurred at prevalence below 5% and 30% with prevalence between 5-10%, such that 61% of the host parasite records had prevalence below 10%. The numbers of the host-parasite records with a low prevalence ($< 5\%$) increased with the increase in the number of fish studied. The maximum prevalence of each parasite species in one host was usually much greater than the mean prevalence in all other infected hosts, indicating that most parasite species had one important host and several where they occurred at lower prevalence. This pattern applied both to host-specific parasites (1 to 4 hosts) and parasites which had 5 to 25 hosts. Altogether, 84% of the host-parasite records with low prevalence ($< 5\%$) consisted of parasite species that cannot accumulate in the food web, and which can thus be regarded as scattered occurrences in hosts that are not important for the maintenance of parasite population. These scattered occurrences form most of the noise that may disturb the observation of the important interactions between the component

communities of parasites in different hosts. Further on in this presentation we examine how the exchange pattern of parasites between hosts is altered when the scattered occurrences are omitted from the data. Diplostomid metacercariae in the eye of fishes comprised one third of all parasite specimens in the Bothnian Bay. Since these parasites occur in almost all hosts, they form a significant component of the parasite community that is shared between the hosts but since they are un-specific to any host, they form another component of the noise which prevents us seeing the structure of exchange of parasites between hosts. We also will show the effect of omitting “the diplostomid cover” on the exchange pattern of parasites. When all host-parasite records were taken into account, the number of other hosts with which each host shared any of its parasites was always high regardless of the number of parasites the host species harboured, indicating that even the fish species with a low number of parasite species shared generalist parasites with several other host species. However, when

the scattered occurrences and further also the diplostomids were omitted from the data, the numbers of other hosts that the parasites were shared with decreased considerably and it was revealed that the hosts with the highest number of parasite species generally also shared the highest number of parasites occurring at high prevalences (> 5%) with other hosts. When the sharing of the parasites was studied within and between the fish families that were presented with more than one species in the Bothnian Bay, it was seen that the families shared 10 to 17 parasites between other families, when all host-parasite records were taken into account. An exception to this was the Cyprinidae, which shared only 5 to 8 parasite species with other families (Table 1). When the scattered occurrences and diplostomids were omitted from the data, the number of species shared with other families was decreased in some cases to only one species and the highest number shared was found between Salmonidae and

Number of species in the family	Family							
		Salmonidae	Cyprinidae	Percidae	Gasterosteidae	Cottidae	Gadidae	Total
5	Salmonidae	5 (5)	7 (4) 2	13 (3) 1	11 (6) 4	10 (5) 3	15 (8) 7	26 (17) 15
6	Cyprinidae		7 (6)	7 (3) 1	8 (4) 2	5 (2) 1	8 (3) 2	15 (11) 9
2	Percidae			3 (5)	13 (4) 2	13 (4) 2	16 (6) 4	24 (13) 11
2	Gasterosteidae				6 (3)	9 (2) 1	17 (5) 3	25 (11) 9
2	Cottidae					0 (1)	12 (7) 5	17 (11) 9
2	Gadidae						3 (5)	30 (22) 21

Table 1. The number of parasite species shared within a fish family or between the families (the first number gives the shared species when all parasite occurrences were included, in brackets are the numbers of species shared when host-parasite records with a prevalence < 5% were omitted and the third number is the number of species shared when both the occurrences with a prevalences < 5 % and diplostomids (*Diplostomum spathaceum* and *Tylodelphus clavata*) were omitted)

Gadidae (7). However, the numbers of parasite species shared within a family did not decrease in most cases, they even increased when the scattered occurrences were omitted, showing that all families harboured parasites specific to the group that occurred at high prevalences only within a family. The fish species that shared the maximum number of parasite species between them were usually related species (e.g. among Coregonids, among Cyprinids), non-related species that shared similar food habits (e.g. *Esox lucius* and *Lota lota*) or were a predator and a prey (*L. lota* and several small fish species). When the scattered occurrences and diplostomids were omitted, the coregonids still shared the maximum number of parasites within the family, but in Cyprinidae the prevalent parasites were shared with several other fish, indicating that they harboured mostly generalist parasites.

References

- Gregory RD, Blackburn TM. Parasite prevalence and host sample size. *Parasitology Today* 1991; 7: 316-8
- Guegan J-F, Kennedy CR. Maximum local helminth parasite community richness in British freshwater fish: a test of the colonization time hypothesis. *Parasitology* 1993; 106: 91-100
- Holmes JC, Hobbs RP, Leong TS. Populations in perspective: community organization and regulation of parasite populations. In: Esch GW, ed. *Regulations of Parasite Populations*. Academic Press. New York 1977: 209-45
- Leong TS, Holmes JC. Communities of meta-zoan parasites in open water fishes of Cold Lake, Alberta. *J Fish Biol* 1981; 18: 693-713
- Poulin R. Phylogeny, ecology, and the richness of parasite communities in vertebrates. *Ecol Monogr* 1995; 65: 283-302
- Poulin R. Parasite faunas of freshwater fish: the relationship between richness and the specificity of parasites. *Int J Parasitol* 1997a; 27: 1091-8
- Poulin R. Species richness of parasite assemblages: Evolution and patterns. *Annual Reviews of Ecology and Systematics* 1997b; 28: 341-58

SUBMITTED PAPERS- ORAL PRESENTATIONS

SIGNIFICANCE OF THE AMOEBOCYTE-PRODUCING ORGAN OF *BIOMPHALARIA GLABRATA* SNAILS (STRAINS SELECTED FOR SUSCEPTIBILITY/RESISTANCE) IN CELLULAR RESPONSE TO *ECHINOSTOMA CAPRONI* MOTHER SPOROCYST INFECTION

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The dynamics of haemocyte encapsulation of *Echinostoma caproni* mother sporocysts (MS) in a resistant strain of *Biomphalaria glabrata* snails was investigated previously (Ataev, Coustau, 1999). The result of further research was the determination of the role of the snail's amebocyte-producing "organ" (APO) in this process and the collection of information on the cellular response to sporocyst early development. The first signs of a cellular response to *Echinostoma caproni* MS in susceptible and resistant strains of *Biomphalaria glabrata* snails were observed several hours after infection. This reaction is usually manifested by insignificant infiltration of small parenchymatous lacunas by haemocytes. Sometimes one could see large aggre-

gations of haemolymph cells around sporocysts. Haemocytes from surrounding tissues take part only in such local heart formation. However, real capsules are not formed and MS retain their ability to complete their migration to the heart of the snail (Ataev, 1998).

In addition, MS penetration activates APO situated between the pericardium and mantle epithelium. Therefore, rapid increase in the number of haemolymph haemocytes is observed in snails of both strains after approximately one day of infection (Ataev, Coustau, 1999). But MS encapsulation occurs in a resistant strain at 3-4 days post-exposure (PE) only. The result of this is MS death at 5-7 days PE, by which time APO reaches a full development. Haemocytes safely isolate disintegrated sporocyst remains and dead amebocytes in the centre of the capsule. The decrease in APO activity in resistant snails was noted at 10 days PE. After 15 days of infection there will be neither capsules nor agglutinations (haemocyte accumulation not observed in MS location). Snails remained viable throughout the experiment.

APO stays in active condition in susceptible snails. However, haemocytes do not encapsulate MS, and they become adherent in agglutinations.

The observed variations of resistant snails for single species are probably some of the reasons for local differences of host infection in natural populations.

THE MAIN FEATURES AND FACTORS LIMITING METAZOAN PARASITE COMMUNITIES IN FISH OF THE BALTIC SEA (LITHUANIAN COASTAL ZONE) AND CURONIAN LAGOON

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Parasite communities found in fresh and brackish water fish species are different in their origin and structure as well as in their patterns of seasonal and spatial variation.

I have tried to summarize both literature and my own data on brackish and freshwater fish and parasite systems. Fish biology, population structure, feeding habits, distribution of fish belonging to different trophic groups (nine each from Baltic and Curonian Lagoon) as well as developmental cycles, population structure and biodiversity of parasites and their intermediate hosts, were analyzed.

Both brackish and fresh waters were dominated by generalist (nonspecific) fish parasites with developmental cycles including more than one intermediate stage. Biodiversity of parasite species in fresh water was found to be higher than in the brackish Baltic Sea (63/13). In brackish waters the greatest number of species belonged to the following taxa: Acanthocephala (5), Nematoda (3) and Cestoda (3), while in fresh water they belonged to Trematoda (20), Monogenea (20), Cestoda (10), Nematoda (6), Acanthocephala (2) and Crustacea (2). Intermediate hosts of fish parasites in fresh water were Bivalvia (3), Gastropoda (5), Insecta (3), Crustacea (3) and Pisces (3), while in brackish water they were Crustacea (3), Gastropoda (2), Oligochaeta (1) and Pisces (2). Fish with

macroparasite infestations correlated with fish age (body length), feeding habits (consecutive change of trophic niches) and migration. Macroparasite diversities and abundances within any particular fish trophic group were found to be similar. The highest degree of parasite diversity and infestation was found among benthophagous fish.

We have also observed several variations in parasite diversity, abundance and dominating patterns of these (prevalence of *Cucullaneus minutus* and *Argulus foliaceus* during the summer, glochidians of Anodontids in early spring, and *Cucullaneus heterochous* in winter - spring). During summer and autumn in the sea coastal zone near the estuary of the Curonian Lagoon several freshwater fish metazoan parasites (Digenean, *Diplozoon* sp., *Ergasilus sieboldi*, *Argulus foliaceus*, *Pradilepus scolecina*, *Proteocephalus* sp., *Philometra* sp., *Camallanus lacustris*, etc.) were found, but these could not complete their entire life cycle in this environment and were counted as individuals eliminated from parasitic systems.

Neither enzooses nor noticeable pathology to fish organs were observed. All parasites found were of univoltic (in brackish and fresh water) or bivoltic (in fresh water) developmental types.

The main factors limiting biodiversity of parasites and their intermediate hosts are considered to be salinity, temperature, and bottom type.

THE COMMUNITY OF MYXOSPOREA FROM THE KIDNEY OF THE ROACH *Rutilus rutilus lacustris*

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Objective: To investigate the community of Myxosporea from the kidney of the roach *Rutilus rutilus lacustris* in the Chivirkuiyski Bay of Lake Baikal in January through August 1999.

Materials and Methods: Counting of the myxosporean vegetative stages in the tissue of the kidney was done according to Roitman (1997).

Results: The kidney of roach is infected with four species of Myxosporea. The prevalence of infection by *Myxidium rhodei* was 98.48 %, *Myxobolus ellipsoides* 47.94 %, *Myxobolus mulleri* 42.52 % and *Henneguya cutanea* 9.52 %. These species formed 16 combinations: single species infections - 4, two species - 6, three species - 5, four species - 1.

Conclusion: The absolutely predominant species in the community of Myxosporea from the kidney of *Rutilus rutilus lacustris* is *M. rhodei*. The correlation of one, two, three and four species combinations changes during the whole year and probably depends on seasonal infection dynamics of some species.

COMPARISON OF IMMUNE RESPONSE MECHANISMS IN RAINBOW TROUT AGAINST GYRODACTYLIDS AND CILIATES

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Objective: Characterization and comparison of immune response mechanisms in rainbow trout (*Oncorhynchus mykiss*) following infections with monogeneans (*Gyrodactylus derjavini*) or ciliates (*Ichthyophthirius multifiliis*).

Materials and Methods: Various techniques for the study of fish immune mechanisms (cellular and humoral) were applied for characterization of the responses in the fish towards the ectoparasitic *Gyrodactylus derjavini* and the epidermis invading ciliate *Ichthyophthirius multifiliis*.

Results: It was found that specific antibody titres rose significantly following infection with *Ichthyophthirius multifiliis*. In contrast no binding of specific immunoglobulins to the monogenean was detected. The alternative complement cascade was in both cases found to affect the parasites significantly. Cellular reactions (oxidative burst reactions of macrophages) were also activated by both parasite species. In addition, putative mastcells (metachromatic thionin-positive cells) in the skin were seen to degranulate as a reaction to infection with both ciliates and gyrodactylids. Mucous cell densities in the fish skin were affected differently by the two parasites but activity of lymphocytes may be involved in both reactions. The non-specific reactions may play a part in the host response and it was found that fish protected against gyrodac-

tylids showed a partial resistance to infections with *Ichthyophthirius multifiliis*.

Conclusions: The immune response mechanisms involved in the acquired resistance of rainbow trout towards *Ichthyophthirius multifiliis* is relatively specific compared to the reactions against *Gyrodactylus derjavini*. However, both specific and non-specific elements play a role in the response towards both species.

PARASITIC GASTROENTERITIS OF CATTLE IN SWEDEN: IMPORTANCE OF THE ECOLOGY OF THE FREE-LIVING STAGES

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Objective: Typically throughout Europe, overwintered populations of free-living stages of nematode parasites of cattle are small. However, these are a very important source of infection to animals following turnout, whereas the following generations are responsible for production loss and clinical disease. In Sweden, outbreaks of clinical parasitism have been reported within one month following turnout. What is the reason for this difference? This study was aimed at providing information on this important ecological question.

Materials and Methods: A pasture plot study was conducted, whereby 12 artificial 400g dung pats derived from naturally parasitized young cattle, were deposited on seven occasions at three-weekly intervals throughout the 1997 grazing season. Half the pats were protected from snow cover. The following spring, pasture and soil samples were taken for infective larval recovery from a 28 cm circular area centred over the deposited dung pats.

Results: Larvae from pasture and soil were recorded on all deposition occasions. The highest recovery was from the mid third of the grazing season, both relative to egg count and in absolute numbers. Larvae were also found in soil.

Conclusion: Faecal contamination throughout the grazing period contributes to the overwintered larval population under Swedish conditions. However contamination early in the previous season is relatively more important in contributing to these larval numbers. Soil can also act as a significant reservoir. Because the period of snow cover was limited and transient during the period of this study, the purported "buffering" effect from extended snow cover, resulting in enhanced survival of parasitic free living stages, could not be ascertained.

Acknowledgement: This work was financially supported by the Swedish Council for Forestry and Agricultural Research (SJFR).

HOST SPECIFICITY AND DISPERSAL STRATEGY OF GYRODACTYLIDS IN THE BLACK SEA COASTAL BIOCOENOSIS

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Objective: Two parasite systems were studied: *Gyrodactylus* sp. 2 (G.s.2) with one host species (*Blennius sphinx* (B.s.)), and *Gyrodactylus* sp. 1 (G.s.1) with eleven host species (excluding B.s.).

Aims: 1). To show the role of host specificity of two gyrodactylid species and their occurrence in the environment; 2). To deter-

mine the mechanisms and means of dispersal of gyrodactylids in the biocoenosis.

Results: The data were obtained as result of laboratory experiments. Individuals of *G.s.2* were detached during several hours after they were transferred to fish species other than *B.s.* Individuals of *G.s.1* survived, but did not reproduce, during 5-10 days after they were transferred to *B.s.* and other fish species from their natural host range. All detached specimens of *G.s.2* were found at the bottom and on the walls of the aquarium, in contrast to *G.s.1* which preferred macrophytes (80 % - on macrophytes and 20 % - at the bottom). 72 % of *G.s.2* specimens transferred to uninfected hosts had functioning male reproductive systems and 28% had also empty uteri. Taking into consideration that the worms belonging to this ontogenetic stage account for only 5% of a gyrodactylid population (Harris, 1985), their high proportion among migrating gyrodactylids shows that such specimens migrate more actively.

Conclusion: Gyrodactylid transmission is realized mainly by specimens with functioning male systems, full formation of which may be a migration behavioural trigger. Specimens of *G.s.2* infect suitable hosts due to genetic specificity and host behaviour. Detached worms move on the substrate, which conforms to the behaviour of hosts preferring to lie on parts of substrate without macrophytes. Specimens of *G.s.1* can apparently use a wide range of transport hosts and macrophytes for transfer.

ISOSPORA (PROTOZOA, SPOROZOA) INFECTION IN PASSERINE BIRDS OF VARIOUS FEEDING HABITS

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Objective: *Isoospora* infects a new host via occasional swallowing of oocysts that appear in bird's faeces. Thus, the diet of the bird can influence its chances to become infected by *Isoospora*.

Materials and Methods: In total 1131 birds of 47 passerine species were trapped in summer and autumn after 2 p.m. at the Baltic Sea coast (Curonian Spit) and the North Sea (Helgoland Island). Faecal samples of every bird were examined for *Isoospora* oocysts. The number of oocysts in every faecal sample was counted after flotation centrifuging by standard method. Bird species were divided into four groups, according to their feeding habits.

Results: Both prevalence of infection (% of infected birds) and infection rate (C =number of oocysts per sample) increase together: birds catching insects in the air (5%, $C=3$), collecting insects from leafs and sprouts (55%, $C=147$), including berries into diet (72%, $C=730$), and feeding on the ground (76%, $C=3879$). The difference between the first and the last feeding group is significant.

Conclusions: The probability of transferring oocysts is reduced if the bird catches insects in the air, but picking insects from leaves increases it. Berries attract many birds which get a chance to swallow oocysts in faeces that cover berries. Feeding on humid ground gives an opportunity for *Isoospora* infection because bird droppings

accumulate there and oocysts can survive there longer.

PARASITE COMMUNITY STRUCTURE AS AN INDEX OF ENVIRONMENTAL CONDITIONS

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Objective: Parasites create a community by taking part in certain relationships, including quantitative. That the existence of a certain parasite community structure is determined by the biomass of specific species was shown for *Phoxinus phoxinus*. Does this structure remain the same in individual reservoirs and how does it react to environmental conditions?

Materials and Methods: The present work has been performed on the basis of the parasite fauna of fish from the reservoirs of the north-eastern part of European Russia. The combination and conditional biomass of species are taken as the characteristics of the community.

Results: In ecologically pure reservoirs, and in parts of them, and in the areas which are not heavily polluted, three groups of parasites have been identified in the parasite community of all host species researched. The logarithms of their conditional biomass lie on line segments separated by gaps, and having different slope angles. As the reservoir is polluted and the biocoenosis degrades, species not typical of the community structure appear (points of their conditional biomass do not lie on a line segment). Then the groups are divided into subgroups, and, finally, in greatly polluted reservoirs, the number of groups of parasites decreases from three to two.

Conclusion: It is obvious that the character of change of the community does not depend on the type of polluting substance. It is determined by the level of pollutant influence on the reservoir and the degree of biocoenosis degradation.

PARASITOLOGICAL MONITORING IN EVACUATION ZONE NEAR CHERNOBYL NPP

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Objective: Parasitological monitoring in the evacuation zone near Chernobyl Nuclear Power Plant was undertaken for the purpose of improvement of sanitary conditions in the territory of Polesky radio-ecological reserve and of the state of health of the staff of the reserve.

Materials and Methods: The parasitic arthropods of 697 birds and 367 bird nests were studied.

Results: Positive dynamics of an increase in the numbers of *Ixodes ricinus* L. were recorded. The prevalence of tick infestation of the birds was 1.5-2.0 times higher than on the control territory. A large number of parasitic arthropods were found in the nests (ticks fam. Dermanyssidae, Laelaptidae, fleas, bugs).

Conclusion: The location of the populated area near the evacuation zone in conjunction with the presence of the foci of tick-borne encephalitis and tick-borne Lyme borreliosis necessitate conducting regular annual epidemic controls on this territory.

THE EEL SWIMBLADDER NEMATODE *ANGUILLICOLA CRASSUS* (NEMATODA: DRACUNCULOIDEA) IN IRISH EELS

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Objectives: The Erne lake system is the fourth largest catchment in Ireland supporting an important commercial eel fishery. *Anguillicola crassus* was first documented here in 1998 during investigations by the Erne Eel Enhancement Programme into eel population structures. Analysis has continued in order to monitor changes in prevalence, intensity and parasite distribution.

Materials and Methods: In 1998 the swimbladders from 372 eels (328 yellow and 44 silver) from various lakes within the Erne catchment were examined for *A. crassus*. Total worm burdens were recorded. This process was repeated in 1999 analysing 658 eels (432 yellow and 226 silver). Lakes examined in 1998 were re-examined in 1999 in addition to several lakes not surveyed before.

Results: In 1998 prevalence in yellow eels for the catchment was 7.3 % and mean intensity 4.3. In silver eels prevalence was 4.5 % and mean intensity 2.5. The parasite was not distributed throughout the entire catchment but was confined to several localities in the northern half. In 1999 the range of the parasite had increased, moving further upstream and downstream. Prevalence in yellow eels had risen to 10% and there was an increase in mean intensity to 6.7. Likewise, in silver eels there was an

increased prevalence (15%) and mean intensity (8.6).

Conclusion: *A. crassus* is firmly established in the Erne. Within this catchment it has become more widely distributed by utilizing the migratory behaviour of eels. Moreover, with the commercial movement of live eels from the Erne, further reports of this parasite within Ireland are anticipated.

FISH ANISAKIDAE IN KHUZESTAN PROVINCE OF SOUTH WEST IRAN

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Objective: Fishes, including *Barbus* spp., *Cyprinus carpio*, *Liza abu*, *Aspius vorax*, have a very important role in the economic condition of rural areas of Khuzestan province. These fishes are consumed barbecued or roasted. These inadequately cooked fishes could serve as a source of infection in these communities.

Material and Methods: For these reasons 283 fishes were caught from four lagoons (Hooral Azim, Shadegan, Al Hai, Seid naser) and transported live to a health research centre and their intestine, body cavity and muscle examined carefully.

Results: In 20.8% of fishes, infections with *Contracaecum* sp. (Anisakidae) and/or *Rhabdochona* sp. (probably *R. denudata*) were found. These results suggested that human anisakiosis could be a medical problem in this area.

THE ECOLOGY OF IXODIDAE TICKS IN NOVGOROD FOREST REGION UNDER THE CONDITION OF ANTHROPOGENIC LOADING

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The problem of tick ecology relates to the studying of several different aspects connected with anthropogenic loading of the environment. Firstly, at the end of the XX century global changes in the biosphere, as a result of intensive economic activity, can be clearly seen, and this affects climate change. It is known (Pomerantsev, 1935;) that the Ixodidae ticks are rather sensitive to changes in abiotic factors (temperature, soil humidity and forest litter).

Anthropogenic interference in natural complexes, especially industrial deforestation, shrubbery, low forest stubbing, etc., improve natural landscapes. The change of forest biocoenosis into clarified agrocoenosis is the main feature in changing the ecological situation for Ixodidae ticks.

Accumulation of heavy metals in soil, nitrogen through the use of mineral fertilizers, electromagnetic radiation, heavy traffic and other factors influence the physiology, the survival rate and the numbers of ticks.

During the last three years in Novgorod Region, experimental investigations of tick (*Ixodes persulcatus*) populations were carried out in forest areas treated with mineral fertilizers in the village of Lesnaya, with simultaneous control in the identical biotopes of the village of Golino. The experiments were also held in laboratories. We considered that mineral fertilizers could influence the development and the survival rate of larvae of *Ixodes persulcatus*.

In Novgorod Region before the drainage of agricultural fields on vast territories there was a stubbing of shrubbery and low forest which led to the decrease of biotopes for setting of *I. ricinus* ticks and their.

So, anthropogenic factors are the main ones in the change of environment for the setting and activity of Ixodidae ticks.

COMPARATIVE ANALYSIS OF THE MONOGENEAN FAUNAS OF THE BLACK AND BALTIC SEAS

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Objective: The specific aim of this research was to analyse the composition of monogenean faunas from two different seas having similar hydrochemical conditions, namely the Black and Baltic Seas.

Materials and Methods: Authors' own and literature data on monogenean faunas from the Black and Baltic Seas were used.

Results: The monogenean fauna of the Black Sea (38 species) is much richer than that from the Baltic Sea (15). The latter fauna is mainly represented by boreal species and has no endemic species. The Black Sea monogenean fauna is represented by Mediterranean invaders (30%), boreal-Atlantic species (30%), endemic species (20%) and includes small groups of cosmopolitan species and ponto-caspian relicts. Only five from 15 Black Sea species which occur in northern latitudes are also found in the Baltic Sea: *Nitzschia sturionis*, *Gyrodactylus arcuatus*, *G. pungitii*, *G. flesi* and *G. harengi*. The first-named species is a specific parasite of sturgeons and penetrates into the seas with their hosts from river

systems. The following two species are specific parasites of sticklebacks and apparently occur over all the distribution of their hosts. Despite the wide distribution of the fish host of *G. flesi*, namely *Platichthys flesus*, this monogenean species was found only in the Baltic, White and Black Seas. *G. harengi* parasitizes the herring in the Baltic, White and Black Seas and in the northern part of the Pacific Ocean. According to Malmberg (1970), three subspecies of *Clupea harengus* are parasitized with three different species of *Gyrodactylus*. *G. flesi* and *G. harengi* apparently have penetrated into the Black Sea during river floods in the anthropogenic period. The last 10 species are typical marine monogeneans, the distribution of which is restricted to a salinity of not less than 15‰.

The present status of the Baltic Sea was formed approximately four thousand years ago, thus it is only half as old as the Black Sea. Its fauna can be enriched as was that of the Black Sea, which continues to be extended by species from the Mediterranean Sea.

Conclusion: The results of this survey are discussed in relation to the geological history and ecological conditions of these two seas.

«CORE AND SATELLITE» HYPOTHESIS: AN EXAMPLE FROM FISH PARASITE COMMUNITIES

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Objective: "Core and satellite" hypothesis was tested on fish parasite populations according to the empirical relationship

between the local abundance of a species and its regional distribution.

Materials and Methods: 122 chubs (*Leuciscus cephalus*) were caught by backpack electrofishing from March to October 1998 in 13 water courses (northern Italy). Parasites were collected from gut, eyes and gills and identified to species level. The level of parasitic infestation was analysed for each species, using prevalence, intensity, mean intensity and abundance.

Results: 12 parasite species were identified: Platyhelminthes: *Dactylogyrus vistulae*, *Paradiplozoon ergensi*, *Allocreadium isoporum*, *Bucephalus polymorphus*, *Diplostomum spathaceum*, *Tylodelphys clavata*, *Proteocephalus torulosus*; Nematoda: *Rhabdochona demudata*; Acanthocephala: *Acanthocephalus anguillae* and *Pomphorhynchus laevis*; Crustacea: *Lamproglana pulchella*; Mollusca: glochidia.

Mean parasite abundance, log transformed, and number of infected fish shown a significant correlation (Spearman rank correlation $r=0.66$, $p<0.005$). At each level of community scale a positive correlation between abundance and regional distribution was observed.

Conclusion: The results allow us to classify *P. laevis* and *D. vistulae* within the core species group, *A. anguillae* and *A. isoporum* as secondary species, and all the remaining parasites as satellite species.

DIVERSITY OF FISH PARASITES IN RELATION TO ENVIRONMENTAL STRESS

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Objective: A comparison of three different levels of parasite-host systems (e.g. parasite individual, population and community) has been performed to assess the use of parasites as indicators of environmental stress.

Material and Methods: The current infracommunity and component community approach using different biodiversity measures (e.g. species abundance models, Q - statistics) of various parasite assemblages was used.

Results: An apparent decrease in parasite species richness and an increase in the homogeneity of parasite distribution within the population of the model host fish (*Leuciscus cephalus*) was found, corresponding to the levels of contamination of the river bottom sediment and the bioaccumulation of selected pollutants in individual host fish.

Conclusion: This contribution represents an attempt to compare and analyse, on a precise current statistical basis, the relationships among composition and structure of parasite communities (infracommunity and component community levels) with respect to the level of bioaccumulation of pollutants by individual fish host and to the level of contamination of river bottom sediments.

COMMUNITY ECOLOGY OF THREE DIFFERENT MONOGENEAN PARASITE-HOST SYSTEMS

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Objective: Three different monogenean parasite-host systems were investigated to analyse aggregation, coexistence and competition among potentially competing parasites.

Material and Methods: Current methods of ecological and evolutionary parasitology (e.g. nestedness analysis, aggregation model of coexistence, parsimony analysis) were used.

Results: A nested pattern was recorded in parasite assemblages of minnow, the host with a dominant number of specialist gyrodactylids. A non-nested pattern was observed in gyrodactylid assemblages of roach, the host with a dominant number of generalists. Comparative analysis of dactylogyrid coexistence showed that parasite abundance is positively correlated with niche breadth. A parsimony analysis of the evolution of the parasite gill distribution indicates a change in one parameter of the niche at each branching event. Inter- and intra-specific competition between two monogeneans, *Eudiplozoon nipponicum* and *Dactylogyrus extensus*, parasitic on the gills of carp (*Cyprinus carpio*), were investigated.

Conclusion: There is no doubt that monogenean parasites represent a perspective model for investigation of parasite aggregation, competition and coexistence.

SPECIES LIFE CYCLE, DEVELOPMENTAL CYCLE AND LIFE SCHEME IN PARASITOLOGY (DEFINITION AND CORRELATION OF TERMS)

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Life cycle (LC) is the term defined as the system of adaptations ensuring continuous species existence in space and time and applicable only to the species as a whole. The LC is based on the principle of "reproduction of similar not directly, but through a more or less long chain of non-similarity". In other words, the LC is the sequence of events which are necessary and sufficient for species preservation. Thus realization of the LC is the form of species existence, and the notion of the LC proper is basic and universal, at least for all eukaryotes including parasitic species.

Life cycles of exact species could be examined through two aspects.

The morphogenetic aspect reflects the realization of a genetically determined consecutive developmental programme peculiar to this species; that is morphogenesis as such, independently from the exact environment of its realization.

The term developmental cycle corresponds to the essence of this aspect (the morphogenetic aspect of the LC), recognized as the ontogenetic complex of all generations that compose the species LC.

This aspect is not a subject of parasitology as an ecological discipline.

The ecological aspect reflects the adaption of the LC to the exact environment. The notion of the species life scheme (Beklemishev, 1957) corresponds to this aspect most

accurately. It can be distinguished as the way of LC realization in specific environments. Thus the life scheme is the ecological aspect of the LC understood as the complex of all life forms constituting it.

This aspect is particularly a subject of parasitology.

A STUDY OF THE PARASITE FAUNA OF *PHOXINUS PHOXINUS* L. FROM THE SMALL RIVERS OF NORTHERN DVINA BASIN

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Objective: The parasite fauna of *Phoxinus phoxinus* L. from small rivers of the Northern Dvina basin and seasonal dynamics of infection were investigated.

Materials and Methods: Two hundred and fifty-seven fish specimens were caught from the small rivers of Vychegda basin in the vicinity of Syktyvkar in 1996-1999. The examination of material was carried out by the method of total parasitological dissection.

Results: Twenty-two parasite species belonging to six classes were recovered from *P. phoxinus* during the research period. The following species were found for the first time in *P. phoxinus* from the Northern Dvina River basin: *Apiosoma piscicolum* ssp. *perci*, *Myxidium rhodei*, *Myxobolus muelleri*, *M. musculi*, *M. albovae*, *Dactylogyrus borealis*, *Pellucidhaptor merus*, *Gyrodactylus magnificus*, *G. minimus*, *G. laevis*. It was shown that the minnow parasite fauna from the River Chovju (20 species) and from the River Kyltymju (18 species) differ only in their rarely occurring species. The parasite fauna of *P. phoxinus* is considerably impoverished in the River

Dyrnos (eight species). Seasonal changes in the infection rate in the River Chovju and River Kyltymju showed a general regularity: the majority of parasites increase in numbers during May through June, and common features are determined by a number of factors: hydrological, hydrobiological and anthropogenic.

Conclusion: The available data allow us to conclude that the River Chovju and River Kyltymju are subject to anthropogenic eutrophication, and the River Dyrnos is characterized by an extremely high rate of pollution.

EXPLOITATION OF GASTROPODS BY TREMATODES: HOST MORPHOLOGY AND PARASITE STRATEGY

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Objective: Morpho-functional patterns of pathogenesis in various mollusc - trematode combinations are very different. To evaluate the level of antagonism between the host and parasite it is reasonable to use a summarized parameter of the general physiological state of the infected individual.

Materials and Methods: Analysis of host growth rate following infection and patterns of histopathological modification was used in this study. A comparative analysis was conducted of original and literature data on 40 snail - trematode combinations.

Results: Growth response to infection depends on the life history of the mollusc. Growth acceleration (gigantism) is common for snails with intermediate longevity (3-4 yr) – Rissoacea (Prosobranchia). Gigantism

is only observed as an exception in short-lived species, which generally do not change growth rate when parasitized – Basommatophora (Pulmonata). The only trend manifested in infected long-lived species (6-27 yr) – Littorinacea and Cerithiacea (Prosobranchia) – is a decrease in growth rate. The morpho-functional distinctions in the systems formed by trematodes and molluscs from different taxa are expressed in the pattern of parthenitae localization in the host body and in the degree of digestive gland and/or gonad destruction.

Conclusions: Snail species from different taxa are not even in terms of the living space «granted» to the parasite without risk of host viability reduction. Hypothetically, an «equilibrium» exploitation strategy is favoured in long-lived hosts which may be viewed as a stable environment with low variation in habitat quality. Trematodes parasiting shorter lived hosts may use an «opportunistic» strategy which maximizes the exploiting capability in environments that change frequently on a relatively small temporal scale.

PARASITIC SYSTEMS OF TREMATODES AND THE MECHANISMS OF THEIR REGULATION

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A parasitic system is a complex of population systems of hosts, united by the population system of the parasite on the basis of stable parasite-host community relationships. The structures of parasitic systems are highly variable. However there are two general aspects of their organization: a)

depending on the specific life cycle peculiarities of the parasite; b) depending on the environmental subdivision of the parasite. Correspondingly, we can separate meta- and para- aspects of the structure of a parasitic system.

Mechanisms which lead to the stability of parasitic systems of trematodes were considered. The investigation was carried out in two regions of the White Sea (Kandalaksha Bay, Russia) and one of the North Sea (Skagerrak, Sweden). Populations of marine littoral molluscs and their trematode parasites were examined.

The specific regulatory mechanisms in the parasitic systems may be considered on two levels at least (of the systems of different «scale»).

1. The level of host and parasite populations. The population of separate mollusc species interacts with the hemipopulation group of trematodes (i.e. individuals of one stage of their life cycle). Severe prevalence may deform various ecological, behavioural and demographic characteristics of the mollusc population. However, the persistence of the host population under conditions of heavy infection suggests the presence of mechanisms that compensate for the influence of the parasites.

2. The level of the parasitic system. The distribution of the trematode hemipopulation over several host species (paraxenia) appears to be an important possibility for regulation of the parasitic system (paraxenic regulation). Other essential mechanisms at this level are metaxenic regulations of the parasitic system. That is the possibility to change the «flow» of parasites through the successive (metaxenic) hosts, which are used by successive stages of the life cycle of the parasite.

POPULATION DYNAMICS OF *ARGULUS COREGONI* THORELL (CRUSTACEA: BRANCHIURA)

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Argulus coregoni is a free-swimming, obligate ectoparasite of fishes. After copulation they leave their fish hosts in order to deposit eggs on hard substrata. Ectoparasites from boreal regions face a severe and long winter when their populations are suppressed. It has been suggested that *Argulus* eggs can rest throughout winter and hatch next summer having 2-3 generations in a year.

Objectives: To describe *A. coregoni* population rhythms in a fish farm during summer: number of generations, hatching rhythms, hatching duration and the influence of drying and temperature on hatching.

Materials and Methods: The size and sex structure of the *A. coregoni* population was monitored weekly in a fish farm in Central Finland during the open water period in 1999. Overwintering eggs were collected in September and kept at a steady temperature in the laboratory to study their hatching dynamics after different treatments.

Results: Results indicate that *A. coregoni* overwinter as eggs and there might be only one generation in a year. However the hatching of eggs is very prolonged. Drying in all treatment combinations and freezing at -18°C for 12 days killed all the *A. coregoni* eggs. After other treatments (+ 4°C, + 10°C and normal winter temperature with fluctuations) juveniles were still able to hatch. The stones with *A. coregoni* eggs produced

juveniles continuously from November to March.

Conclusion: After the ice cover period, overwintered eggs will hatch synchronously. First *A. coregoni* females mature and lay eggs in late June in Finland. During the summer newly hatched juveniles appear from overwintered eggs continuously as new females mature and lay eggs. We suggest that eggs, laid at any time in the summer, will hatch only after winter in the following summer. This is why we suggest the occurrence of only one generation with a long annual recruitment time. This however needs experimental verification.

A SEROEPIDEMIOLOGICAL SURVEY OF *DICTYOCAULUS VIVIPARUS*, LUNGWORM INFECTION OF CATTLE IN SWEDEN

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Objective: To investigate the seroprevalence of *Dictyocaulus viviparus* infection in Swedish cattle, with particular emphasis on the role of adult cattle as silent carriers.

Material and Methods: This survey was carried out in 1999 in 10 herds which had a history of dictyocaulosis in 1998. Accordingly, some animals on each of the farms were treated either with ivermectin, morantel or febantel. Nevertheless, all cattle that had been on pasture during 1998 were sampled at the beginning (turnout) and end (housing) of the grazing period in 1999. From each farm, blood samples were collected from 23 - 114 animals, serum was obtained and specific levels of serum antibodies to *Dictyocaulus viviparus* were measured with a commercially available ELISA.

Results: All herds, except one, were infected with *D. viviparus* at some time during 1999. The overall seroprevalence was 8.3% (101/1212). Elevated levels of antibodies were identified in 4.6% (28/604) and 12.0% (73/608) of the serum samples at turnout and housing, respectively. On the infected farms, seroprevalences varied between 0% - 15.7% at turnout and 5.2% - 24.6% at housing. The seroprevalence in calves < 1 year and in older cattle > 2 years was 20.3% and 6.0%, respectively. No clinical signs of disease were observed.

Conclusion: Although the highest seroprevalence was noted at housing, some animals were also infected at turnout. Despite that there was a significantly greater proportion of calves than older cattle infected, and seropositive animals were found in all age groups. These results suggest that arrested larvae and older cattle as a means of survival over-winter may play important roles in the epidemiology of lungworm infection in Sweden.

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ECOLOGICAL CHARACTERISTICS OF FISH PARASITE FAUNAS IN NORTH-EASTERN AZERBAIJAN RIVERS

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Objective: To define the ecological characteristics of the fish parasite faunas in north-eastern Azerbaijan rivers.

Material and Methods: In 1994-98, 657 fishes belonging to 24 species were examined by total parasitological dissection

method in north-eastern Azerbaijan rivers: Samur, Gusarchay, Gudialchay, Devechichay and Gilgilchay.

Results: 121 fish parasite species were found in the north-eastern Azerbaijan rivers.

Conclusion: Only four species of ichthyoparasites are typically rheophilous, while the other 117 species are limnophilous. The majority of the recovered parasites are typical freshwater inhabitants, some are euryhaline, and 10 species are marine. All marine parasites were noted in marine fish and migratory fish only. The typically marine *Corynosoma caspicum* infects all species of marine and migratory fishes, and it can be a natural indicator, permitting differentiation of typically freshwater and migratory populations of fishes.

The predatory fishes accumulate 13 helminth species. The plankton-eating fishes were infected by six helminth species, larvae of which live in planktonic invertebrates. The benthophagous fishes have 12 helminth species connected with the benthos, but they also have 12 helminth species connected with the plankton because some copepods inhabit both the water column and bottom areas.

CONSECUTIVE FLAGGING SAMPLES - A SIMPLE METHOD TO OBTAIN DETAILED INFORMATION ON THE HOSTSEEKING ACTIVITY OF *IXODES RICINUS*

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Objective: Observations on tick activity are mostly based on flagging samples. The typical patterns of tick activity by this

method consist of a dominant peak in activity in spring and a minor peak in autumn. Flagging, however, does not reveal any details on whether the seasonal variation in activity originates from variation in population size or activity of the tick population. It is thus unknown whether the differences observed by flagging vegetation are a measure of population size or activity of the individual ticks. The purpose of this study was to obtain information on how well the peaks in activity relate to population size.

Material and Methods: Ticks were collected by flagging vegetation for three consecutive days on eight occasions.

Results: The first day's flagging showed a bimodal pattern, with a peak in abundance of nymphs in June and September which resembles traditional flagging results. Results from the third day's flagging did not show a clear bimodal pattern. The hostseeking period as defined by the ratio between first and third day samples appeared almost exclusively to be responsible for the bimodal pattern of activity in first day samples.

Conclusion: The variation in hostseeking periods may have profound influence on the observed abundance and seasonality of ticks. Consecutive flagging appears to be a convenient method of obtaining information on the hostseeking period and ascending numbers of ticks. The latter may possibly be closely related to population size.

VARIABILITY OF THE PARASITE FAUNA OF OCEANIC FISH SPECIES DURING DIFFERENT PERIODS OF A MIGRATION CYCLE (BY THE EXAMPLE OF BLUE WHITING OF THE NORTHWEST ATLANTIC)

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Objective: The parasite fauna of blue whiting *Micromesistius poutassou* (Risso) was studied in different intrapopulation host groups.

Materials and Methods: Parasitological and ichthyological samples from blue whiting of the Hebrido-Norwegian population taken in the area from the Irish shelf to Spitsbergen during 10 years were analysed. 1210 fishes were examined by the total parasitological dissection method. Incomplete dissection of 15 000 specimens was performed. The material encompassed different intrapopulation groupings of blue whiting at the ages of 1-16 years.

Results: In the distribution area of blue whiting 37 parasite species of 10 taxa were recorded. Ecological analysis revealed the characteristic features of tropho-parasitic relations of the host, typical features of age- and area-related variability of infestation on the spawning, feeding and wintering grounds of young and mature fish. Indicator parasites - microsporidians *Pleistophora* sp. and trematodes *Bucephaloides gracilescens* etc. - were used to trace the formation of peculiar features of the parasite fauna in the intrapopulation groupings. The distribution of immature fish is related to the dispersal of larvae and fry by currents. In different parts of the distribution area (the North, Norwegian and Barents Seas, Iceland) fish live in different environmental conditions, which

has an effect on parasite fauna. As fish mature, most of them begin spawning (Irish shelf), feeding and wintering (the Norwegian Sea) migrations. However, there are also migrants with delayed gonadal development, as well as specimens missing spawning. In the north of the distribution area pseudopopulations of never-spawning fish are formed. In different periods of the migration cycle fish stay either in the centres of parasite infestation, or spatially far from them.

Conclusion: On the basis of parasitological data using indicator parasites, the relationships between intrapopulation groupings of blue whiting were mapped.

GENETIC HETEROGENEITY OF TREMATODE SPECIES REFLECTS THE STRUCTURE OF THEIR NATURAL POPULATIONS

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Objective: We studied two sibling trematode species *Microphallus piriformes* and *M. pygmaeus* belonging to the Microphallidae family. About 400 individual sporocysts (containing metacercariae) infesting *Littorina saxatilis* and *L. littorea* periwinkles were used for the analysis. All individuals were collected in the Chupa Bay of the White Sea and the largest distance between the analyzed localities was 20 km.

Methods: We used Chelex 100 method to extract total DNA from individual trematodes. This extraction has earlier been proven to be useful for very small sample

sizes and we successfully scored individual sporocysts of both species. The random amplified polymorphic DNA (RAPD) technique was applied for the studies of genetic heterogeneity.

Results: Amplification of the total DNA, extracted from the whole sporocysts, never showed any differences in RAPD patterns between the parasites derived from one infested snail (local parasite hemipopulation). That allowed us to compare different parasite populations, referring to the RAPD pattern of one sporocyst from a snail as representative of one local hemipopulation.

The data showed considerable genetic differences between the subpopulations of *M. piriformes* infesting different paraxenic intermediate hosts – *L. saxatilis* and *L. obtusata* – which were statistically significant for two out of three localities studied. No such heterogeneity within populations was recorded for *M. pygmaeus*. Moreover, both *M. piriformes* and *M. pygmaeus* are characterized by the genetic differentiation on the microgeographic scale. According to the frequencies of the RAPD-loci, parasites from the sheltered locality differ significantly from the parasites of the other two localities exposed to the open sea. For both species the degree of genetic similarity between the populations correlates positively with the distance between the localities.

Conclusions: Genetic population structure of microphallids is dependent on the population structures of their intermediate and definitive hosts and the geographical structure of the area. Because of low motility of snails, we believe that the distribution, migration and species composition of the definitive hosts play the key role in the genetic structuring of *M. pygmaeus* and *M. piriformes* hemipopulations.

THE EFFECT OF HOST DENSITY ON ECTOPARASITE DISTRIBUTION

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Objective: We studied the pattern of parasitism of the fleas *Xenopsylla dipodilli* (mainly spring and summer flea) and *Nosopsyllus iramus theodori* (winter flea) on a small rodent, *Gerbillus dasyurus*, in different habitats of the Negev Desert, Israel. We predicted that the intensity of flea infestation would increase with the increase of the host density curvilinearly to a plateau that will be attained at the level of the host density that corresponds to the abundance of resident individuals (those having their own burrows). We predicted also that the prevalence of flea infestation plotted against host density would be hump-shaped.

Material and Methods: We captured rodents on 20 one-hectare plots and collected fleas from them. In total, 657 gerbils were captured and 1265 fleas were collected.

Results: The distributions of both fleas on *G. dasyurus* conform to the negative binomial distribution. The intensity of infestation by both fleas increased with the increased gerbil density to a plateau. However, the threshold host density for this plateau coincided with the number of resident individuals for *X. dipodilli* and with overall host density for *N. i. theodori*. Prevalence of infestation by *X. dipodilli* plotted against host density was hump-shaped, whereas that for *N. i. theodori*

increased linearly with increase in host density.

Conclusion: The habitat patch of a flea should be considered not only as a particular host, but rather as a particular host with a particular burrow or nest in a particular habitat. The flea abundance parameters are influenced by the density of the resident hosts rather than by the overall host density.

MORTALITY OF ATLANTIC SALMON PARR DUE TO HIGH INTENSITIES OF EYEFUKES

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Objective: The density of Atlantic salmon parr in the upper part of the Alta river has declined 90 % since the regulation of the river for hydroelectric power production in 1987. No changes in density were detected in the lower part. Preliminary studies have demonstrated high intensities of eyeflukes in the Atlantic salmon parr of the river. The aim of the present study was to investigate whether the decline in the density of Atlantic salmon parr in the upper part of the river are due to high intensities of eyeflukes, and whether the high intensities of eyeflukes are connected with the regulation of the river.

Materials and Methods: Atlantic salmon parr were collected by electrofishing. Metacercaria of *Tylodelphys clavata* and *Diplostomum* sp. (eyeflukes) were registered in each year class in autumn and spring.

Results: The intensity of eyeflukes in Atlantic salmon parr of the Alta river was more than ten times higher than that recorded in neighbouring rivers and what is reported from Atlantic salmon parr in other rivers in

Europe and North America. The disappearance of heavily infected parr (age < 3+) during the winter in the upper part of the river indicates parasite dependent mortality. Possible spreading mechanisms of the parasite include attraction of the final hosts (seagulls) by dead fish in the effluent water from the turbines.

INTERRELATIONSHIPS OF CRABS, LEECHES, FISH AND TRYPANOSOMES IN COASTAL WATERS OF NORTH NORWAY

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The red king crab, *Paralithodes camtschaticus*, was introduced to the Barents Sea from its native North Pacific by Russian scientists in the 1960s and 1970s. A thriving population now established in the southern Barents Sea is steadily spreading westwards across the coast of Finnmark. The arctic leech, *Johannsonia arctica*, lays its eggs on the carapace of the crabs and is a vector for the haematozoan *Trypanosoma murmanensis*, which it transmits to cod and other fish while feeding on the blood of the fish.

In October 1999 we investigated the occurrence of trypanosomes in cod caught at 18 stations along the coast of Finnmark. We found two foci of infection: one in Værangerfjord in eastern Finnmark where there is a dense population of king crabs, and one in western Finnmark where there are no king crabs. Station prevalences varied from 0 to

96%, with both extremes occurring in western Finnmark. The heaviest infection was found in an area where native spider crabs *Lithodes maja* are known to be particularly abundant. We discuss the interrelationships of crabs, leeches, fish and trypanosomes in the study area, including the possibility that we may be dealing with two species of trypanosome with different leech vectors.

NOTES ON MESOPARASITISM

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In parasitology it is accepted that parasites can be subdivided into two categories traditionally based on their spatial relations with the host organism. Ectoparasites, i.e. organisms which live «on external covers, skin, gills», are placed in the first category. Endoparasites, i.e. organisms living «in internal cavities, tissues and cells of the host» are placed in the second category (Dogiel, 1941).

Feizullaev (1971) offered a third category – mesoparasites – where he places «the parasites inhabiting localities which are connected with cavities opening to the external environment». According to the above author such places are oral, nasal, eye cavity, cloaca, etc.

Since some parasitic copepods living in a certain kind of spatial relation with the host can be referred neither to ectoparasites nor to endoparasites, the author offers the following three criteria for the definition of mesoparasitism.

1. Morphological and anatomic subdivision of the body of the parasite into two

main parts: ectosoma, located in the external environment (environment of the first order) and endosoma, located inside the organism of the host (environment of the second order).

2. Functional subdivision of the body of the parasite into two parts: endosoma, which performs the trophic function, and ectosoma, with genital organs performing the reproductive function

3. Concurrent existence in the environments of the first and the second order, each of the environments influencing the parasite immediately.

Up to now the typical mesoparasites have been only found among the parasitic copepods.

PATTERNS OF SIMILARITY IN THE PARASITE FAUNAS OF *LARUS* GULLS

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Objective: The reported parasite fauna of *Larus* gulls was reviewed for completeness, similarity, and evidence of geographic patterns.

Materials and Methods: Analysis was conducted on reported parasites for 21 species of *Larus* gulls with two or more reports recorded in the Index Catalog of Medical and Veterinary Zoology (USDA), and Helminthological Abstracts. The influence of the size of host breeding range (drawn on Fuller-projections) and number of studies reported on parasite species richness of the compound fauna of 21 gull species was evaluated by partial correlation analysis. Similarity analysis was conducted using

Simpson's and Jaccard's coefficients and UMPGA clustering.

Results: Host breeding range was not significantly correlated with the species richness of parasite fauna. However, the number of published studies was statistically significant. Simpson's coefficient generated similarity patterns of parasite faunas that were highly consistent with the biogeographic realms associated with the host breeding range.

Conclusions: The parasite fauna of *Larus* gulls remains poorly known for many species, particularly in the southern hemisphere. New records represent a large proportion of reports. The highest affinities (> 80 percent) between parasite faunas were among two pairs of gulls with overlapping or neighboring breeding ranges in northern Europe (*L. camus*-*L. fuscus* and *L. argentatus*-*L. hyperboreus*). Other high similarities in parasite faunas were found between host pairs composed of one large and one small geographic distribution, a condition to which the Simpson's coefficient is sensitive. Results of preliminary field work in 1999 suggest the high similarity between *L. argentatus* and *L. camus* near the White Sea Biological Station (Chupa, Karelia) is not an artifact of analysis.

HOW DOES *ARGULUS FOLIACEUS* L. (CRUSTACEA: BRANCHIURA) MATCH WITH ITS HOSTS AT THE BEHAVIOURAL AND ECOLOGICAL LEVELS?

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Argulus foliaceus, an obligatory fish ectoparasite, has to match with its relatively rare, poorly predictable, and evasive hosts temporally and spatially. Parasites need to adjust recruitment to the period of high fish availability. Free swimming individuals have to find the hosts as quickly as possible.

Objectives: Are a synchronized recruitment and regular fluctuations of the population number typical of *A. foliaceus*? What behavioural traits ensure efficient host searching in *A. foliaceus*?

Materials and Methods: Size and sex structure of *A. foliaceus* populations were monitored in a lake and fish farm in Central Finland. Hatching dynamics were observed in the laboratory. Host searching activity patterns together with external and internal controlling factors were studied using specially designed experimental aquariums.

Results: Synchronized recruitment controlled abiotically (temperature and, perhaps, illumination) was observed only in late spring. Later, asynchronous egg laying and, especially, hatching extended recruitment with no clear seasonal peaks of larvae. A distinct midsummer peak of larvae was observed only in a densely farmed popula-

tion of *Onchorhynchus mykiss*. Light-mediated switching from a «hover-and-wait» (day) to «cruising» (night) host searching strategy makes parasites efficient around the clock. *A. foliaceus* swimming activity is controlled both internally (hunger state) and externally (visual, chemical, and hydromechanical stimuli related to fish).

Conclusions: A prolonged period of recruitment in *A. foliaceus* plays an adaptive role in unpredictable ambient conditions, extending a "net of infectivity". A number of individual behavioural adaptations facilitate finding of rare and evasive hosts. Intensity and prevalence of infection depend on interplay between the behaviour of parasites and their fish hosts.

SEASONAL DYNAMICS OF THE FEATHER MITE *MONOJOUBERTIA MICROPHYLLA* (ASTIGAMATA: ANALGOIDEA: PROCTOPHYLLODIDAE) ON THE CHAFFINCH *FRINGILLA COELEBS*

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Objective: Seasonal dynamics of the structure of *Monojoubertia microphylla* (Robin, 1877) micropopulations on different sex and age groups of chaffinches *Fringilla coelebs* (Passeriformes: Fringillidae) have been studied during the nesting and migration periods in the North-West of Russia (in 1981-1982 and 1999).

Materials and Methods: The data on structure of mite micropopulations were obtained monthly from April to October, and 353 live individuals of chaffinches were examined. Three bird groups were determined within the chaffinch population

during the study: adult males, adult females and immature chaffinches.

Results: The dynamics of *M. microphylla* micropopulations on all chaffinch groups were similar and gradually increased during the spring migration (April - May). On the adult male chaffinches, the mite number continued to increase during the nesting period (June) and began to decrease significantly in July, because of plumage postmating moult; the mite number slowly decreased at the end of summer and the autumn migration (September - October). On the adult female chaffinches, the mite number decreased abruptly during the nesting period, when the females sit together with nestlings. About 60% of mites migrated from the adult female chaffinches on to young birds. The mite micropopulation on the nestling ready to leave the nest was represented mainly by males, females (about 25% each) and tritonymphs (38%). The mite numbers on the female chaffinches continued to decrease in July under the influence of plumage moult and slightly increased up to the autumn migration only. On young chaffinches, mite numbers quickly increased up to the beginning of the autumn migration due to the intense reproduction of mites. The decrease of the micropopulation on the young birds began only in the end of autumn migration.

Conclusion: The dynamics of *M. microphylla* micropopulations during the nesting period and autumn migration are considerably different on adult males, females and immature chaffinches. These differences are determined by the different roles of adult chaffinch males and females in the process of infesting the nestlings with mites. The mite micropopulation migrating from the adult female chaffinches on to the nestlings is represented mainly by older instars ready for

reproduction, females, males and tritonymphs. In the migration periods and probably the winter, the main part of the mite population is represented by females, while in summer the preimaginal instars predominated.

FEEDING RELATIONSHIPS OF INTERMEDIATE HOSTS AFFECT TRANSMISSION SUCCESS OF LARVAL CESTODES

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Copepods often serve as first intermediate hosts for tapeworms. Parasite larvae are eaten by copepods which, in turn, are consumed by fish. The entire life cycle of tapeworms is determined by the feeding relationships of the hosts.

Objectives: Does the presence of alternative food influence the acquisition of coracidia by copepods? Is acquisition of coracidia connected with the developmental stages of copepods? How do procercooids alter the vulnerability of copepods to fish?

Material and Methods: Experimental and field data on *Cyclops strenuus* - *Triaenophorus crassus* and *C. strenuus* - *Diphyllbothrium* spp. systems.

Results: Alternative food reduced acquisition of coracidia by copepods. In experiments, the CVs of *C. strenuus* were infected with *T. crassus* four times more frequently

than CIVs, and prevalence in the adults was 2.4 times higher than in the CVs, which could result from a higher feeding activity of older stages. Similar results were obtained on the wild population of *C. strenuus* infected with *Diphyllbothrium* spp. Infection with both parasites impaired the escape ability of copepods, and influenced the number of takeoffs to swim and time spent swimming. In experiments, the infected copepods stayed near the surface while the uninfected remained close to the bottom. A higher percentage of infected copepods was consumed by fish in the laboratory.

Conclusions: The success of parasite transmission depends not only on host/parasite concentrations, but also on availability of alternative prey. Prevalence is higher in older copepodids due to their increased feeding activity. Alterations in escape ability and motility influencing conspicuousness of infected copepods increased the risk of being eaten by fish.

KARYOTYPICAL DIFFERENTIATION OF THE SPECIES OF *EUBOTHRUM* (CESTODA: PSEUDOPHYLLIDEA)

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Objective: The identification of the species of *Eubothrium* has always been a complex problem. The problem is particularly acute in respect of *E. crassum* and *E. salvelini*. There are a limited number of morphological characters available, several of these are variable and hence unreliable. Cytogenetic information can reveal differences and similarities that may not be obvious at the morphological level.

Materials and Methods: Karyotypes of *E. salvelini* from *Salvelinus leucomaenis* and *S. malma*, *E. crassum* from *Salmo salar* and *S. trutta trutta* and *Eubothrium* sp. from *Clupea harengus membras* were studied using conventional Giemsa staining and comparative karyometric analysis.

Results: The karyotypes, reported here for the first time, consist of eight chromosome pairs ($2n=16$). In the karyotype of *E. salvelini* chromosome pairs 1 and 2 are metacentric, pairs 3 and 4 are subtelocentric, pair 5 is subtelocentric to submetacentric, pairs 6 and 7 are submetacentric and pair 8 is acrocentric. The two first pairs of homologues are markedly larger than the remaining elements. The karyotype of *E. crassum* shows fairly close affinity with that of *E. salvelini*. The only statistically significant interspecific difference in relative lengths was revealed between chromosomes pair 5. The best cytogenetic marker for species discrimination is the last 8th pair of chromosomes, which is metacentric in the karyotype of *E. crassum*. Comparative study revealed no significant interspecific differences between karyotypes of *Eubothrium* sp. and *E. crassum*.

Conclusions: The obvious similarity in karyotype structure do not exclude the possibility to discriminate between *E. salvelini* and *E. crassum* by karyotypic characters. Karyological observations provide strong evidence to assign *Eubothrium* sp. from *C. harengus membras* to *E. crassum*.

CHANGING RISK OF TICK-BORNE ENCEPHALITIS IN SCANDINAVIA WITH PREDICTED CLIMATE CHANGE

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Objective: To understand the determinants of the current distribution of tick-borne encephalitis virus (TBEv) in order to predict any future changes in response to climate change.

Methods: Complementary statistical and biological approaches were used to relate the observed spatial patterns of TBEv foci and the temporal dynamics of the transmission process to satellite-derived climatic factors. The results were applied to future climate scenarios, based on Global Circulation Models, to predict future distributions.

Results: Enzootic cycles of TBEv were shown to depend on specific seasonal temperature profiles which determine a specific pattern of the seasonal dynamics of tick populations necessary for TBEv transmission. Predicted warmer winters and drier summers in the future appear to disrupt this system, leading to a northward shift, but overall decrease in the geographical range of TBEv.

Conclusions: When all the biological multi-factorial variables are taken into account, the threat of global warming does not necessarily presage a markedly worsening situation for all vector-borne disease systems.

NEMATODE FAUNA OF SHEEP WITH EMPHASIS ON ZOONOSES IN THE WEST OF IRAN

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Objective: Determination of gastrointestinal nematode fauna of sheep, especially those which cause disease in man and are zoonotic.

Materials and Methods: The contents of the abomasum, small intestine, colon and caecum of 160 slaughtered sheep were collected separately. The contents of each part of the gastrointestinal tract were filtered through meshes placed in a column and deposits were collected and fixed in 10% formol saline solution. All nematodes were detected, counted and identified using azocarmine lactophenol.

Results: More than 90% of the sheep were infected by at least one genus or species of worm. A total of 24 genera or species of nematodes were identified as follows: From abomasum: *Marshallagia marshalli*, *Ostertagia occidentalis*, *O. circumcincta*, *Ostertagia* sp., *Parabronema skrjabini*, *Haemonchus contortus*, *Nematodirus abnormalis*, *N. oiriatianus*, *N. archari*. From small intestine: *Nematodirus abnormalis* 58 %, *N. oiriatianus* 21 %, *N. helvetianus* 5 %, *N. spathiger* 1%, *N. filicollis* 2%, *N. battus* 1%, *N. archari* 1%, *N. sp.* 1%, *Capillaria* sp. 2%, *Trichostrongylus colubriformis* 1% and *T. vitrinus* 1%. From colon and caecum: *Skrjabinema ovis*, *Trichuris ovis*, *T. skrjabini*, *T. lani*, *T. ovina*, *T. discolor* and *Trichuris* sp. More than 10 000 nematodes were found in the small intestine of which *Nematodirus abnormalis* at 7078 had the highest intensity.

Conclusion: *Trichostrongylus* had the lowest prevalence and intensity. The zoonotic nematodes had low prevalences and intensities in the region.

ELECTROPHORETYPES, GENOTYPES AND *BORRELIA* AGENTS OF *IXODES PERSULCATUS* TICKS

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Objective: *Ixodes persulcatus* ticks collected in the vicinity of St. Petersburg were tested for MDH (malatdehydrogenase) loci heterogeneity, *Borrelia burgdorferi* species and etiological agents of ehrlichiosis (HGE – human granulocytarian ehrlichiosis and HME – human monocytarian ehrlichiosis).

Material and Methods: Isoenzyme analysis was used for MDH electrophoretyping and genotyping. All ticks were examined using darkfield microscopy (DF) to detect live spirochaetes. DF positive specimens were used for *Borrelia* and *Ehrlichia* species determination. *Borrelia* species (*B. afzelii*, *B. garinii*, *B. burgdorferi* sensu stricto) and HGE & HME agents were detected using genus- and species-specific primers by PCR analysis.

Results: Six detected MDH-electrophoretotypes were referred to three alleles of MDH gene and marked as genotypes 1.1 (65% of total observations), 1.2 (5%), 1.3 (19%), 2.2 (2%), 2.3 (3%), 3.3 (6%) respectively. 56% of DF positive ticks were *Borrelia*-positive (13.4% of them were multiinfected with two or three types of *Borrelia* simultaneously). The most fre-

quently detected *Borrelia* agent was *B. afzelii* (45% of all cases, *B. garinii* – 21%, *B. burgdorferi* s. s. – 3%). HGE and HME agents were found in 11.8% of samples tested (9.4% - HME, 2.4% - HGE).

Conclusion: The *I. persulcatus* population in the vicinity of St. Petersburg was found to be heavily infected with *Borrelia* and HME agents. The degree of *Borrelia* infection between MDH-genotypes was different. This is the first case of HGE agent finding in the St. Petersburg region.

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MORPHOPHYSIOLOGICAL AND ECOLOGICAL ANALYSIS OF ONTOGENESIS IN TERRESTRIAL PARASITENGONA (ACARIFORMES)

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Objective: A combined analysis of ontogenesis in parasitengona mites that is characterized by the phenomenon of «alternating calyptostasy» was carried out from the standpoint of their ecological and morphological specialization.

Materials and Methods: Field and culture observations as well as light and electron microscopy of different organ systems during life cycle were used for the purpose of this study.

Results and conclusion: The enrichment of eggs in yolk and the progressive embryonization of the prelarva instar represent an evolutionary tendency for accelerated development that theoretically could lead to a complete loss of feeding capability

at the larval phase because the utilization of the embryonic yolk takes place already in the larva. This, however, does not occur because it is necessary for a small larva to attain, during its parasitic feeding, the large sizes of deutonymph and adult mites, which reproduce a rather conservative morphological prototype with apparent secondary simplification. The rapid ingestion of large masses of food by the parasitic larva has an inevitable result in non-feeding and significant regression of the protonymphal instar. The tritonymphal instar undergoes a quite synchronous morphological reduction that obviously indicates the concordant evolution of the whole ontogenesis in this group of trombidiform mites.

MORPHOLOGICAL AND KARYOLOGICAL STUDIES OF *ECHINOCHASMUS* SP. CERCARIAE (TREMATODA, ECHINOCHASMIDAE)

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Objective: To present the results of morphological and karyological investigations of *Echinochasmus* sp. Cytogenetic information can reveal differences and similarities that may not be obvious at the morphological level.

Materials and Methods: Macrocerous (zygocercous) cercariae were emitted by naturally infected hydrobiid prosobranch snails *Lithoglyphus naticoides*. Molluscs were collected in the River Nemunas near Kaunas (Lithuania) during the years 1996-1998. Cercariae were observed alive in egg albumin in order to reveal the morphology, especially the excretory system. The mitotic chromosomes of somatic cells of parthenites

were analyzed using air-drying technique and Giemsa staining.

Results: Macrocerous (zygocercous) cercariae of *Echinochasmus* sp. have an oval body and very large tail (reddish and 3-4 longer than body). Flame cell formula: $2[(1+1+1+1) + (1+1+1+1)] = 16$. The ducts of excretory systems contain 8-10 large composite and 2-3 small granules. The caudal excretory duct is bifurcated at its end, opening in the first third of tail.

The mitotic complement of *Echinochasmus* sp. consisted from 20 chromosomes, ranging in size from 2.11 to 7.64 μm . The first pair of submetacentric-metacentric homologues was larger than the remaining elements, which decrease in size fairly gradually and represent acrocentrics (2nd pair), submetacentrics (6th pair) and subtelocentrics (all the rest) units of genome.

Conclusions: Cytogenetic data about this genus is poor and controversial. According to existing data, *Echinochasmus beleocephalus* has diploid chromosome number $2n=14$ and morphology of chromosomes are very similar to the chromosome set of *Sphaeridiotrema globulus*. The karyotype of *Echinochasmus* sp. displays a pattern typical of most genera of Echinostomatidae – *Echinopharyphium*, *Moliniella*, *Hypoderaeum*. According to the morphological data on *Echinochasmus* cercariae, this genus seems to belong to a valid family Echinochasmidae, which appears more closely related to Psilostomidae than to Echinostomatidae.

THE ECOLOGICAL VALUE OF ACANTHOCEPHALANS FOR DETECTING TRAFFIC RELATED POLLUTION

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A major source of aquatic metal contamination is road runoff entering lakes and rivers. This runoff contains a complex mixture of potential toxicants. High sediment and water concentrations of heavy metals like zinc (Zn), cadmium (Cd), chromium (Cr) and lead (Pb) are commonly found near highways as these toxic metals are constituents of fuel, brake linings and vehicle tyres. In recent years another traffic related metal emission could be observed: following the introduction of automobile catalysts in the middle of the 80^s there is an increasing emission of the platinum-group metals (PGM) platinum (Pt), palladium (Pd) and rhodium (Rh). Still, it remains unclear if these metals are bioavailable for aquatic animals at all, and to what extent they become accumulated by the aquatic biosphere.

Therefore field studies as well as experimental investigations were conducted on the accumulation of the above mentioned metals in different fish species, their acanthocephalans and the established free living bioindicator, *Dreissena polymorpha*. To analyse metal levels in the fish tissues, the parasites and the mussels, various modern analytical techniques like electrothermal atomic absorption spectrometry (Et-AAS), inductively coupled mass spectrometry (ICP-MS) and total-reflection X-ray fluorescence analysis (TXRF) were applied.

The results demonstrate that the zebra mussels and the parasites are suitable to

detect differences in contamination derived from motorway runoff. But the bioconcentration of metals by the acanthocephalans was several times greater than that by zebra mussels. Acanthocephalans are therefore more sensitive indicators for detecting low concentrations of dissolved heavy metals in aquatic ecosystems than zebra mussels. The experimental studies revealed for the first time an uptake and therefore the bioavailability of traffic related Pd by the exposed aquatic organisms.

FIRST STUDIES ON THE STRESS RESPONSE OF MAMMALS FOLLOWING HELMINTH INFECTIONS AND HEAVY METAL EXPOSURE

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The impact of an infection with the acanthocephalan *Moniliformis moniliformis* and a simultaneous Cd-exposure on the stress hormone levels of rats was studied. After the application of cadmium, cortisol levels in rats, as quantified by radioimmunoassay (RIA), significantly increased. Although the animals were heavily stressed by the metal, cortisol levels at the time of killing did not significantly differ from those in control rats, indicating that their adrenal systems were exhausted. Experimental infections with the acanthocephalan *M. moniliformis* enhanced the impact of cadmium on the host animal, as cortisol concentrations in infected

rats reached higher levels than in the uninfected exposed rats. Additionally, the adrenal tissue of only the exposed and infected rats showed hyperplasia, indicating that the infection acts as a synergistic stressor in addition to cadmium. While the acanthocephalan infection leads to increases in the catecholamine levels, the levels of adrenaline and noradrenaline, as determined by high performance liquid chromatography (HPLC), decreased after heavy metal exposure. Accordingly, the infection was antagonistic to Cd-exposure. The mean cadmium concentration in *M. moniliformis* determined by electrothermal atomic absorption spectrometry (ET-AAS) was $5.8 \mu\text{g g}^{-1}$ wet weight, which was 20, 23 and 119 times higher than in host kidney, liver and intestine, respectively. While female worms accumulated higher amounts of cadmium than males, no tendency emerged between the cadmium concentration and the weight of individual acanthocephalans.

Thus, our results show that parasites have to be considered in (eco-) toxicological studies as they are able to accumulate high amounts of heavy metals taken up by the host organism. On the other hand they also affect the health of their hosts as demonstrated by the exacerbation of cadmium-induced stress due to the acanthocephalan infection.

ESTONIAN *OESOPHAGOSTOMUM* SPP. ISOLATES IN PIGS

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Objective: Until recently, only the presence of *Oesophagostomum dentatum* had been documented in Estonia and no observations had been carried out to determine the length of the prepatent period of the porcine nodular worm infection.

Materials and Methods: Therefore, eight Landrace/Estonian Big White Pig crossbred piglets of approx. 15 kg body weight were inoculated with 2000 infective larvae of four *Oesophagostomum* spp. isolates collected from different Estonian pig farms. Daily faecal samples were examined from day 15 p.i. and pigs were slaughtered between days 44–60 p.i. Worms were recovered by the agar-gel migration technique and 100 worms from each pig were identified.

Results: The pigs commenced excretion of *Oesophagostomum* spp. eggs between days 18 to 43 p.i. The length of the prepatent period was found to depend on both isolate and pig. Two pigs showed single eggs on day 24 p.i., whereafter all samples were negative again until days 32 and 43 which were therefore suggested to be the «true» prepatent period. All Estonian isolates contained *O. quadrispinulatum* that predominated in the two isolates which had the latest average onset of egg excretion. The two isolates dominated by *O. dentatum* showed markedly shorter prepatent periods and fairly constant egg excretion, compared to isolates with *O. quadrispinulatum* pre-

dominance which showed unstable egg excretion.

Conclusion: The present study describes for the first time *O. quadrispinulatum* in Estonian pigs. We suggest that this species may occasionally give rise to prolonged prepatent periods.

SEXUAL ORNAMENTS SIGNAL PARASITE RESISTANCE IN A MALE FISH

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Objective: The «Hamilton and Zuk hypothesis» proposed that male sexual ornaments could signal parasite resistance. We tested the hypothesis by applying a novel method—separation of dead and live parasites.

Materials and Methods: We used the leaking fish *Rutilus rutilus* (males of which develop breeding tubercles as sexual ornaments), and the following measures of host resistance: proportion of dead parasites, parasite load (intensity/prevalence) and immune function (spleen size).

Results: As anticipated by the hypothesis, there was a significant positive relationship between male ornamentation and host resistance (proportion of dead parasites) against the gill parasite *Rhipidocotyle campanula* (Trematoda) in all of the three populations where the parasite occurred. Correspondingly, numbers of live *R. campanula* were significantly negatively associated with ornamentation in two populations. However, we found no relationship between ornamentation and the proportion of dead liver parasites *Raphidascaris acus* (Nema-

toda), load of *R. campanula* or *R. acus*, load of the gill parasite *Myxobolus* sp. (Protozoa), load of the liver parasite *M. mülleri*, load of the gill parasite *Paradiplozoon homoiom* (Monogenea), relative spleen size, or somatic condition of fish.

Conclusions: Breeding tubercles on the body of male roach may signal parasite resistance in the present system against *R. campanula*, which also happened to be the locally most prevalent and abundant parasite. In addition, we propose the proportion of dead parasites to be a useful measure of resistance since it may provide a specific, direct, long-term measure of host immunological response.

PARASITES IN HOSTS WITH SPECIAL LIFE HISTORIES

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Objective: To analyse the haemosporidian parasites (Protista: Haemosporida) in birds with special life histories.

Material and Methods: A total of 107 specimens of Cuckoo (this bird species is characterised by brood parasitism), 307 specimens of juvenile Crossbill (the birds breed during the cold months of the year) and 57 specimens of Swift (the birds spend up to 20 hours per day in the sky and even more when they do not breed) were examined in the Western Baltics using the blood smear technique.

Results: The haemosporidians were not recorded in Cuckoo and Swift, but they were common in juvenile Crossbills. *Haemoproteus tartakovskyi* (7.2%) and *Leucocytozoon fringillinarum* (14.3%) were the dominant species of parasite.

Conclusions: The juvenile Crossbills born during a cold season can be infected only after the breeding period (outside of nest). The high haematozoa prevalence in the juvenile Crossbills shows that the period while small passerines are in the nest does not play a decisive role in their infection. This contributes to the discussion on the role of the nesting period in the infection of birds with blood parasites. Unusual life histories may protect birds from infection with some parasites either completely (Cuckoo, Swift) or at least during first months of their life (Crossbill) when individuals are especially vulnerable to parasitic infections. Conceivably, this advantage contributed to the evolution of unusual life histories of birds, such as the brood parasitism of Cuckoo, winter breeding in Crossbill, nearly all-day flight in Swift. The parasites in hosts with special life histories provide opportunities to answer some intricate questions in ecological parasitology, using relatively simple and inexpensive methods.

ENVIRONMENTAL IMPACT ASSESSMENT OF PARASITE CONTROL MEASURES IN CATTLE

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Objective: Environmental impact assessments are important issues with regard to registration of control agents (principally chemicals and drugs) for widespread agricultural use. This study was undertaken to determine the effect of long-term administration of ivermectin (Ivomec® controlled release device), and the nematophagous fungus *Duddingtonia flagrans*, compared

with untreated control cattle, on the range of generally beneficial soil nematode populations found in pasture soils.

Materials and Methods: A plot study and a paddock field trial with the various parasite control options in cattle were monitored during two grazing seasons (1998, 1999). Soil samples were taken to a depth of about 3 cm using soil corers. Frequency of sampling and number of samples varied according to the design of the two investigations. Soil nematodes were recovered by standard procedures, counted, differentiated into various taxa and then aggregated into "functional groups" (i.e. plant feeders, fungivores, bacteriovores, carnivores, omnivores, plant-associated etc). This study will be continued during the grazing year 2000.

Results: In analysis of initial data, no significant differences in either total abundance, or of functional groups, emerged. However, in early samples there appeared to be a greater proportion of bacterial-feeding and predacious nematodes in soil from the bolus treated paddock, whereas the proportion of plant-feeding nematodes was lower. Although the same general trend is reflected in the plot study, on some sample dates there was an apparent decrease in the fungivorous nematodes *Aphelenchus*, *Aphelenchoides*.

Conclusion: Results suggest that differences may emerge in soil microfaunal populations in relation to parasitological treatments applied to grazing livestock. These may affect decomposition and nutrient cycling processes.

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SUBMITTED PAPERS- POSTER PRESENTATIONS

SPOROZOANS (SPOROZOA, API-COMPLEXA) – BLOOD PARASITES OF TUNDRA WATER-SWAMP BIRDS, SPENDING WINTER IN AZERBAIJAN

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Objective: Haemoparasites of birds of passage (seagulls, swans, diving ducks and geese) wintering in the Island of Kur-Cosa (Kizil-Agadj Bay) of the Caspian Sea were investigated.

Materials and Methods: Approximately 100 birds were examined. Blood of the birds caught with traps and nets was taken by piercing the vein or cutting the claw (in small species). Thin smears of blood were taken and stained azure-eosin by Giemsa-Romanowsky. The slides were examined using a light microscope.

Results: Blood sporozoans were discovered in one species of the family Anatidae and in one species of the family Laridae.

Conclusion: At the present stage of research it is too early to make conclusions about the poor fauna of haemococcidians of birds. Investigation of blood of birds of passage at the end of the winter is not enough to understand the circulation of parasites. It is necessary to study

not only seasonal, but also age characteristics of haemoparasite infection of hosts in a discrete population.

COMPARATIVE ANALYSIS OF THE HELMINTHOCOENOSSES OF NATIVE RIPARIAN MUSTELIDS (*LUTRA LUTRA*, *MUSTELA LUTREOLA*) IN RELATION TO WIDTH OF FOOD SPECTRA

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Objective: Helminthocoenoses of the otter (*Lutra lutra*) and European mink (*Mustela lutreola*) were compared.

Materials and Methods: In Belarus, 49 otters and 41 European mink were examined for helminth parasites. At the same time the width of food spectra of these predators was evaluated and results: The dissected otters were infested only by five helminth species. The helminthocoenosis of the European mink population was characterized by higher diversity (17 helminth species). Analysis of 1474 scats of the European minks revealed 49 prey species. Food niche breadth calculated for eight prey categories comprised 3.36. By analysing 802 otter spraints, 29 prey species (including 19 species of fish) were found. Food niche breadth for eight prey categories was significantly lower than that of the European minks (2.62 versus 3.36).

Conclusion: Width of ecological niche is one of the main factors influencing the formation of helminthocoenosis in mustelid populations.

THE SIGNIFICANCE OF MOLLUSCS IN CONSERVATION OF TREMATODE LIFE CYCLES

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The role of molluscs is generally recognized not only in supporting trematode life cycles as intermediate hosts, but also in dispersion of the parasites in the environment. However, the question of the significance of molluscs in long-term conservation of hotbeds of trematode invasion remains insufficiently studied. Moreover, the leading role in this is often attributed to definitive hosts.

During 1990-1998 monitoring of the parasite fauna of molluscs *Bithynia tentaculata* was conducted in a pond in the St. Petersburg area. About 6000 snails were collected and investigated. The overall prevalence of trematode infection was approximately 30%. During the investigation deformation of the age structure of the *Bithynia* population took place, induced by the elevated mortality of molluscs born that year and by a decrease in their fertility in 1992 through 1993. However, despite the almost complete renovation of the mollusc population, all trematode species – *Notocotylus imbricatus*, *Psilotrema tuberculata*, *Sphaeriodiotrema globulus*, *Holostephanus volgensis*, *Cercaria helvetica* XII, *Pleuro-*

genoides medians and *Metorchis intermemius* – were conserved. Analysis of the age structure of the mollusc population and of the seasonal dynamics of their invasion allows us to conclude that life cycle stability in many trematode species is provided by intramolluscan stages of development.

The above conclusion is well supported by examples from parasites of Anatidae – *N. imbricatus*, *P. tuberculata*, *S. globules* and *H. volgensis*. At least 30% of molluscs containing parthenites of these species survive the winter period. It is these that become a source of infection for birds the following year.

The data obtained demonstrate that under temperate climatic conditions molluscs can play an important role in supporting natural hotbeds of infection. Earlier a similar conclusion was reached for more northerly latitudes (Galaktionov, 1993). Probably such a conclusion is especially true for models where migrating species play the role of the definitive host.

PARASITE SYSTEMS WITH ACANTHOCEPHALANS OF THE GENUS *FILICOLLIS* LUHE, 1911 (ACANTHOCEPHALA) AND THEIR GEOGRAPHICAL MODIFICATIONS

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Objective: Long-term studies of bird acanthocephalans were conducted to show the main features of parasitic helminth systems of migratory birds.

Materials and Methods: Original materials from the Asiatic Subarctic were collected during twenty years study using the

original methods of Kontrimavichus & Atrashkevich (1982).

Results: The genus *Filicollis* includes two species – *F. anatis* (Schrank, 1788) and *F. trophimenkoi* Atrashkevich, 1982. The dabbling duck *A. acuta* (Anatidae, Anseriformes) is absolutely dominant as a definitive host (90%) in northern populations of transpalaeartic *F. anatis*, but in some southern regions (Ukraine, Caucasus, S. Ural) the main definitive host is *Fulica atra* (Rallidae), whose distribution range hardly reaches the subArctic. Only *Asellus aquaticus* (Isopoda) is known to be the intermediate host for *F. anatis* in Europe, whereas in Asia five other endemic species of the genus *Asellus* have been identified as intermediate hosts (Atrashkevich, 1997).

F. trophimenkoi is endemic to North-East Asia. Among 20 definitive host species only a few diving ducks are obligatory hosts, with *Clangula hyemalis* dominant (up to 70% prevalence). Only two species of intermediate hosts are known. Parasitic systems of both acanthocephalan species in sympatric areas include the same intermediate host – one of the endemic *Asellus* species, but different definitive hosts (*F. anatis* in *A. acuta* and *F. trophimenkoi* in *C. hyemalis*).

Conclusion: The spatial structures of parasite systems with subarctic *F. trophimenkoi* are remarkable for the homogeneity of their intermediate hosts. The transpalaeartic *F. anatis* consists of heterogeneous parasite systems that differ in that their intermediate and obligatory definitive host species are multifunctional through changes in the main definitive hosts. Thus, the widely distributed parasite species of migratory birds can form relatively isolated populations, even in northern regions, with little or no mixing between them.

HISTOLOGICAL AND HISTOCHEMICAL CHANGES IN *TOXOCARA CANIS* TISSUES UNDER THE ACTION OF LEVAMISOLE

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Changes in the micromorphology and of glycogen deposits in the tissues of *T. canis* under the action of 7 mg/kg levamisole were studied *in vivo*. Puppies naturally infected with *T. canis* were used and examinations were carried out on the worms eliminated from the host intestine 4, 10, 15, 25 and 46 hr after the levamisole treatment. Semithin sections of the worms were stained standardly with haematoxylin – eosin for micromorphological investigation and for PAS reaction for glycogen deposit changes in tissues of the worms. Amylase was used to control PAS reaction.

The results show that levamisole causes serious alterations in the structures of cuticle, intestinal cells, hypodermis and muscle cells of *T. canis* and influences their carbohydrate metabolism. The changes seen in *T. canis* after the treatment with levamisole in the first few hours were slight. At 4 hr after treatment noticeable alterations were seen only in cuticle. Small granules and vacuoles appeared in other tissues only at 25 hr post treatment. Weak swelling of all tissues was observed after treatment with levamisole. The fine structure of nerve cords showed no noticeable changes.

PAS reaction was used to examine glycogen deposits in *T. canis* tissues. Under the action of levamisole the decrease in glycogen was seen only in the intestinal cells at 4-

25 hr. At the end of the experiment there was positive PAS reaction in all tissues.

It is concluded from these obvious and quick changes of cuticle after treatment with levamisole that this drug penetrates the *T. canis* body surface.

ECOLOGICAL ANALYSIS OF FISH PARASITE FAUNA IN KALININGRAD REGION RESERVOIRS

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Objective: During 1990 through 1999 a complex of investigations was carried out with the aim of determining the fish parasite fauna in Kaliningrad Region reservoirs.

Materials and Methods: eight species of fish in Rivers Pregel and Prokhladnaya, seven species of fish of Kaliningrad Bay and five species of fish in Lake Chistoye were investigated with the method of total parasitological dissection.

Results: Parasites with a direct life cycle dominated in 17 fish species. Parasites with a complex life cycle were represented by 13 species. In most cases trematodes infected fish as metacercariae. Infections by other types of parasites were insignificant.

Conclusion: Deterioration of the ecosystem in a reservoir resulted in a decrease in the number of smooth myxosporean spores, and in variations in the size of their valves and polar capsules. Sexually mature trematodes were rarely represented in polluted reservoirs. Few parasite species develop through Copepoda. Apparently the influence of sewage water in reservoirs results in depression of the development of planktonic Copepoda.

HAEMOSPORIDIAN PARASITES OF BIRDS FROM BELARUS

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Objective: Based on the results of preliminary original investigations and literature data, to collate the available information on the distribution of haemosporidian parasites (Protista: Haemosporida) of birds in Belarus.

Materials and Methods: A total of 21 specimens of birds belonging to 10 species of the order Passeriformes were investigated for haematozoa using the blood smear technique. The birds were sampled from the State National Park Belovezhskaya Puscha in June 1999.

Results: Parasites belonging to three genera of haemosporidians were found: *Haemoproteus*, *Leucocytozoon* and *Plasmodium*. We recorded haemoproteids in three species of birds. The highest intensity (3-4 parasites per one field of the oil immersion objective) was found in *Luscinia luscinia*. According to the literature, *Haemoproteus* sp. has been recorded in 22 species of birds in

Belarus so far. We found *Leucocytozoon* sp. in *Turdus merula*. The common passerine hosts of leucocytozoids in Belarus are crows (Corvidae). Nine species of leucocytozoids have been reported in Belarus so far. In *T. merula*, we found *Plasmodium* sp. in mixed infections with *Leucocytozoon* sp. Only one species of *Plasmodium* has been recorded in birds in Belarus.

Conclusion: Haemosporidian parasites are common in birds in Belarus. All genera of these parasites known to parasitize Palaearctic birds have been recorded. However,

the fauna and its distribution pattern remain insufficiently studied.

POMPHORHYNCHUS LAEVIS
(MÜLLER, 1776) (ACANTHOCEPHALA) REMAINS IN MESENTERIUM TISSUE OF FLOUNDER (*PLATICHTHYS FLESUS* L.): MORPHOLOGY, LOCALIZATION AND ORIGIN

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More or less decomposed remains of *Pomphorhynchus laevis* were found in the body cavities of flounder. There is no common opinion about the origin, structure, and role of those remains in the life cycle of *P. laevis*. Two hundred *P. laevis* remains from flounder ($n=850$, $l=5-35$ cm) intestinal tracts were studied. All the remains could be classified as follows: those having only a proboscis sucker – 37 %, with proboscis bulb and neck – 53 %, and those mummified by salinization – 10 %. Deformed, shrunk bodies («mummies») were found on liver mesentery. Depending on the location in the host body cavity proboscides were either connected to the external side of the intestinal wall by a fibroblast thread or, in those attached to a liver mesentery or in the peritoneal cavity (70 %), without a thread. Remains attached via the connecting tissue are mostly aggregated in the middle part of the intestinal tract or on either side of a rectal sphincter (68 %). The length of fibroblast thread (mm) was positively correlated with the distance from the rectal ($r=0.95$) or intestinal ($r=0.72$) wall. The longer the thread, the older were the *P. laevis* remains.

The developmental cycle of *P. laevis* does not include a stage of encapsulated cystacanth. The bodies of acanthocephalans deformed and extruded from the intestine are not involved in the developmental cycle of the parasite.

P. laevis remains can be classified into three types according to their origin:

a) residuals of early stage or adult individuals that migrated but settled in unfavourable environmental conditions (20%),

b) residuals of migrating unsuccessful cystacanths which had returned and adhered by suction to the external wall of the intestine (11%),

c) residuals of dead adults extruded by the immune response from the intestinal wall (69%).

Flounders infected with encapsulated worms do not fill the role of transport hosts.

GAMMARIDS OF LAKE BAIKAL BASIN AS INTERMEDIATE HOSTS OF HELMINTHS

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Objective: Helminthological research of gammarids in Baikal was conducted. Gammarids are one of the most diverse groups of animals in Baikal (270 species and 80 subspecies). Two hundred and twenty-nine gammarid species are endemic to Baikal.

Materials and Methods: Helminthological dissections of 44121 specimens belonging to 209 species was carried out. Literature data (Bekman, 1954; Zaika, 1965; Shabaev, 1966; Pronin *et al.*, 1986;

Baldanova, Pronin, 1992; Baldanova, 1998) and results of the authors' own research of gammarids are summarised.

Results: Gammarids are infected with 14 helminth species. The hosts of *Cyathocephalus truncatus* are *Gammarus lacustris*, *Gmellinoides fasciatus*, *Pallasea cancellus*, *P. cancelloides*, *Poecilogammarus pictus* and *Eulimnogammarus fuscus*. A cestode of fam. Hymenolepididae has been reported in *Gmellinoides fasciatus*. The trematode *Crepidostomum farionis* has been found in *Micruropus posolskii* and *Gmellinoides fasciatus*, while *Crepidostomum metoecus* was found in *Gammarus lacustris* and *Gammarus kozhowi*. *Allocreadium* sp. has been recorded in *Acanthogammarus victorii*. The nematode *Cystidicola farionis* is a parasite of *Gammarus lacustris* and *Gammarus kozhowi*. *Tetrameres fissispina* and *Streptocara crassicauda* have been reported in *Gammarus lacustris*. The acanthocephalans *Polymorphus magnus* and *P. minutus* have been recorded in *Gammarus lacustris* and *Gmellinoides fasciatus*. Hosts of *Echinorhynchus borealis* are *G. fasciatus*, *Eulimnogammarus cyanoides* and *Pallasea cancelloides*. Hosts of *E. salmonis* are *G. fasciatus*, *E. cyanoides* and *Micruropus posolskii*. The host of *E. truttae* is *M. posolskii*.

Conclusion: Palaearctic helminth species use endemic species of gammarids as intermediate hosts in Baikal Lake.

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COMPARATIVE ANALYSIS OF THE PARASITE FAUNAS OF BROWN TROUT PARR (*SALMO TRUTTA* L.) FROM SOME WATER BODIES OF THE PAANAJARVINATIONAL PARK AND THE RIVER OULANKA

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Objective: The purpose of the present study was to reveal the diversity of the parasite fauna of brown trout parr (*Salmo trutta* L.) of the Oulanka - Paanajarvi - Olanga lake-river system.

Materials and Methods: Brown trout parr aged 2+ from the Paanajarvi National Park (Mutkajoki River, Siltajoki River, Lohioya River) and the River Oulanka (Finland) were studied. The research was carried out in 1998-1999. Fifteen specimens from each locality were dissected. The study was carried out according to standard methods (Bikhovskaya-Pavlovskaya, 1985).

Results: In the Mutkajoki River five species of parasites were found: Myxosporea - 1, Ciliophora - 1, Protozoa incertae sedis - 1, Cestoda - 1, Acanthocephala - 1. The parr in this river were mostly infected by *Dermocystidium* sp. (prevalence - 67%, intensity - 40). The parasite fauna of brown trout parr from the Siltajoki River consisted of eight species: Myxosporea - 1, Ciliophora - 3, Trematoda - 2, Acanthocephala - 1, Copepoda - 1. *Crepidostomum farionis* was the most widespread parasite. The species composition of brown trout parr in the Lohioya River consisted of nine species: Myxosporea - 4, Ciliophora - 3, Monogenea - 1, Trematoda - 1. The prevalence and intensity of infection by all parasites were low. In the Oulanka River 12 species of

parasites were found: Ciliophora - 3, Nematoda - 3, Trematoda - 5, Acanthocephala - 1. The acanthocephalan *Neoechinorhynchus crassus* was recorded in Fennoscandia for the first time. The prevalence and intensity of infection by Ciliophora (*Apiosoma* sp. 78/22, *Capriniana piscium* 83/39) were quite high.

Conclusion: Species composition of parasites of brown trout parr from the rivers studied was found to consist of 23 species. Analysis of the parasite fauna shows that the species composition in some of the rivers displayed low species diversity. Parasitological data indicate that the Oulanka River ecosystem is exposed to considerable anthropogenic impact whereas the Paanajarvi NP water bodies remain undisturbed.

IMPORTANCE OF ECOLOGICALLY DETERMINED CHARACTERS IN THE TAXONOMY OF CESTODES

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Sometimes, in order to differentiate between closely related species of cestodes mainly parasitizing the same or similar species of definitive hosts, investigation of the morphological characters of the parasites is not sufficient. The problem can be solved by analyzing ecological data acquired during the investigation of life cycles of the parasites. The most important data are: 1) the structure of outer membranes of live eggs determining the mode of infection of their intermediate hosts; 2) the taxonomic rank of hosts (definitive and intermediate); 3) localization of parasites in the definitive and intermediate hosts; 4) the structure of cysticercoids. The structure of the outer membrane of eggs (1) as a specific charac-

ter depends directly on the species of obligatory intermediate host of a cestode and its trophic relationships. An example of four species of *Hymenolepis* (s.l.) parasitizing the gulls of the subarctic Region and using the same crustaceans (Branchiopoda) as intermediate hosts shows distinct specific differences in the structure of their eggs which determine their flotation qualities. This character, together with the determination of differences in the morphology of copulative organs, enabled us to differentiate between species, while the participation of crustaceans as intermediate hosts (2) allowed to distinguish this group of cestodes from the composition of the genus *Wardium* (= *Hymenolepis* s.l.). The taxonomic rank of hosts (2) and localization of parasites (3) played an important role in the description of new Cestoda species parasitizing the diving ducks and shorebirds of the Subarctic region. A special place in solving the problems related to our revision of cestodes of the subfamily Aploparaksinae is given by (4). Allocation of the metacestodes of closely related species of cestodes to different types of cysticercoid was useful in most cases in solving disputed questions of cestode identification.

PARASITE COMMUNITIES OF SMALL RODENTS IN THE PAANAJARVI AND OULANKA NATIONAL PARKS

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Objective: The diversity of helminth and ectoparasite communities of rodents in undisturbed ecosystems (Paanajarvi National Park, Russia and Oulanka National Park, Finland) was studied.

Materials and Methods: The material was collected early in July 1998 (i), early in October 1999 (ii) in the south-eastern part of the PNP and in late September 1999 (iii) around Oulanka Biological Station. Hosts were captured by snap-traps arranged in a line. 63 small rodents belonging to three species were examined for parasites during the period of investigation. The diversity (H) and evenness (E) of parasite communities was measured using the Shannon index.

Results: (i) Fifteen individuals of the family Cricetidae were examined, representing the species *Microtus oeconomus* (3) and *Clethrionomys glareolus* (12) of two age groups: overwintered adults and juveniles. Their parasite fauna was represented by 15 species, belonging to four taxonomic groups: Cestoda (4), Nematoda (3), Ixodidae (1) and Gamasina (7) (also Siphonaptera and Anoplura). Lice (55%, 4.9), fleas (53%, 2.8), *Hirstionyssus isabellinus* (30%, 4.3) and the nematode *Heligmosomum mixtum* (52%, 1.1) dominated the community. The measured diversity index and evenness were 2.34 and 0.8, respectively.

(ii) The host material consisted of 17 bank voles of two age groups: juveniles and subadults. Nine parasite species were found: Nematoda (4), Cestoda (2) and Gamasina (3). The dominant nematodes were *Syphacia petruszewiczi* (30%, 7.1) and *H. mixtum* (88%, 2.5). $H=1.73$, $E=0.72$.

(iii) Thirty-one bank voles and two grey-sided voles were examined. Six parasite species were recorded: Nematoda (2), Cestoda (1) and Gamasina (3). The most abundant were *S. petruszewiczi* (18%, 4.6), *H. mixtum* (97%, 5.2) and lice (55%, 5.6). $H=1.54$, $E=0.74$.

Conclusion: The species diversity in a parasite community depends on the age structure of the host population. Thus, in our case, the presence of overwintered animals

in the sample predetermines the highest H value.

SPECIAL FEATURES OF THE FORMATION OF RODENT HELMINTHOCOENOSSES IN URBAN LANDSCAPES OF BELARUS

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The objective of this investigation was to study specific features of the formation of helminthocoenoses under urban pressure.

Materials and Methods: In 1996-99, 1520 rodents from Minsk belonging to the following eight species were dissected and examined for helminth parasites: *Apodemus flavicollis*, Melchior, 1834 – 100 specimens; *Apodemus sylvaticus*, Linnaeus, 1758 – eight specimens; *Apodemus agrarius* Pallas, 1771 – 120 specimens; *Clethrionomys glareolus* Schreber, 1780 – 27 specimens; *Microtus oeconomus* Pallas, 1778 – one specimen; *Microtus arvalis*, Pallas, 1778 – 72 specimens; *Mus musculus* Linnaeus, 1758 – 1087 specimens; and *Rattus rattus* Linnaeus, 1758 – 105 specimens.

Results: The community of rodents in Minsk consists of synanthropic species 78.4 %, forest species 8.9% and field rodents 12.7%. Host ecology, dynamics of intrapopulation and interspecific relationships had great influences on the formation of helminthocoenoses. The low population density of forest rodents is the reason for low helminth infestation in the city. The specific habitats of rodents in urban territories limit contact between different ecological groups of rodents. Rare contacts caused decreased richness of the helminthofauna in different ecological groups of rodents.

Conclusion: The specific feature of the helminthofauna of different species of rodents in urban territory is the dominance of helminths from synanthropic rodent groups.

ROLE OF HORSEFLIES (DIPTERA, TABANIDAE) IN THE ECOLOGICAL BALANCE OF BIOTA

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Objective: The nature of horseflies localisation being heterogeneous, their species composition, abundance and probable role in agent transmission in different ecosystems of the Lower Volga Region were studied.

Materials and Methods: Tabanids were collected from horses in various ecosystems in the territory of Kalmykia, Astrakhan, Volgograd and Saratov regions. The total number of horseflies collected was 25000.

Results: Forty-eight species of horseflies were found, 13 of which were new for the region studied. Horsefly females were able to have over five gonotrophic cycles during a season. This determined their high fecundity and abundance in their habitats with stable conditions for their development. The duration of horsefly activity was 100-150 days. Mass flight lasted from 1 to 1.5 months in different landscapes. Particularly high abundance (up to 210 individuals per collection), which have negative effects on the horses pastures, was noted in the north-western region of the Caspian Sea. The weights of wild and domestic animals subject to mass attack by tabanids declined and the animals' resistance to transmitted diseases decreased. Decrease in resistance was conducive to transmission of tularae-

mia, anthrax, paraphylariosis and other diseases.

Conclusion: The study of horsefly species composition and abundance in various ecosystems of the Lower Volga Region allowed us to determine the location where tabanids had a severe influence on the productivity and resistance of domestic animals. The presence of natural foci of infections, the agents of which can be transmitted by horseflies, necessitates protecting animals against their attack.

HOUSE DUST MITES IN FOUR VILNIUS PRE-SCHOOLS

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Objectives: To describe house dust mite species, their prevalence and seasonal variation in Vilnius pre-schools.

Materials and Methods: The study was carried out during one year - March 1999-February 2000. From the total list of Vilnius pre-schools (total number 117) four were randomly selected: two where children stay for the whole week and two of 12 working hours per day. Dust was collected in March, June, October and January, taking 14 samples at each institution per day (from mattresses, stuffed toys, and carpets) and later examined using the Acarological method. The total number of samples examined was 224.

Results: Twelve mite species were found in all samples examined. *Dermatophagoides pteronyssinus* (Trouessart) and *D. farinae* Hughes (Pyroglyphidae) were present in samples at 2-2000 and 2-200 individuals/gram respectively. Mites were present in all room sites examined. The numbers of

mites detected in one gram of dust varied in samples taken from different floors and at different seasons. In the samples gathered from the ground floor mites were present 2.95 times more frequently than on the first floor. For the first time in Vilnius stuffed toys were examined and the numbers of mites found was surprisingly high. According to our study the number of mites was highest in October and lowest in March.

DIFFERENTIATION AND PLACENTAL-LIKE ORGANIZATION OF THE UTERUS IN *NIPPOTAENIA MOGURNDAE* (CESTODA)

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Objective: Investigations were carried out on *Nippotaenia mogurndae* Yamaguti et Miyata, 1940 (Cestoda: Nippotaeniidea).

Materials and Methods: Adult worms were removed from the intestine of the fish *Perccottus glenii*, collected from shallow lakes near Vladivostok, Russia. Materials were fixed in 4% glutaraldehyde in cacodylate buffer, post-fixed in OsO₄ (for 1 h), dehydrated and processed for TEM examination.

Results: The process of uterine differentiation can be divided into three main stages. In the first stage, aggregation of undifferentiated cells leads to the syncytium formation. In the second stage, as a result of active autophagic processes, the uterine cavity is formed. Then the uterus is separated from the parenchyma by the interstitial basal plate and is surrounded by bands of circular muscle. For cestodes the unique

relationship between eggs and uterine wall, the so called placental-like interaction, was established. The maturing eggs of *N. mogurndae* are attached to the uterine wall. The cytoplasmic outgrowths and lamellae of uterine epithelium are believed to interlace intimately with the shell and an outer envelope surrounding the eggs.

Conclusion: The process of uterus development in *N. mogurndae* is similar to that in a group of lowest cestodes of the order Caryophyllidea and is one of the general ways to form both the uterus and ducts of the reproductive system.

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ENDOPARASITES OF JUVENILE (AGE 0+, 1+) COD, *GADUS MORHUA*, IN ICELANDIC WATERS – PRELIMINARY RESULTS

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Objective: To investigate when endoparasites start to infect wild cod (age 0+ and 1+) in Icelandic waters and to analyse the progress of infection.

Materials and Methods: Approximately 1,000 fish caught in 1998-1999, at 2, 4, 6, 10 and 18 months of age, have been examined so far. Two year classes, 1998 and 1999, were studied. All major organs were screened fresh, frozen or formalin fixed (conventional histology) and blood samples were taken.

Results: The following parasites were found: Protozoa - coccidian oocysts and

other coccidian stages, *Loma* sp.; Myxosporrea; Digenea - *Brachyphallus crenatus*, *Derogenes varicus*, *Lepidapedon elongatum*, *Podocotyle atomon*, *Proisorhynchoides gracilescens* (metacercariae) *Stephanostomum* sp. (metacercariae); Cestoda - Pseudophyllidea and other plerocercoids (larvae); Nematoda - *Anisakis simplex*, *Cucullanus cirratus*, *Hysterothylacium aduncum*, *Pseudoterranova decipiens*; Acanthocephala - *Corynosoma* sp. (larvae), *Echinorhynchus gadi*. No blood parasites were found. Endoparasites (i.e. metacercariae) were first detected in a two months old juvenile cod. At least six species of parasites have been found in four months old cod, 11 in six months old, 11 in 10 months old and 17 species in 18 months old cod. Prevalence and intensity of each species generally increased with age.

Some species reached a prevalence of 100% (*D. varicus*, *P. atomon*, *A. simplex*). Among the helminths, digenean species reached the highest intensities, with numbers up to 270 per fish (*L. elongatum*).

Some parasites/pathogens still remain to be identified. Other diseases/pathogens detected include: Pseudobranch tumor, epitheliocystis (bacterium) and *Ichthyophonus hoferi* (fungus).

Conclusions: Diversity of parasites increases with age, as does prevalence and intensity of infection, although there are differences between year classes and localities. It seems that metacercariae of *Stephanostomum* sp. (found mainly in the eyes) have not been reported earlier in this host.

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HOW NEMATODES COMMUNICATE, - WITH A NOTE ON PHASMID ULTRASTRUCTURE

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In ascaridoidean nematodes, only a few somatic sense organs are present: A/. Lateral amphids (n=2) in the head region, B/. Cephalic sense organs (4), C/. Labial sense organs (12), D/. Cervical deirids (2), E/. Asymmetrically oriented midbody centrids (Fagerholm et al.: J. Parasitol., 1999, 85: 41-47; probably homologous to the not well defined structures often called post-deirids), F/. Lateral phasmids on the tail (2). Caudal sense organs of the male (21- ca. 200). Results to date on the structure and function of somatic sense organs deal primarily with the single pair of lateral cephalic amphids (see Ashton & Shad: Vet. Parasitol. 84, (1999) 297-316). With the sequencing of the total *C. elegans* genome in 1998 a perception of the number of genes involved in the function of sensory dendrites has been obtained. The number of functional genes involved in chemoreception amounts to no less than some 500. These can be divided into four basic receptor families (Troemel (1999), BioEssay 21: 1011-1020). The function of the 11 pairs of chemosensory neurons found in the amphid is now known while that of the neurons in other sensory organs largely remain to be investigated. This applies also to basic structure.

The phasmid ultrastructure has, so far, only rarely been studied. This is the case although the presence or absence of phasmids is a feature traditionally used for dividing nematodes into basic clades. In the present study serial ultrathin sections of the phasmid of *Hysterothylacium auctum* (Rud. 1819) (Ascaridoidea: Raphidascarididae) from the gut of *Zoarcetes viviparus* L. were studied under TEM. The results give support to the general view of a single dendrite being present in phasmids. Each phasmid was laterally situated and the dendrite runs anteriorly (The nucleus apparently being situated at the level of the cloaca, as in *C. elegans*). Close to the papilla the dendrite of the left-hand phasmid was provided with numerous blunt and rather short fingerlike protuberances extending into the sheath cell. These are apparently homologous with the abundant rather thin radiating extensions that we have observed in *Ascaris suum*. When phasmids are present in nematodes a conservative basic ultrastructure of these would give additional support for Secernentea forming one basic clade in the Nematoda. However, only by research on further representative entities can this be verified. It is worth noting that the orientation of the caudal male sense organs is also governed by specific genes, as recently shown in studies by Emmons and Fitch. It is evident that nematode sense organs are much more complicated both structurally and functionally than previously imagined and that communication between individual worms and the perception of the environment are well evolved.

INTERCOMMUNICATIONS BETWEEN ZONE OF MITEBITE (GENUS *IXODES*) LOCALIZATION AND THE HUMAN BIOENERGETICAL SYSTEM

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The problem of the increase in the number of mitebites (*Ixodes*) among local inhabitants is a vital question toward the end of the 20th century.

This is the result of social problems in modern Russia because townspeople, owing to the state of national economics, must work on plots of cultivated land, so contact between the urban population and the natural environment is becoming greater. The number of persons who had mitebites increased fourfold during the last 10 years (1987-1997) in the territory of Novgorod Region alone (Bolshacova et al., 1997).

The object of our research is the study of intercommunication between zones of mitebites (*Ixodes*) and the human bioenergetic system.

Methods: Measurements were carried out with the help of device ACEC (analyser of condition of power canals) with appropriate programme-apparatus complex. The basic working principle of the device is a diagnostic method, based on the registration of change in the impedance of the tissues as a result of the vital activity of the organism. Device ACEC allows us to find biologically active points (BAP), to measure power parameters (module of full electrical resistance) of these points and with the help of the programme-apparatus module to process the results of the changes.

Results: During the research 13 zones were identified where bites of the ticks were found. The greatest number of large bites of these ticks takes place on the ear, neck, armpit and on the head. This is explained by the fact that except for these areas the whole body is covered by clothes, so it is easier for ticks to bite the above mentioned places. The human body consists of bioenergetic points which are very visible on the outside surface of the human body.

When 53 tick bitten victims with bioenergetic points were compared it was noted that the sites of bites were the same for these two species of ticks *I. persulcatus*, and *I. ricinus*.

These experiments showed that the females always sucked blood from the region of medium resistance. Hailer's organ helps these species to find places of high biological activity on the body (BAP).

COCCIDIA (SPOROZOA, APICOMPLEXA) OF WATER AND MARSH FOWL OF THE TUNDRA OVERWINTERING IN AZERBAIJAN

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Objective: Some water and marsh birds of the tundra overwintering on Kur-Kosa Island in the Caspian Sea (Kyzylagaj Bay) in the winter-spring period were studied to find out if they carry oocysts of coccidia (Eucoccidia, Coccidia, Apicomplexa).

Materials and Methods: Fresh faeces of passing gulls, swans, pochards, and geese caught by special nets were collected. Fine smears of faeces on slides were prepared

and stained with carbol-fuchsin by the Ziehl-Nielsen technique. The faeces were also preserved in 2.5% solution of potassium bichromate. The preserved faeces were centrifuged with the flotation liquid according to the standard technique. All preparations were examined with a light microscope.

Results: Oocysts of coccidia were detected in two swan species and in one gull species (*Larus argentatus*).

Conclusion: In late winter the fauna of intestinal coccidia in the water and marsh fowl of the tundra is rather poor. Examination of these birds at the time of their arrival for overwintering is desirable.

CESTODES OF THE EIDER DUCK POPULATION INHABITING SPITSBERGEN AND FRANZ JOSEF LAND (PRELIMINARY COMMUNICATION)

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Objective: The cestode fauna of eider duck, *Somateria mollissima*, is reported for the first time from the northern border of the species distribution, Spitsbergen and Franz Josef Land.

Materials and Methods: In August 1991 three birds were collected in Spitsbergen (Bellsund) and four on Franz Josef Land (FJL). In August – September 1992 10 more birds were captured on FJL: six in the vicinity of Hooker Island,

as in 1991, and four on Apollonov Island (81° 20' N), much farther to the north.

Results: All cestodes collected belong to the genus *Microsomacanthus*. Prevalence of cestodes in eiders everywhere was 100% and the parasite load was very high (up to 250.000 specimens per bird). In Spitsbergen and in the southern parts of FJL *M. microsoma* dominated, while the subdominant species was *M. jägerskioldi*. These species are distinguished from each other mainly by the form of the strobila, slender and long in *M. microsoma* and short but broad in *M. jägerskioldi*. The third related species, *M. diorchis*, only once noted in Spitsbergen, was more widespread in the vicinity of Hooker Island. At the northern extremity of FJL all the eider ducks examined, juveniles and adult, were infected by *M. duc-tilis*. The latter is a common parasite of gulls and has never been recorded before in eider ducks.

Conclusion: In comparison with Subarctic regions such as Iceland (Baer, 1962) and Murman Coast (Belopolskaya, 1952; Galkin, 1997), the cestode fauna of eider duck in Spitsbergen and FJL is scanty in species composition but not in prevalence and intensity of infection. Further investigations may confirm the lack of dilepidids (*Lateriporus*), fimbriariins and *M. heterospinus* there. Verified systematic data for comparative ecological studies is of great value. Correct analysis of eider ducks' parasite fauna is impossible without the detailed description of *M. microsoma* (Creplin, 1829) – the type species of the genus – based on old collections (Fuhrmann, 1913) and newly obtained material.

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PARASITE INVASION AS A RISK FACTOR IN THE DEVELOPMENT OF INFLAMMATORY DISEASES OF THE PELVIS ORGANS

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Objective: The aim of the study is to estimate the parasite (*Giardia lamblia*, pinworms, *Toxocara*) infection among female patients with chronic inflammatory diseases of pelvis organs (pelvis inflammation disease - PID).

Material and Methods: Immuno-enzymatic analyses [Test sets of Toxocara-strip, LambliaAT-strip of Vector (Best production)] were used to investigate the level of *Toxocara* and *G. lamblia* invasion. Faeces smears and solutions were also analysed to detect *Giardia* cysts. Pinworm eggs were detected in the morning urine centrifugate and also by the study of perianal folds imprints on adhesive tape. Total number of patients - 144 females. Age of patients ranged from 2 to 36.

Results: The frequency of PID cases is shown in Table 1 (next page).

The high level of parasite invasion common in children at ages 2-5 might be a result of insufficient hygiene.

Conclusion: Parasite invasion of PID patients increases the inflammatory processes, lowers the effectiveness of antibacterial therapy, prolongs the recovery period and is a main risk factor for development of chronic PID promoting decompensation of genitourinary tract mucous membrane dis-bacteriosis and activation of persistent infections. All PID patients had to be examined for giardiasis, enterobiosis and toxocarosis for the female PID prophylaxis.

Parasites	Ratio of patients (%)		
	Girls of 2-5 yr with chronic vul- vovaginitis (n = 27)	Girls of 9-14 yr with acute salpin- goophoritis (n = 34)	Women with infertility in marriage (n = 83)
<i>Giardia</i>	25.9	11.7	30.1
Pinworms	40.7	14.7	15.7
<i>Toxocara</i>	40.7	20.6	40.9

Table 1. Frequency of PID cases

***EUDIPLOZOOM NIPPONICUM* (DI-
PLOZOIDAE, MONOGENEA) –
COMPARATIVE ANALYSIS OF MI-
CROECOLOGY AND HABITAT
SPECIFICITY IN RELATION TO
PARASITE ONTOGENETIC DEVEL-
OPMENT**

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Šimková AND T.H. Zurawski

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Objective: Study of *Eudiplozoon nip-
ponicum* (Goto, 1891) (Monogenea, Diplo-
zoidae), parasitic on the gills of carp (*Cy-
prinus carpio*), a parasite of Far East origin
which was introduced to Europe.

Materials and Methods: During the
period from 1988 to 1998, a long term study
of the morphology, biology and ecology of
E. nipponicum was performed under the
conditions of a fish farm pond system.
Scanning electron microscope techniques
were used to study the parasite surface to

describe tegumentary structures during the
parasite's ontogenetic development.

Results: Considerable seasonal changes
were observed in population dynamics,
population age structure, development of
sexual organs and tegumentary structures.

Conclusion: There is no doubt that *E.
nipponicum* seems to be a very useful
model parasite species for microecological
studies of parasite spatial distribution in-
cluding analysis of niche segregation, intra-
and interspecific competition and aggrega-
tion. There is also need for a detailed TEM
study to clarify the structure and function of
some tegumentary papillae and their role in
parasite microhabitat segregation.

TAXONOMY AND SYSTEMATICS OF THE MONOGENEAN FAMILY DIPLOZOIDAE IN THE LIGHT OF RECENT KNOWLEDGE

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Objective: Members of the Diplozoidae are unique among platyhelminths in that two adult worms are fused in permanent copulation, each individual being unable to survive alone. Until now there have been no data on the morphometric variability of structures of taxonomic importance. Because of this species identification is very difficult.

Materials and Methods: Phase Contrast microscopy, Nomarski DIC, special staining techniques and digital image analysis have been used for investigation of structures of taxonomic importance.

Results: Out of nine tested methods for staining of attachment apparatus sclerites of individuals of model parasite species (*Paradiplozoon homoion*, *P. bliccae*, *Eudiplozoon nipponicum* and *Diplozoon paradoxum*), three methods are suggested for use: Gomori trichrome, Lignin Pink and modified peracetic acid alcian blue for SS groups.

Conclusion: Due to the above-mentioned staining techniques, a comparative analysis of the morphometric variability of structures of taxonomic importance were performed to evaluate current criteria used in species identification. Taxonomic revision of this parasite group is recommended.

SOME CHARACTERISTICS OF THE DISTRIBUTION OF *TETRAONCHUS MONENTERON* (MONOGENEA) AND *ERGASILUS SIEBOLDI* (CRUSTACEA) ON GILLS OF PIKE *ESOX LUCIUS*

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Objective: Study of gill parasites of pike.

Materials and Methods: Pike (N=22) were collected in Pskov Region in May 1995 and 1996. All parasites, plus areas of gills, hemibranchs and sectors of gills were counted as percentages. For comparisons of percentages the Fisher criterion was applied.

Results: Significant positive correlations were found between monogeneans and area of 1) gills ($r = +0.91$), 2) hemibranchs ($r = +0.86$) and 3) sum of areas of two hemibranchs of gill pairs adjacent to each other ($r = +0.92$). Percentage distribution of crustaceans had 1) negative correlations with the area of gills ($r = -0.34$), 2) hemibranchs ($r = -0.19$) and 3) a positive correlation ($r = +0.58$) with the percentage of total area of two hemibranchs of adjacent pairs of gills. Preference for I-II pairs of gills and middle and angular sectors of gills was revealed in monogeneans and preference for III-IV pair of gills and the anterior and posterior sectors of gills was revealed in crustaceans. Significant negative correlations between worms and crustaceans in the middle ($r = -0.96$) and posterior sectors of gills ($r = -0.91$), and a high positive correlation ($r = +0.56$) between both parasites in the sum of areas of two hemibranchs of adjoining pairs of gills were shown.

Conclusion: Our data suggest antagonistic relationships between these parasites and indicate a direct relationship of occurrence of these gill parasites and the flow of respiratory currents passing through slits between the gill pairs.

COMPARATIVE ANALYSIS OF MONOGENEAN FAUNAS AND POPULATIONS FROM SEVERAL BELONIFORM FISHES

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Objective: A comparative analysis was carried out of both fauna and populations of monogeneans from beloniform fish belonging to different ecological groups (the oceanic group proper, the pseudo-oceanic and neritic). The fauna of a particular unit of the environment is a list of the animal species occupying that unit, while the population is a real community of animals, which depends also on the numbers of single-species populations (Beklemishev, 1970).

Materials and Methods: Monogeneans from 1 520 specimens of fishes belonging to 6 species of Beloniformes. A comparative analysis was carried out using quantitative measurements of similarity.

Results: Fifteen species of monogeneans were recorded. Relatively high similarity indices of monogenean faunas (MF) were found in fish species of the same genus (0.56; 0.57), while the lowest was found in fishes of different families (0.20). Fishes of the same ecological group had lower similarity indices MF (0.30; 0.49) than the most ecologically different groups of fishes (0.33).

Fish species of the same genus had lower similarity indices of monogenean populations (MP) (18.3%; 5.4%) than those from different genera within one family - 32%; and from different families - 23%. MP from fishes of the same ecological group had relatively high similarity indices (33%; 73%). The lowest index (7.6%) was recorded for MP from the most ecologically different groups of fish.

Conclusion: The similarity of MF depends mainly on the degree of affinity (systematic) between the hosts. In contrast, the similarity of MP does not show any clear dependence on the affinities between the hosts, but depends mainly on their ecological similarity.

THE LABORATORY RAT AS DEFINITIVE AND INTERMEDIATE HOST FOR *SARCOCYSTIS RODENTIFELIS* (PROTISTA: COCCIDIA) FROM THE BLACK RAT

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Objective: As we have shown recently, *S. rodentifelis* can circulate among Wistar Norway laboratory rats (*Rattus norvegicus*) by means of cannibalism. In such a life cycle both sexual (oocysts and sporocysts) and asexual (sarcocysts) stages of the parasite were detected in the same host species. This study aimed to investigate the possibility of transmission of *S. rodentifelis* from black rats (*R. rattus*) to Norway rats without the participation of a carnivorous definitive host (cat).

Materials and Methods: Three captured black rats which had been infected with sarcocysts, morphologically indistinguishable from *S. rodentifelis*, served

as the initial source of material. Laboratory rats were infected by feeding them with muscle from black rats. Microscopy of stained muscle sections and unstained squashes of sarcocysts and of small intestine samples were used, as well as various flotation and concentration methods for investigation of other coccidia.

Results: Sarcocysts were detected in muscles of laboratory rats after eating muscles of black rats containing sarcocysts with mature cyst merozoites. In another experiment, thin-walled sporulated oocysts and sporocysts were found in the small intestines of rats on the 9th and 30th days after having fed them with infected muscle. These intestines were infective for healthy rats. The laboratory rat served both as definitive and intermediate host for *S. rodentifelis*.

Conclusion: *S. rodentifelis* can spread between individuals of two different rat species by predation. The Norway rat acts as a predatory definitive host in the parasite's life cycle while the intermediate host is the black rat. Definitive hosts for *S. rodentifelis* (cat and Norway rat) belong to two different orders.

THE HELMINTH FAUNA OF THE COMMON SHREW, *SOREX ARANEUS* L., FROM TWO SITES NEAR VIENNA, AUSTRIA

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Objective: The fauna and infection levels of intestinal helminths of the common shrew, *Sorex araneus* L., were studied. The shrews were collected at

two sites near Vienna, namely Stockerau and Lobau, between 1960 and 1962. A comparison of the helminth species composition and the intensities are given and the dependence of the helminth fauna on the sex and age of the host was also investigated.

Materials and Methods: One hundred and fifty-five specimens of the common shrew, *Sorex araneus* L., 115 obtained from Stockerau and 40 from Lobau, were dissected. Body cavity, the organs (heart, liver, lung, spleen, kidneys, pancreas and urinary bladder) and the alimentary tract (oesophagus, stomach and the intestine) were examined.

Results: So far, four species of cestodes (*Molluscotaenia crassiscolex*, *Hymenolepis diaphana*, *Neoskrjabinoilepis schaladybini*, *Hymenolepis singularis*), eight species of nematodes (*Calodium cholidicola*, *Crenosoma skrjabini*, *Eucoleus oesophagicola*, *Liniscus incrassatus*, *Longistriata* sp.1, *Longistriata* sp.2, *Parastrongyloides winchesi*, *Porrocaecum* sp. larvae) and two species of trematodes (*Brachylaemus fulvus*, *Dicrocoelium soricis*) have been found. In total, 92.9 % (144 out of 155 shrews) carried at least one species of helminth. 78.7 % (122/155) had cestodes, 71.6 % (111/155) nematodes and 54.8% (85/155) trematodes. The maximum intensity of cestodes was 1419, of nematodes 85 and of trematodes 16 per shrew. In general adult shrews were more heavily infested than juveniles.

Conclusion: The high prevalence of helminths in *Sorex araneus* L., as found in the neighbouring countries of Austria, was confirmed for the first time for the environs of Vienna. Nevertheless, there is a need for further investigations, especially with recent collections.

ARE POPULATION DYNAMICS OF WILLOW PTARMIGAN AFFECTED BY PARASITES?

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Most field investigations of host-parasite population dynamics have been restricted to the study of a single parasite species, and often conducted over short time intervals relative to the life expectancy of the host. Willow ptarmigan (*Lagopus lagopus* L.), like most other vertebrate populations, carry a whole community of parasites and the transmission of each is likely to be affected both by host densities and climate.

In order to get a long-term data set in which data for both host and parasite densities could be obtained, we have collected autumn samples of willow ptarmigan since 1992. All hosts have been shot from a single coastal locality in Kattfjord (69°40' N, 18°15' E), at the island Kvaløya in Troms county, Norway. This sampling program will continue at least until 2002. Each ptarmigan is thoroughly searched for protozoans and helminths in the intestinal system, blood and other tissues.

So far we have found four species of nematodes - *Ascaris compar*, *Capillaria caudinflata*, *Splendidofilaria papillocerca* and *Trichostrongylus tenuis*; and two species of cestodes - *Hymenolepis microps* and *Paroniella urogalli*. Oocysts of *Eimeria* sp. have been found in the caecal contents. *Leucocytozoon lovati*, *Trypanosoma* sp. and microfilariae have been found in blood smears. The ptarmigan population has un-

dergone a steady increase in density during the last five years, and our continued study will allow us to obtain detailed, long-term quantitative data on the changes in the parasite community with changing host density. More specifically we will ask the following questions in our study:

Do parasite burdens increase prior to a host population decline?

Which are the dominant parasites associated with the decline?

Is there a relationship between breeding production and parasite intensity?

Is there an association between estimates of host body condition and parasite intensity?

Is there a positive association between parasite species?

Is this relationship linear or non-linear indicating synergism between parasite species?

ECOLOGICAL ANALYSIS OF THE FISH MYXOSPOREAN FAUNA OF AZERBAIJAN WATER BODIES IN THE LIGHT OF NEW DATA ABOUT THE BIOLOGY OF THESE PARASITES

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Objective: The analyses of fish infection with myxosporeans in relation to the location of spores in a water body.

Material and Methods: In 1972-99, 4167 fishes belonging to 63 species and subspecies were examined in Azerbaijan water bodies. The myxosporean collection of the

Institute of Zoology of Azerbaijan Academy of Sciences was also studied.

Results: Sixty-seven species were found in Azerbaijan water bodies.

Conclusion: The myxosporean fauna of benthic fishes is richer (60 species) than that of pelagic fishes (24) because oligochaetes in which the actinosporean phase grows usually inhabit the bottom. The myxosporean fauna of lowland water bodies is richer (60) than that of pre-mountain (42) and especially mountain (18) water bodies because the water current carries the myxosporean away from mountain and pre-mountain areas to the lowland.

The myxosporean fauna depends on the dimensions, geographical location and ecological conditions of every water basin. All Azerbaijan rivers flow down into the Caspian Sea (53 species) and bring myxosporean spores. Kura (49) is the largest river of this region. Araz (29), north-eastern Azerbaijan rivers (17) and Lenkoran rivers (15) are smaller and have very fast currents. Apsheron Peninsula (12) is characterized by semi-desert climate.

ON THE FORMATION OF INFECTION FOCUSES OF ECHINOSTOMOSIS IN SEABIRDS IN THE BARENTS SEA

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Objective: The echinostomatid trematode fauna was studied in the seabird and intertidal mollusc populations of the Barents Sea (East Murman coast) in 1995-1997.

Materials and Methods: Twenty-two birds of five species, *Somateria mollissima*, *Rissa tridactyla*, *Calidris maritima*, *Larus argentatus*, *L. marinus*, and about 8 000 specimens of the intertidal molluscs *Littorina saxatilis* and *Mytilus edulis*, were examined.

Results: *Himasthla larina* was found in the herring gull, while *Himasthla leptosoma* infected the population of the purple sandpiper. The kittiwakes and eiders were free of infection by echinostomatid trematodes. The molluscs infected with larval echinostomatids were found only in the Yarnyshnaya and Khlebnaya inlets in the samples collected on the sand and mud intertidal flats. The infection levels of whelks were rather low (not higher than 3%), while the blue mussels were heavily infected (80-100 %).

Conclusion: Representatives of only one genus of the family Echinostomatidae, *Himasthla*, were recorded in the seabirds of the Barents Sea. Their major definitive hosts here are purple sandpipers and seagulls. The formation of infection focuses occurs strictly in certain areas, which are enclosed or well-sheltered embayments and basins of a fjord type with vast sandy or muddy intertidal flats. The successful establishment of the infection focuses is facilitated by the fact that infection of the second intermediate host, blue mussel, is very high (up to 100 %). This is due to the existence of the endogenic reproductive stage in the first intermediate host *L. saxatilis* and the continuous emission of cercariae into the environment.

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THE TRICHINELLOSIS SITUATION IN ESTONIA

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Objective: To evaluate the present epidemiological situation of trichinellosis.

Materials and Methods: From 1992 to 1999 muscle samples from 1987 sylvatic, domestic and synanthropic animals were collected. Using the method of artificial digestion the prevalence and intensity of trichinellosis were determined. Species of *Trichinella* were identified by PCR (RAPD) analysis.

Results: Cases of human trichinellosis have been registered almost every year. *Trichinella* infection was established in all animal species (14) investigated. The prevalence of infection was highest in wolves (79.4%), raccoon dogs (50.0%), lynxes (47.4%) and red foxes (42.1%). Intensity of invasion was highest in raccoon dogs and red foxes (up to 213 larvae/g). 1.0% of wild boars and 29.4% of bears were infected. Only two foci of trichinellosis in domestic pigs were registered, *T. britovi* and *T. spiralis* being identified. Most of the wild animal species were infected with *T. nativa* and *T. britovi*. In farm fur-animals *T. nativa* and *T. spiralis*, and in brown rats *T. spiralis*, were found.

Conclusion: *Trichinella* spp. are widely distributed in the wildlife fauna in Estonia. Domestic animals and human beings are endangered by trichinellosis.

EFFICACY OF SOME INTEGRATED AND NON-CHEMOTHERAPEUTIC CONTROL METHODS AGAINST LAMB MONIEZIOSIS IN ESTONIA

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Objective: Lamb monieziosis one of the frequently registered diseases in Estonia. According to our investigations, approximately 9–14% of young sheep were infected. To work out control measures, different pasture regimes were combined with prophylactic treatments. The main purposes of our trials were to reduce the use of chemotherapeutic preparations and to avoid contamination of the environment.

Materials and Methods: The major invasion sources of sheep monieziosis in Estonia were examined. Trials were conducted on sheep flocks of several Estonian large-scale farms where lambs were grazed on cultivated pastures. Investigations on the effectiveness of applied measures were estimated by identifying the eggs of *Moniezia* on the basis of faecal flotation procedures.

Results: In three trials, *Moniezia*-free lambs were allowed to graze alone on pastures contaminated with parasites of the previous year. After the observation period 16%, 24% and 55% respectively were infected. The mean prevalences of infection of weaned lambs, grazed with ewes on contaminated pastures, were 8%, 18% and 24% respectively. Lambs weaned during the indoor holding period and grazed separately on contamination-free pastures were not infected with *Moniezia* eggs. With separate grazing on contaminated pasture and a single treatment after 20 days of the grazing period, 3–8% of lambs were still infected

in October. If the lambs were treated twice, after 20 and 45 days, 1.5—2.2% were still infected in autumn. Clinical symptoms of the disease were not observed.

Conclusions: Pastures contaminated with parasites of the previous year are the main sources of infection for lambs. Infection levels in lambs grazed with ewes on contaminated pastures were lower than in lambs grazed separately on comparable pastures. Two treatments of lambs after 20 and 45 days of the grazing period on contaminated pastures eliminated the spread of moniezia in sheep flocks.

SEVERAL ASPECTS OF THE INFLUENCE OF ABNORMAL LIGHT CONDITIONS ON THE PREIMAGINAL STAGES OF BLOOD-SUCKING MOSQUITOES

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Objective: The influence of abnormal light conditions (constant darkness, constant light) on the preimaginal stages of *Aedes communis*, one of the abundant species of blood-sucking mosquitoes in Karelia, was studied to test the hypothesis concerning the existence of a non-specific response to the unfavourable conditions in Culicidae. The rates of larval and pupal development and mortality at preimaginal stages, and the morphometric features of imago were investigated.

Materials and Methods: Fourth-instar larvae collected from natural reservoirs were reared under different light conditions: 1) natural photoperiod (control; light:dark = 17:7 h.), 2) constant darkness, 3) constant light. Onset and duration of

pupation and emergence, numbers of dead individuals, wing length and dry weight of the adult mosquitoes, were recorded.

Results: Under abnormal light conditions, the rates of development and mortality increased and the ratio of wing length and dry weight changed. Response to constant light conditions of some values (duration of larval development, mortality rate) was less pronounced than to constant darkness.

Conclusion: The results obtained agreed with the data on the influence of some unfavourable factors (high temperature, high salinity, overcrowding, toxicants) on Culicidae. Thus, the hypothesis concerning the existence of a non-specific response to abnormal conditions in blood-sucking mosquitoes has been confirmed. More stable values of *Aedes communis* under constant light, in comparison with constant darkness, may be caused by development of preimaginal stages in the nearly constant natural light conditions.

THE HELMINTHS OF REPTILES FROM SOUTH URALS

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Objectives: To investigate the helminthofauna of eight species of reptiles (out of 13 species inhabiting South Ural).

Materials and Methods: Reptiles were collected from the territory of Bashkiria (South Ural, Russia) during 1997-1999 field seasons. One hundred and fourteen specimens of reptiles belonging to eight species (including one turtle, three lizards and four snakes) were examined by total helmintho-

logical dissection. All helminths found were counted, sorted and collected.

Results: We found 16 species of reptile-hosted helminths: eight species of trematodes and eight species of nematodes; five species were present as larval stages. *Anguis fragilis* and *Natrix natrix* were 100% infested (3/3 and 15/15 respectively). The most common parasites were *Telorchis assula* (Dujardin, 1845) from *N. natrix* and *Neoxyssomatium brevicaudatum* (Zeder, 1800) from *A. fragilis*.

Conclusion: The intensity of infection varied considerably from one to 403 parasite individuals per host (74.0 on average); the mean prevalence of invasion was 27.2%. The results obtained are the first contribution to the investigation of the helminthofauna of reptiles in South Urals.

PARASITES OF THE EEL IN LATVIA

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Objective: Eels from the Venta River, Usmas Lake and coastal waters of the Riga Gulf were investigated.

Materials and Methods: Since 1994, 63 eels were studied by the method of total parasitological examination. Thirty-four fishes were investigated completely, while 29 were examined solely for infection by the nematode *Anguillicola crassus*. To study the biology of this nematode we also examined 47 perch and 18 ruff.

Results and discussion: A total of 17 parasite species were found. The monoge-

neans *Pseudodactylogyrus anguillae* and *P. bini* from the gills and the blood flagellate *Trypanosoma granulosum* were found for the first time in reservoirs of Latvia. The most widespread parasite of the eels was the nematode *A. crassus*, which was found for the first time by us in 1994. Nematode infection has increased gradually during the following years and reached a maximum in 1998 when all fishes were infected with a maximum intensity of 126 nematodes. In Usmas Lake a mass disease of eels occurred, with mortalities recorded.

A preliminary study of the *A. crassus* life cycle shows that paratenic hosts of this parasite in Latvia are mainly ruff and rarely perch.

Both species of *Pseudodactylogyrus*, as well as *Acanthocephalus lucii*, were found very frequently. Although the maximum intensity of infection by monogeneans was high, pathogenic changes in the gills were not observed. This was also the case with *Bothriocephalus claviceps*, *Raphidascaris acus* and *Camallanus lacustris*.

Other parasite species infect eels seldom and even rarely. The exception is *Anodonta* sp., maximum numbers of which were observed in the early spring. It occurred frequently at high intensities, but caused no disease.

Conclusion: The parasite fauna of the eel in reservoirs of Latvia is poorer than reported in the literature by other authors (Shulman, 1949; Koie, 1988; Kennedy *et al.*, 1992). It is necessary to study other reservoirs in the country to make a final conclusion.

ON THE ISOPOD FISH PARASITE FAUNA OF THE ATLANTIC COAST OF NORTH-WESTERN EUROPE

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Objective: The present study focuses on the analyses of the Isopoda fish parasite fauna of the Atlantic coast of north-western Europe, which are represented by facultative, temporary and permanent parasites.

Materials and Methods: From the author's own records and from literature data, about 195 species of Isopoda fish parasites are known for the Atlantic Ocean basin. Twenty-six species have been recorded in the North Sea, including three facultative, 17 temporary and 6 permanent parasite species. Fifteen parasitic isopods are known for the Irish Sea, including four facultative and 11 temporary species. Representatives of the family Cymothoidae - permanent parasites of fishes - have not been recorded in this region. Only one species was recorded in the Baltic Sea - *Aega psora* L., 1759, which is widespread throughout the North Atlantic. *Aega psora* is a temporary parasite of fish known also from the North and Irish Seas.

Results: Thus, the parasitic isopod faunas can be compared only for the North and Irish seas. There are 11 common parasitic isopod species in these seas (Czekanovskii-Sorensen index of similarity is equal to 0.54). Of these, two species are facultative and nine species are temporary. There are no common species belonging to the family Cymothoidae.

Conclusion: Isopods representing facultative and temporary parasites are the usual forms found in boreal waters. Permanent

parasites of the family Cymothoidae are characteristic mainly of the tropical regions of the ocean. Most probably this fact is connected with the level of tension within trophic links in different geographic zones of the world's oceans.

ISOPODA PARASITES OF NORTH SEA FISHES

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Objectives: The present study focuses on the analysis of the Isopoda fish parasite fauna of the North Sea which is represented by facultative, temporary and permanent parasites.

Materials and Methods: From the author's own records and from literature data, 26 species of parasitic isopods infecting 29 fish species have been recorded from the North Sea. Facultative and temporary forms are dominant (80%). The family Aegidae is most numerous both in number of species and in number of infected hosts. Four ecological groups of fishes infected with parasitic isopods are recognized for the North Sea. Fishes of the coastal shelf group are dominant (15), and the largest number of parasitic isopods is also known from these (14). 45.8% of them are representatives of the family Aegidae - the characteristic element of the isopod fauna of bottom and near-bottom fishes. Five coastal pelagic fish species have four isopod species. Seven isopod species, common in the shelf waters of the north-eastern Atlantic, have been recorded on the six fish species of the bathypelagic group. One isopod species has been recorded on three species of brackish water and euryhaline fishes.

Results: Most of the 26 isopod species recorded from the North Sea belong to the families Aegidae and Cirolanidae. Widespread in northern waters, they are distributed far to the south, having been recorded even near the coast of Africa. Only five of the most eurybiotic species of the family Cymothoidae have reached this sea, which is the northern boundary of their distribution.

Conclusion: The isopod fauna of the North Sea is heterogeneous, including elements of both boreal and Mediterranean-Lusitanian faunas.

THE PARASITE CAPACITY OF THE HOST POPULATION

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Objective: The problem of parasitic pressure on the host population (PrP) is considered.

Materials and Methods: The approach is based on the concept of changing extinction probability of a host population under the influence of parasites.

The change of host population size is considered as Markov process. The probabilities of all changes of population size for a generation are described by a matrix of transition (π) with dimensions $N_{max} \times N_{max}$ (maximum population size). The probabilities of all possible size changes for T generations can be calculated as π^T .

Only available parameters are used in the construction of matrix π - sex ratio, fecundity, mortality, prevalence of infection (PI). It is assumed that these parameters are constant and that the parasitic castration of the host takes place.

Results: There are critical values of PI above which the host population dies out. These values of PI are proposed to be used as the quantity estimation of permissible PrP. For its designation the term «parasite capacity of the host population» (PCP) is used. The mathematical approach to estimate PCP is developed and its strict definition is given:

PCP is the heaviest possible PI, at which, with the generation number T approaching infinity, there exists at least one initial population size n_i for which the probability of size decrease through T generations is less than the probability of its increase.

Conclusion: Use of empirical values of PI as an estimation of PrP is insufficient. The estimate of PrP should be carried out in the light of the changing extinction probability of the host population under the influence of parasites.

ECTOPARASITES OF JUVENILE (AGE 0+, 1+) COD, *GADUS MORHUA*, IN ICELANDIC WATERS - PRELIMINARY RESULTS

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Objective: To investigate when ectoparasites start to infect juvenile wild cod (age 0+, 1+) in Icelandic waters and to analyse the progress of infection.

Materials and Methods: In 1998-2000 approximately 720 fish at four, six, 10 and 18 months of age were examined for ectoparasites. In addition, 30 cod at 22 months

of age were screened for *Lernaeocera branchialis*.

Results: *Trichodina* sp. was found on six and 18 months old fish with a prevalence of <7% (intensity 1-29). *Gyrodactylus* sp. was found on one six months old fish, with a prevalence of <1% (11). *Caligus* sp. larval stages were found on all age groups. At four months of age no *Caligus* larvae were detected in 1998, but in 1999 the prevalence at the same age was 20% (1-3); > 98% (1-51) at six months; 53% (1-8) at 10 months and 36% (1-2) at 18 months. The prevalence of *Clavella adunca* was <12% (1) at six months, 22% (1-3) at 10 months and 46% (1-6) at 18 months. *Lernaeocera branchialis* was only found on the 18 and 22 months age groups with a prevalence of 10% (1) and 37% (1-2) respectively.

Conclusions: The diversity of ectoparasites increases with age. *Trichodina* sp. and *Gyrodactylus* sp. were occasionally found, their prevalence possibly being underestimated because these parasites are easily lost during sampling. The prevalence of *L. branchialis* and *C. adunca* increases with the age of the host. The prevalence and intensity of infection with *Caligus* sp. larvae reaches a peak at six months of age, followed by a marked decrease. The study is supported by the Icelandic Research Council and the Icelandic Republic Fund.

PARASITISM AS A BIOINDICATOR OF ECOLOGICAL AND SEASONAL CHARACTERISTICS OF SEABIRD POPULATIONS (BY THE EXAMPLE OF THE MURRES FROM SEVEN ISLANDS ARCHIPELAGO)

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Objective: In 1993 and 1999, a parasitological survey of two murre populations, the common guillemot, *Uria aalge*, and Brunnich's guillemot, *U. lomvia*, of Seven Islands Archipelago was carried out to study the main features of their ecology and seasonal dynamics using the methods of helminthological testing.

Materials and Methods: Parasitological examination of digestive tracts and stomach contents of 20 specimens of *U. aalge* and 21 specimens of *U. lomvia* was conducted. Helminths were preserved with either 70 % ethanol or 4 % neutralised formaldehyde.

Results: 20 % of *U. aalge* were infected with cestodes with a maximum intensity of infection of nine worms per specimen, 10 % with nematodes (about one worm per bird). The population of *U. lomvia* was much more heavily infected with parasites. 47.6 % of birds were infected with cestodes (55 worms per specimen), and 52.4 % with nematodes (47 worms per specimen). It is noteworthy that in *U. aalge*, mostly parasites with gammarids and ammodytids as intermediate hosts were found, whereas in *U. lomvia* the intermediate hosts were euphausiids and capelin. Prevalences and abundances of infection of birds were higher in 1999 than in 1993.

Conclusion: The basic diet of *U. adige* in the study area consisted largely of *Ammodytes* spp., whereas the capelin represents the main food item for *U. lomvia*. Feeding grounds of the former species are located much closer to the shoreline. The infection of birds with helminths increases in the years characterised by a peak abundance of birds, and vice versa.

The work was supported by INTAS (project N 97-10224).

ASSESSMENT OF THE PATHOGENICITY OF SEABIRD HELMINTHS USING BIOCHEMICAL TESTING

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Objective: The pathogenicity of different groups of seabird helminths was examined in 1999 using the methods of biochemical testing. The study was carried out in the Dalnezelenetskaya Inlet (East Murman) in two larid populations, the black-backed gull, *Larus marinus*, and the herring gull, *Larus argentatus*.

Materials and Methods: Nine specimens of *L. marinus* and three specimens of *L. argentatus* were studied. Samples of plasma were extracted from bird blood, in which the content of glucose and γ -globulins was measured. The birds were also examined for parasites, then the relationships between the parasitological and biochemical characteristics were studied.

Results: There were no correlations between the biochemical parameters and levels of infection by nematodes and trema-

todes. Increasing intensity of infection by cestodes was accompanied by an increase in glucose concentration. The highest content of γ -globulins was observed in birds infected with larval cestodes and a somewhat lower content in birds infected with adult cestodes. The lowest concentrations of glucose and γ -globulins were found in a gull free of these worms.

Conclusion: The cestodes are the most pathogenic group of helminths infecting the seagull populations on East Murman. The highest stress on the immune system of infected birds was inflicted by the larval cestodes.

The work was supported by INTAS (project N 97-10224).

COPROPHAGY AND TRANSPLACENTAL TRANSMISSION AS POSSIBLE WAYS OF DISTRIBUTION OF SOME SARCOSPORIDIAN (PROTISTA: COCCIDIA) SPECIES IN RODENTS

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Objective: Our knowledge of the modes of transmission of Protozoa of the genus *Sarcocystis* is insufficient. Such studies are of prime importance for species with a cannibalistic mode of transmission. The aim of the present work was to clarify the ecological significance of coprophagy and transplacental transmission of *Sarcocystis rodentifelis*.

Materials and Methods: Three experiments were carried out on 340 Wistar Norway laboratory rats. Sarcocysts in muscle sections were determined microscopically. To detect oocysts or sporocysts, faeces were examined by different methods.

Results: It was determined that the intestines of rats infected with sarcocysts of *S. rodentifelis* became infective for intact rats during the period from the 4th-8th to 54th-70th day (duration of the experiment).

Intact rats became infected on the 6th to 80th day after they were fed on faeces of the rats infected with sarcocysts. Sporocysts and oocysts of *S. rodentifelis* were found in the faeces of rats infected with sarcocysts. This is the first record of the finding of *Sarcocystis* oocysts and sporocysts in the faeces of rodents.

Sarcocysts were not detected in 83 ratlings born from eight females fed on the intestines with oocysts and sporocysts of *S. rodentifelis* at different days during pregnancy.

Conclusions: The faecal-oral way is important in distribution of *S. rodentifelis*, whereas the transplacental route of transmission is ecologically insignificant.

The studies were subsidised by the Lithuanian State Research and Higher Education Fund (1999, Nr. 353).

A NEW DISEASE IN PERCH (*PERCA FLUVIATILIS*): OCCURRENCE OF LYMPHOCYSTIS IN FINNISH LAKES

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like particles inside them were noted on the skin of perch (*Perca fluviatilis*) in three of four lakes studied in central Finland. They were found both on scales and on scaleless regions. The surrounding tissue was not affected, the border between the nodules and the skin being clearly structured. The occurrence of lymphocystis was greatly dependent on the season of the year. Highest prevalences were found in two subareas of the largest and deepest oligotrophic lake of the study in March and April (60%), while nodules were practically absent during the summer and autumn months. The seasonality of the occurrence of lymphocystis is suggested to be due to spawning stress of the host in spring and a temperature-activated immune response of the host in summer, causing the disappearance of the nodules. In addition to the seasonal study in the largest lake, perch were also monitored from all of the four lakes in May during two subsequent years (1997, 1998). The highest prevalences were found in the oligotrophic lake in both years (39%, 34% respectively) and in the most isolated and smallest forest lake (31%, 12% respectively) while in the other forest lake the prevalence was only 10% in both years. In the fourth lake influenced by humic substances, lymphocystis was absent. A study of the localisation of lymphocystis in five sites in the large oligotrophic lake in May 1997 and 1998 revealed that lymphocystis occurred abundantly in all areas of the lake (in 1997 prevalence varied between 33-61% and in 1998 between 20-45%). Lymphocystis has not been reported earlier on perch. How common it is, and what factors induce its appearance need further studies.

Small, white lymphocystis nodules (< 1mm) of hard consistency and with virus-

NEW DATA ON THE EPIDEMIOLOGY OF BIRD HAEMOPROTEIDS ON THE CURONIAN SPIT

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Objective: To determine possible vectors of haemoproteids (Haemosporida: Haemoproteidae) on the Curonian Spit and to investigate the peculiarities of the vectors and the distribution of parasites there.

Materials and Methods: The material was collected in May-August 1997-1999. To investigate the fauna of vectors, 295 specimens of biting midges (genus *Culicoides*) and 106 specimens of hippoboscid flies (genus *Ornithomyia*) were collected. To determine spontaneous infection of vectors with haemoproteids, the salivary glands of 201 specimens of *Culicoides* sp. and 106 specimens of *Ornithomyia* sp. were investigated. Twenty five specimens of *C. impunctatus* were also experimentally infected with *Haemoproteus fringillae*. Spontaneous infection of the Chaffinch (*Fringilla coelebs*) with haemoproteids was monitored on the study site.

Results: *C. impunctatus* was the most abundant species of biting midge (94.6% of the collected specimens), and *O. avicularia* was the most frequently found species among hippoboscid flies (47.2%). *Culicoides* sp. and *Ornithomyia* sp. were not spontaneously infected with haemoproteids. Sporozoites were found in 44.0% of *C. impunctatus*, which were experimentally infected with *H. fringillae*. Over 45% of adult and 15% of juvenile Chaffinches were spontaneously infected with haemoproteids.

Conclusions: The Chaffinch is a common host of haemoproteids. The highest seasonal activity of *Culicoides* sp. coincides

with the appearance of the Chaffinch offspring. *C. impunctatus* is abundant on the study site and is highly susceptible to infection with haemoproteids. The most active transmission of haemoproteids occurs in May-June, and *C. impunctatus* is the most likely vector of haemoproteids on the Curonian Spit.

EFFECTS OF DIFFERENT NATURAL PRODUCTS AGAINST SARCOPTIC MANGE MITES IN SWINE

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Objective: Pig mange caused by the parasitic arthropod mite *Sarcoptes scabiei* var. *suis* is a widespread contagious skin disease and is recognized as a major contributor to losses in swine productivity. As several plants with insect reproductive inhibitors and repellents have long been used for medical purposes, the possibility of the use of natural plant extracts against swine mange mites was investigated.

Materials and Methods: Laboratory tests on the viability of swine sarcoptic mange mites were carried out. Our investigations were made on the effect of ethereal oils of tea tree (*Melaleuca alternifolia*), black pepper (*Piper nigrum*), sweet orange (*Citrus sinensis*), pennyroyal (*Mentha pylegium*), citronella (*Cymbopogon nardus*), eucalyptus (*Eucalyptus globulus*) and juniper (*Juniperus communis*) and on extract of garlic (*Allium sativum*).

Results: According to the results of our laboratory trials, all the tested plant products proved to be effective against adult swine mange mites: in their 0.5—2% water emulsions the lethality *in vitro* was registered up

to 95—100% in 24 hours. Our data show that the most effective preparation against mange mites was tea tree oil - even after only one hour a 100% death rate of parasites was recorded. After three hours comparisons of means were used to compare the results of different variants.

Conclusion: Our results of trials carried out with various plant extracts led to the conclusion that on the basis of such studies it would be possible to develop new biological parasite control methods, and that natural plant products might be used against animal external parasites as alternatives to neurotoxic insecticides.

STUDIES ON THE FEMALE REPRODUCTIVE SYSTEM OF *DIPHYLLOBOOTHRIUM LATUM*

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Objective: The study was carried out on *Diphylllobothrium latum* (L.) (Cestoda: Pseudophyllidea).

Materials and Methods: Adult worms of *D. latum* were obtained from an experimentally infected cat. Plerocercoids of these cestodes were removed from the body cavity of a pike (*Esox lucius*) collected from Rybinsk reservoir. Materials were fixed in 4% glutaraldehyde in cacodylate buffer, then in OsO₄, dehydrated for TEM.

Results: The epithelium of the female reproductive system ducts consists of a nucleate syncytial layer. Structural differences in apical surface of the ducts, the number of nuclei and organoids in syncytial layer as well as the number of underlying muscles were revealed. Numerous cilia were found on the vitelloduct surface, but

no cilia were found in the vitelline reservoir. The oviduct wall was elevated in the form of lamellae, which were plicated along their length. The ootype was characterized by the presence of lamellae, cilia and unicellular Mehlis' glands. It was shown that the formation of egg shells was implemented by the deposition of vitelline globules in their surface in the ootype-uterine duct. The regional differentiations of the uterus wall were recorded. The proximal region of the uterus was covered by microlamellae and the distal one by microtriches. Filamentous microtriches were observed on the apical surface of the vagina.

Conclusion: Structural and functional differences and the origin of different parts of the female reproductive apparatus for various groups of cestodes are conditioned by the biology of each species.

Acknowledgments: The study was supported by the Russian Foundation for Basic Research (N 99-04-48465).

INFLUENCE OF ENVIRONMENTAL FACTORS ON SURVIVAL OF TREMATODE CERCARIAE FROM LITTORAL PROSOBRANCHS OF THE WHITE AND THE BARENTS SEAS: AN EXPERIMENTAL STUDY

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Objective: To study the influence of different water temperatures and salinities on the survival of free-living larvae (cercariae) of marine trematodes.

Material and Methods: The average longevities (LT₅₀) of cercariae of seven trematode species were studied experimentally at three temperatures (5°C, 10°C, 20°C) and four salinities (8, 16, 24 and 32‰). Cer-

cariae used in experiments were released in the laboratory from naturally infected intertidal molluscs *Hydrobia ulvae* and *Littorina saxatilis*. *H. ulvae* infected by *Cryptocotyle concavum* (Heterophyidae), *Levinseniella brachysoma*, *Maritrema subdolum* (Microphallidae), *Himasthla elongata* (Echinostomatidae), and *L. saxatilis* by *Renicola roscovita* (Renicolidae), were collected in the White Sea, and *L. saxatilis* infected by *Podocotyle atomon* (Opecoelidae) and *Renicola thaidus* (Renicolidae) in the Barents Sea.

Results: The results of the experiments showed that temperature resistance and salinity tolerance of cercariae from the White Sea snails were higher than of those from the Barents Sea. Significant decreases in the LT_{50} of the «White Sea cercariae» was recorded in water of 8‰ salinity and of the «Barents Sea cercariae» even at 16‰. The rate of LT_{50} decrease with increase in water temperature was also lower in the former cercariae than in the latter.

Conclusion: Cercariae shed from the White Sea molluscs are able to survive under a relatively wider range of environmental factors (temperature, salinity) than larvae from the Barents Sea periwinkles. This might be determined by the fact that the seasonal and daily fluctuations of water temperature and salinity in the intertidal zone of the White Sea are higher than of the Barents Sea.

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PLATELET ACTIVATION MARKERS IN PARASITIC DISEASES

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Objective: Blood platelets actively participate in the immune mechanisms of the organism (e.g. antiparasitic immunity). Platelet stimulation may be caused by contact with a parasite, the increase of IgE antibody concentration, and the presence of complement and lymphokines. In our studies we have tried to answer the question of whether a parasitic infection can cause the platelet activation.

Materials and Methods: Thirty-five patients (aged 19 - 58) treated in the Department of Infectious Diseases underwent the examinations. Twenty-one patients were infected with *Giardia intestinalis* (Gi) and 14 patients with *Echinococcus granulosus* (Eg). Blood samples were taken twice: before treatment (A1) and after antiparasitic therapy (A2). The control group consisted of 33 healthy individuals, aged 19 - 45. The venal blood was transferred to Vacutainer testing tubes containing CTAD (citrate, theophylline, adenosine, and dipiridamol). β -thromboglobulin and PF4 concentrations were determined with the use of AS-SERACHROM kit (Boehringer Mannheim) by the immunoenzymatic method.

Results: Blood platelet secretory activity was determined by the release of two proteins (β -thromboglobulin and PF4) out of α -granules. The concentration of these proteins is shown in Table 1 (next page).

Parameters	Examined group, n=35		Control group, (K) n=33	p*
	Al	A2		
Platelet factor 4 (IU/ml)	20.3±9.4	6.0±3.0	2.27±0.88	Al:K p<0.05* A2:K p<0.05* Al:A2 p<0.05*
β-thromboglobulin (IU/ml)	33.6±5.8	7.5±2.8	4.73±2.1	Al:K p<0.05* A2:K p<0.05* Al:A2 p<0.05*

Table 1. Blood protein concentrations

Conclusion: Despite the lack of platelet direct contact with a parasite, the increase in concentrations of β-thromboglobulin and PF4 (especially before antiparasitic treatment) points to the increased platelet activation.

A PCR – BASED METHOD FOR THE DETECTION OF *TETRAHYMENA CORLISSI* CONTAMINATION OF *ICHTHYOPHTHIRIUS MULTIFILIIS* IN *IN VITRO* CULTURE

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Objective: Development of a PCR-based method to test *in-vitro* *Ichthyophthirius multifiliis* cultures for *Tetrahymena corlissi* contamination.

Materials and Methods: Primers derived from the 18S-rRNA gene were tested for specificity and sensitivity for detection of *I. multifiliis* and *T. corlissi*. Parasites

included in the tests were sampled from both *in-vitro* cultures and from infected rainbow trout (*Oncorhynchus mykiss*). *I. multifiliis* was maintained in Blue fin (BF) cell lines at 15°C using minimal essential medium (MEM).

The selected PCR primers

D-1 (5'-CTAATTGTTGGGCTAATACATG-3'),
D-2 (5'-TCAATGCCGTAGAGAGAAGAATC-3'),
and

D-3 (5'-GACGAGTCGTTATGAGTCTG-3')
were obtained from GIBCO BRL Life technologies (Basel, Switzerland).

Results: The PCR test used was found to be sensitive even for single cell analysis, and an effective discriminator of the two species during all life-cycle stages.

Conclusion: This test was found to be a rapid and accurate tool for the detection and differentiation of the two related parasites *I. multifiliis* and *T. corlissi*. This procedure will now facilitate the *in-vitro* culture of *I. multifiliis* by overcoming the initial difficulties encountered in determining the contamination status of cell cultures.

DEPENDENCE OF TELEOSTEI HELMINTH FAUNA FROM ATLANTIC ANTARCTIC WATERS ON THEIR FEEDING PECULIARITIES

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Teleost fishes from South Georgia, the South Shetlands and Antarctic Peninsula waters were examined to determine the dependence of their helminth fauna (species with complex life cycles) on the host's feeding habits. The helminths were collected from fresh and frozen fish specimens in 1972-1989.

In total 1036 specimens belonging to 38 fish species (12 families) were investigated. Forty helminth species (11 acanthocephalans, 7 cestodes, 14 trematodes, 8 nematodes) were found (32 species at South Georgia, 33 at South Shetlands and 19 at Antarctic Peninsula). The helminth species composition indicates that Antarctic fishes feed intensively on krill and benthic invertebrates, such as mysids and amphipods.

The highest similarity of fish helminth fauna was observed between South Georgia and South Shetlands (Sorensen-Czekanowski index - 81.8%). Despite the fact that both areas were similar in the number of helminth species, they differed in the number of helminth species developing via krill as well as in quantitative aspects. The prevalence and intensity of infection by helminth species developing via krill increased in the more southern Antarctic areas (South Shetlands and Antarctic Peninsula) as compared with South Georgia. The differences in helminth faunas were a result of an increase in the proportion of euphausiids

consumed by Antarctic fishes in the southern Antarctic areas (South Shetlands and Antarctic Peninsula).

The helminth fauna of Antarctic fishes depends on the features of the Antarctic trophic network.

THE INFLUENCE OF MAGNETIZED WATER ON THE LARVAE OF *CULEX PIPPIENS*

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During recent years there has been considerable interest in studies of the influence of magnetism on living organisms. Studies of the influence of magnetic fields on various biological subjects are increasingly needed. However, published experimental data are insufficient and do not always reflect modern views upon the biological effect of a magnetic field. By studying an organism on the quantum level scientists point to the fact that every chemical and biological reaction is closely bonded to magnetic energy (Holodov, 1996). It is known that the mechanism of the effect of a magnetic field on a living organism is based on significant changes in the energy of chemical bonds during biological processes. These researches testify that an organism is a multilevel system which is characterized by selected magnetic phenomena.

Under laboratory conditions a number of experiments were conducted by us on the influence of magnetic fields on living organisms from unicellular organisms to larvae of the dipteran *Culex pipiens*.

Methods: In the experiments larvae of II-IV chrysalis stages of *Culex pipiens*,

Anopheles messeae and Chaoborinae were used.

1. Water from a natural source was poured into two vessels and the second vessel was magnetized using a device called a 'magnetometer'.
2. The same conditions were maintained in both vessels: temperature regime, lighting, pH, and intervals of observations.

The experiments showed that Culicidae larvae are sensitive to a magnetic field. In magnetized water they were the first to become excited and move to the upper surface of the water, which is probably connected with changes in the viscosity of the magnetized water. The most important result of the experiment was the speeding up of metamorphoses of *C. pipiens* and *Anopheles messeae* larvae. Therefore, magnetized water influences the behaviour of Culicidae larvae and the process of metamorphosis.

PRELIMINARY DATA ON NUCLEOTIDE SEQUENCES OF 18S rDNA OF TWO SPECIES OF CRUSTACEAN PARASITES FROM LAKE BAIKAL

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Objective: In 1998-99, material from *Salmincola thymalli* (from *Thymallus arcticus*) and *Basanisthes briani* (from *Brachymystax lenok*) were sampled from rivers of Barguzinski Nature Reserve to investigate their molecular structure.

Materials and Methods: Total DNA was extracted from 96%-ethanol-fixed crustaceans according to previously described

techniques (de Vos, Dick, 1989). All other techniques were as described by Kuznedelov et al. (1996). The sequences' comparison analysis was made with data registered in EMBL under the accession numbers *Limnadia lenticularis* - L81934, *Cancrincola plumipes* - L81938, *Calanus pacificus* - L81939, *Eucyclops serrulatus* - L81940, *Berntia purpurea* - 26511, *Amblytelus curtus* - AF012482, *Raphetis* sp. - AF012485, *Mecyclothorax vulcans* - AF012482, *Tropopterus* sp. - AF012483, *Clambus arnetti* - AF012526, *Pamborus guerinii* - AF012508, *Mecodema fulgidum* - AF012501. Comparative analysis was done by calculation of evolutionary distances (number of differences) between the sequences according to the method of Jukes & Cantor (1969). Evolutionary distance matrix obtained in pairwise comparison was used to construct dendrograms according to the method of Saitou & Nei (1987), showing the degree of affinity between sequences compared. TREECON program package (Van de Peer, De Wachter, 1993) was used for comparative analysis.

Results: Determination of nucleotide sequences in amplified fragments revealed 537 aligned nucleotide positions.

Conclusion: The phylogenetic analysis showed that molecular data of *S. thymalli* and *B. briani* have 100 % statistical support. These data correlate well with the phylogenetic conception of Kabata (1979), suggesting that species of the genera *Basanisthes* and *Salmincola* are closely related and that the first-named genus originated from the second.

COMPARISON OF THE HELMINTH FAUNAS OF *BUFO VIRIDIS* LAURENTI, 1768 AND *B. REGULARIS* REUSS, 1828 COLLECTED IN EGYPT

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Objective: Toads of the species *Bufo regularis*, *B. viridis* and several frogs from Egypt were examined to determine differences and conformities in their helminthofaunas. In addition food analyses were made to investigate an ecological factor influencing the composition of the helminth faunas.

Materials and Methods: In 1982, 106 anurans from different locations in Egypt were collected. From dissections of these 106 host specimens, Nematoda, Trematoda, Cestoda and Acanthocephala were extracted. The parasites were preserved, stained and cleared according to standard methods.

Results: The mean prevalence of infection was 86.8%. The great majority of extracted helminths were nematodes. Ecological and geographical aspects will be discussed.

SOME RESULTS OF INVESTIGATION OF "BLACK SPOT" DISEASE OF BREAM (*ABRAMIS BRAMA*) FROM THE CURONIAN LAGOON (SOUTH-EAST PART OF THE BALTIC SEA)

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"Black spot" disease of bream from the Curonian Lagoon was studied during 1998-99. A total of 3919 specimens (TL=2.8-54.0 cm) were examined. The disease occurred on average in 23 % of all the fishes examined. The numbers of fishes with black spots in samples varied from 4.9 % up to 46 %, and the number of spots on a single specimen varied from 1 to 268.

Two types of black spot were found. The first type did not contain cysts with metacercariae and occurred within the whole period of observation. The spots of the second type, containing cysts with metacercariae of *Posthodiplostomum cuticola*, were only found from April through November. The metacercariae had a large size range (0.7 - 2.1 mm). Features of their allometric growth were studied.

The relationship between fish length and prevalence of black spots was established: prevalence of black spots increased from 0.5 to 46% with increasing fish length from 2.8 to 54.0 cm.

The seasonal dynamics of black spot disease of bream were also studied. Only black spots of the first type were found from November through April. Living metacercariae were found on bream from April through October.

WHY DO BROWN RATS *RATTUS NORVEGICUS* LIVING IN THE SEWER SYSTEM OF THE OLD TOWN OF REYKJAVÍK HAVE SO FEW PARASITES?

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Introduction: During the last decade of the 20th century effective pest control measures finally exterminated brown rats (*Rattus norvegicus*) everywhere in Reykjavík except in the old town where isolated populations still survive in association with the sewer system. The nests are usually located in recesses beneath buildings where pipes of the sewer system are open or damaged. Black rats (*R. rattus*), however, have not occurred in Reykjavík for decades.

Objective: To study the parasite fauna of the brown rat in the sewer system.

Materials and Methods: A total of 24 subadult and adult brown rats, trapped within houses in the old town of Reykjavík where damaged sewers or open water traps had enabled rats to enter the buildings, were examined for intestinal endoparasites and ectoparasites.

Results: Nine parasite species were found: The protozoans *Eimeria falciformis*, *E. nieschulzi* and *Cryptosporidium parvum*; the cestode *Hymenolepis nana*; the nematodes *Trichuris muris*, *Syphacia* sp. and *Heterakis spumosa*; the mite *Radfordia affinis* and nit of a louse, probably *Polyplax spinulosa*.

Conclusions: All parasites found in the survey are known parasites of brown rats, although all were reported for the first time in rats in Iceland in the present study. A feature which all the species found have in common is that they have direct life-cycles.

A provisional list of brown rat parasites, compiled from surveys carried out in various countries of the world, includes at least 20 protozoans, 10 trematodes, 7 cestodes, 19 nematodes and 24 ectoparasites – altogether 80 species. Only 11% of these parasites were reported in the present study.

Various factors were considered to explain why so few parasites occur among the sewer rats in Reykjavík. Firstly, potential intermediate hosts like gastropods, crustaceans and insects are absent in the closed, uniform sewage environment. Therefore, brown rat parasites having complicated life-cycles have no possibility of being maintained in the population. Secondly, in past decades intensive control measures have been carried out during the summer months whereby baits containing rodenticides have been systematically put into manholes of the sewer system. As a result the brown rat population has temporarily been controlled every year, and even eradicated in some parts of the sewer system. As a consequence, rare parasites could also have been driven to extinction. Thirdly, due to the effective pest control measures no rats occur anymore in Reykjavík outside of the closed sewer system. Therefore, import of «new» parasites from other populations into this closed environment seems very unlikely.

HOST SPECIFICITY OF GAMASID MITES (GAMASINA: SPINTURNICIDAE, MACRONYSSIDAE) FROM BATS (CHIROPTERA)

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Objective: Analysis of host specificity of gamasids (Gamasina: Spinturnicidae, Macronyssidae), parasitizing bats (Chiroptera) in Russia and adjacent countries.

Materials and Methods: About 16 000 gamasids of 42 species (own material and collection of the Zoological Institute, Russian Academy of Sciences) were collected from more than 2000 bats belonging to 34 species.

Results: Monoxenic species: *Spinturnix acuminatus* (on *Nyctalus noctula*), *S. psi* (on *Miniopterus schreibersii*), *S. emarginatus* (on *M. emarginatus*), *Eyndhovenia euryalis* (on *Rhinolophus euryale*), *Macronyssus barbastellinus* (on *Barbastella barbastella*), etc. Oligoxenic species: *S. myotis* (on *Myotis*), *Paraperiglishrus rhinolophinus* (on *Rhinolophus*), etc. Polyxenic species: *M. cyclopsis*, *Steatonyssus spinosus*, *Ornithonyssus pipistrelli*, etc.

Conclusion: Very close relationships between gamasids and their hosts – bats – have led to the appearance of monoxenic and oligoxenic species. The number of polyxenic species is considerably smaller. All polyxenic species of gamasids are from the family Macronyssidae. The latter parasitize bats of different species in one colony. All mites of Spinturnicidae are monoxenic or oligoxenic. The fauna of parasitic gamasids is richest on *Myotis mystacinus* (17 species), *M. daubentoni* (15), *M. brandtii* and *Plecotus auritus* (14). Bats inhabiting

the southern part of the studied region (e.g. *Barbastella*) are infected by a smaller number of gamasid species. Bats inhabiting the northern part of the region are infected by a considerably larger number of gamasid species. In mixed colonies of bats the diversity of parasites is richer than in monospecies colonies. There appears to be a weak correlation between the numbers of spinturnicids (permanent parasites) and macronyssids (some are permanent [*Macronyssus*], some are temporary parasites [*Steatonyssus*, *Ornithonyssus*]). The species composition of gamasids on bats of the same species may be different in different populations. This depends on certain characteristics of host populations or colonies, i.e. geographical position, other species of bats in a mixed colony, season, migration routes, etc.

IS THE MONOGENEAN *ANCYROCEPHALUS PARADOXUS* CAPABLE OF REGULATING THE POPULATION STRUCTURE OF 0+ CLASS OF *STIZOSTEDION LUCIOPERCA* ?

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Objective: In the Kurish Bay (Curonian Lagoon) of the Baltic Sea, mature forms of the typical gill monogenean *Ancyrocephalus paradoxus* were found parasitizing zander on the isthmus (lower surface of the head between opercula) in mature (4-14+; 5%), but mostly in young (1-3+; 54%) fish.

Materials and Methods: Fishes of 0+ class (N=454) were collected in 1997 from May through October. The sample of hosts was split into 10 mm size classes.

Results: In the total sample, size group II (31-40 mm) had 2.4% prevalence and the lowest intensities of infection (abundance=0.45), with the proportion of worms infecting the gills being very high (60%). Group V (61-70 mm; A=10.3) had 36% prevalence, with the proportion of worms being minimal on the gills (19.3%) and maximal on the isthmus (more than 80%). Prevalences in groups VI and VII (71-90 mm) decreased (12% and 4%), intensities of infection increased (A=23; 26.5), and the proportion of worms on the gills was 20%.

Conclusion: It can be concluded that survival of the host and its parasite depends on a decrease in the proportion of worms parasitizing the gills and on the possibility of monogeneans locating on the isthmus. Fishes of the 0+ age class with worms mostly on gills may suffer from anaemia, delay in growth, etc., and then may be eliminated by cannibalism. Monogeneans in the parasite/0+ host relationship apparently act as a factor in regulating the population of middle size groups.

TUMOUR-LIKE INFECTIONS OF CYPRINID FISH (CYPRINIDAE) FROM CURONIAN LAGOON (THE BALTIC SEA)

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Objective: In the south-eastern Curonian Lagoon five cyprinid species were examined for tumours from September 1998 through May 1999.

Materials and Methods: Fishes were caught by nets (mesh 40 and 70 mm) at 800-1500 m from the shoreline. A total of

4300 cyprinid specimens were caught: *Abramis brama* (L.) (2953), *Rutilus rutilus* (L.) (1022), *Carassius carassius* (L.) (151), *Pelecus cultratus* (L.) (164), *Vimba vimba* (L.) (8). The frequency of occurrence of external tumours, their types and distribution on the fish body, fish size, sex and age, and internal tumours were all recorded.

Results: Prevalence of tumours was 19.9% in bream, 9.0% in roach, 6.0% in crucian carp, and only 0.6% in *P. cultratus*. Seven morphological types of tumours were recognized: type I – epithelium-like non-pigmented, II – epithelium-like pigmented, III – papilloma-like non-pigmented, IV – papilloma-like pigmented, V – lipoma-like, VI – carcinoma-like, VII – tumours of internal organs. Bream had all types of tumours, with type I predominant (68.3%). In roach, types I (62.5%) and II (37.5%) predominated. In crucian carp, only types IV (100%) and III (11.1%) were found.

Analysis of infections in bream and roach by tumour occurrence in different age classes showed 50.0% type I tumour occurrence in class 1-3; 22.7% in 4-6, 18.2 % in 7-9; 4.5% in 10-12; 2.3% in 13-15, 2.3% in 16-18.

Conclusion: Infections of different types of tumours in bream and roach are similar. Crucian carp differs in the nature and degree of infection, apparently related to the degree of relationship between species, different infection nature and host population density. All three species are benthophagous; *P. cultratus* is planktonophagous, tumours in it being rare.

DISTRIBUTION OF MOSQUITOES (DIPTERA: CULICIDAE) IN DIFFERENT HABITATS OF URBAN TERRITORY

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Objective: To study the influence of urban pressure upon the fauna and larval stages of mosquitoes.

Materials and Methods: In 1996-99 larval stages of mosquitoes were found in different parts of Minsk territory, such as suburban areas, park zones, green areas of housing estates and the centre of the city. Larvae and imago captures were carried out using entomological and water nets.

Results: Of 39 species of mosquitoes occurring in Belarus, 25 have been recorded in Minsk. Fourteen species which were not found in the city belong to Holarctic and Palearctic fauna and are not common. Urban pressure caused a change in the composition of dominant species. *C. pipiens*, *A. dorsalis*, *A. flavescens* and *A. excrucians* were dominant in urban territory, while *A. communis*, *A. cantans* and *A. excrucians* were the most numerous in Belarus. Eight water body types of natural origin and four types of man-made larval habitats have been recorded in the Minsk region. The highest densities of larvae were in temporary water bodies in park zones and in basement of houses.

Conclusion: Urban pressure caused a decrease in the number of species to 64%, influenced the composition of dominant species, decreased the number of species and changed the types of larval habitats.

DYNAMICS OF ABUNDANCE OF *HYSTEROETHYLACIUM ADUNCUM* (NEMATODA), A PARASITE OF SPRAT IN THE BLACK SEA

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Objective: Long-term studies of infection of sprat, *Sprattus sprattus phalericus* with larvae of the nematode *Hysterothylacium aduncum* have shown increasing intensity of infection from single specimens in 5-6 cm fish to 317 in 12 cm fish.

Material and Methods: Sampling was carried out from vessels along the Crimean coast from 1976 through 1999. Fresh and frozen fish of 5-12 cm length were studied. Standard parasitological methods were used. Tests of statistical significance on mean differences were conducted.

Results: The nematode *H. aduncum* uses sprat as a transport host. Adult forms of this parasite were found in the stomach and intestine of about 20 Black Sea fish species. In sprat (2-12 mm), larvae were found on the pyloric caeca and in the abdominal cavity. Intensity of infection increases with fish length. Specimens of the 5-6 cm size group were either not infected or infected with a single worm. In the largest sprats (8.1-9.0 cm) parasite abundance was greater than twice that of fish in the 7.1-8.0 cm group. Intensity of infection in similar-sized fish is always similar. In the first and second length-groups, parasites were found on the pyloric caeca, in the third length-group on the pyloric caeca and in the abdominal cavity. From 988 sprats 800 were examined immediately after capture, in the region of the fishery. Another 188 sprats were dis-

sected after freezing or pickling. In the first group the parasite distribution was normal, whereas in the second almost all the inner organs were infected. The greatest number of worms was observed in those organs and tissues with the greatest fat content. No significant differences in mean lengths of parasites were found.

Conclusion: Sprat habitats distant from the shore in the Black Sea facilitated preservation of established host-parasite relationships. Coastal marine communities suffer most from pollution. Parasite abundance increased with fish length. Changes in the condition of the fish before examination (frozen or salted) caused an increase of parasite activity, which was expressed by changes in distribution.

THE INFLUENCE OF AN ENVIRONMENTAL FACTOR (POLLUTION) ON ABUNDANCE OF THE DOMINANT PARASITE SPECIES OF SHRIMP *PALAEMON ELEGANS* RATHKE IN THE BLACK SEA

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Objective: Monitoring of the parasite fauna (1995-1999) of shrimp *Palaemon elegans* Rathke, 1837 in two differently polluted bays near Sevastopol showed sharp increases in the numbers of three parasite species: the fungus *Actinomyces* sp., the infusorian *Terebrospira lenticularis* and the trematode *Helicometra fasciata*, and the disappearance of the previously common isopod species *Bopyrus squillarum*.

Material and Methods: About 3000 shrimps 27-65 mm in length, caught at depths of 0.5-1.0 m, were examined. The

material was sampled yearly from May through September in Karantin Bay isolated from the sea at a site of unfiltered urban wastes discharge, and in the estuary of Omega Bay with good water flow and low pollution. Standard parasitological methods were used in the work.

Results: Shrimps were infected with parasites in both regions. *Actinomyces* sp. inhabits the cuticular shell of all the shrimps' organs, but most often the carapace, epimeral plates and uropods. The infection level of cuticular shell in Karantin Bay exceeded that from Omega Bay three-fold. *T. lenticularis* parasitizes the thickness of the shrimp's cuticle. It was abundant in rostrum cuticula, carapace, genital segment, and uropods. Infusoria infection in Karantin Bay was two times higher than in Omega Bay. Trematode metacercariae occur more often in the anterior muscles of shrimps, less often in the muscles of posterior segments and swimming legs. Its intensity of infection in Karantin Bay exceeded that in Omega Bay 6-16-fold, and its prevalence 2-6-fold. Intensity of infection of all parasite species in similar-sized shrimps (50-60 mm), according to the long-term data, shows a considerable difference between the two regions. Isopods occurred in 11.3% of shrimps in 1970 and 1.6% of shrimps in 1975, but from 1997 up to the present time these parasites have not been found.

Conclusion: The disappearance of *B. squillarum* led to a decrease of diversity of *P. elegans* parasites. A sharp increase in the number of dominant parasite species took place because they (fungi, infusoria) or their hosts, taking part in the trematode life cycle, are characterized by adaptation to an abundance of organic remnants and low oxygen content in the water. But it should be noted that the extent of organic pollution determines this situation.

TENDENCY FOR A POLYCYCLIC SEASONAL DEVELOPMENT OF *PROTEOCEPHALUS CERNUAE* IN THE RYBINSK RESERVOIR

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Objective: To evaluate the level of infection of ruff (*Gymnocephalus cernua*) by the cestode *Proteocephalus cernuae* (Gmelin, 1790) and to study its seasonal maturation in the Rybinsk Reservoir, one of the largest reservoirs in the world.

Materials and Methods: In 1992-1994 a total of 716 specimens of fish, mainly from the Volga part of the reservoir, were captured and examined.

Results: Seasonal variation in prevalence of the tapeworm was observed (winter: 51.2 ± 2.9 , spring: 60.5 ± 3.9 , summer: 48.6 ± 3.7 , autumn: $37.7 \pm 5.5\%$). Unlike *P. percae*, the proportions of adult *P. cernuae* in the total worm population appeared to be greatest from May to September (maximums in June and August). A certain number of these maturing cestodes were found even in winter: $6.0 \pm 1.0\%$ (spring: 19.3 ± 2.2 , summer: 62.9 ± 4.1 , autumn: $34.1 \pm 7.2\%$). The ratio of variance to abundance of adult worms was always about 1, therefore the distribution of this group of helminths was uniform. A two-month delay was observed between peaks (May and October) of *P. cernuae* adults in comparison with overall prevalence and abundance.

Conclusion: There are at least two parasite generations with maturation periods in winter-spring and summer-autumn. Similar trends in the polycyclic seasonal development were previously observed by many authors for *P. exiguus* from *Coregonus*

albula. It may be hypothesized that the changes in the feeding activity of the definitive host depending on the type of water-body affects the biology of the cestodes.

REGULARITIES IN THE DISTRIBUTION OF LETHAL HAEMOSPORIDIAN PARASITES OF POULTRY

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Objective: To specify the regularities of distribution of haemosporidians (Protista: Haemosporida) which cause lethal diseases in poultry.

Material and Methods: The original data of a long-term period of investigation by the authors using traditional methods as well as analyses of collections and literature data.

Results: So far, 210 species of Haemosporida are known to parasitize birds. Only 14 of them are of practical significance, among them one species of *Haemoproteus*, eight of *Plasmodium*, and five of *Leucocytozoon*. Approximately 80% of the practically important species parasitize galliform birds. *H. masoni* (= *H. meleagridis*) and *L. smithi* cause lethal diseases in turkeys in the south east (SE) of the USA, *L. simondi* in ducks and geese in the Northern Holarctic, *L. caulleryi* in hens in SE Asia, *L. struthionis* in ostriches in S. Africa, *P. gallinaceum* in hens in the Oriental region, and *P. jaxtanucleare* in hens in the tropics worldwide except for Australia. Lethal haemosporidiosis are totally absent in Australia and rare in S. America, but they may be introduced.

Conclusions: Haemosporidian parasites of poultry are clearly spotty in their distribution, and the majority of their species parasitize galliform birds which are the main

source for introduction of the diseases into new territories. Leucocytozoonosis is the main practically important haemosporidiosis.

DISTRIBUTION OF *PARACOENOGONIMUS OVATUS* KATSURADA, 1914 IN FISHES OF RUSSIA

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Objective: *Paracoenogonimus ovatus* Katsurada, 1914 is one of the common parasites of many species of freshwater fishes in Europe and in Asia. Definitive hosts of *P. ovatus* are different fish-eating birds and carnivores (experimental data).

Materials and Results: During 1999, 491 muscle samples of 18 fish species from the Gulf of Finland and the Volga River as well as literature data were analyzed to study the ecological aspects and geographical distribution of *P. ovatus* in Russia. Among cyprinids the highest prevalences and intensities of infection were observed in roach (*Rutilus rutilus*), bream (*Abramis brama*), silver bream (*Blicca bjoerkna*) and ide (*Leuciscus idus*). The lowest levels of infection were observed in pelagic fishes: bleak (*Alburnus alburnus*) and ziege (*Pelecus cultratus*). Among percids the occurrence of *P. ovatus* was low in contrast to cyprinids and minimal infestation was observed for perch (*Perca fluviatilis*). The predatory fishes pike (*Esox lucius*) and asp (*Aspius aspius*) were also infected. Ecological conditions in the water reservoir or its different localities are

also important in determining the prevalence and intensity of infection.

Conclusions: In general fishes of the Volga and the Gulf of Finland are highly infected with *P. ovatus*. The northern border of this parasite's distribution coincides with the distribution of its first intermediate hosts – the molluscs *Viviparus viviparus* and *V. contectus*. But the finding of *P. ovatus* in the rivers Amur and Irtysh do not coincide with the area of these molluscs. There is an opinion that *P. ovatus* is a complex of several species.

OCCURRENCE OF MICROSPORIDIA AND *SCHISTOCEPHALUS* SPP. IN STICKLEBACKS OF THE GULF OF FINLAND NEAR ST. PETERSBURG: RESULTS OF LONG-TERM OBSERVATIONS

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Objective: The three-spined stickleback *Gasterosteus aculeatus* L. and nine-spined stickleback *Pungitius pungitius* (L.) are commercial fishes of the Gulf of Finland. Catches of these fish near St. Petersburg during 1972-1975 were approximately 3000 tons per year but only 300 tons per year during 1998-1999. Two new microsporidian species, *Glugea gasterostei* Voronin, 1974 and *Thelohania baueri* Voronin, 1974 were detected in sticklebacks of the Gulf of Finland.

Materials and Results: Of 1659 *G. aculeatus* specimens examined during 1972-1975 36 (2.2%) were infected by *Glugea gasterostei* and 54 of 1084 (5.0%) female specimens were infected by *Thelohania baueri*. At the same time, 135 of 1659

G. aculeatus (8.1%) and 81 of 924 *P. pungitius* (8.8%) were infected by plerocercoids of *Schistocephalus* spp. During 1998-1999 (about 25 years later) sticklebacks from the same localities were reinvestigated. *G. gasterostei* was found in 2.8% of *Gasterosteus aculeatus* and *T. baueri* in 3.0% of females of 425 fish specimens. *Schistocephalus solidus* was found in 25.5% *G. aculeatus* (60 of 235) during autumn 1998 and in 40.0% specimens (76 of 190) during autumn 1999.

Conclusions: Our long-term observations demonstrated the different models of parasite-host relations for Microsporidia and plerocercoids of *Schistocephalus solidus*. In general the permanent low level of Microsporidia infection of sticklebacks is confirmed. On the other hand, the significant increase of *S. solidus* infection of three-spined stickleback during recent years is unusual. The reasons may be changes in the ecological situation as a result of dam construction or the effect of low fishing effort on the host population.

THE PLATYHELMINTHS OF INSECTIVORES IN LITHUANIA

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Objective: Plathelminthes of Lithuania's insectivores: *Sorex araneus*, *Sorex minutus*, *Neomys fodiens*, *Talpa europaea*, *Erinaceus concolor*, were studied for the first time.

Materials and Methods: Twenty three specimens of shrews (Soricidae), thirteen specimens of moles (Talpidae) and one specimen of hedgehog (Erinaceidae) were collected from June to October in 1999 from a town park in Vilnius, the edge of a

forest in Šilutė district and from forest and a river pond in Šakiai district. The specimens were examined by the method of total parasitological autopsy.

Results: Six species of cestodes and three species of trematodes were found in *Sorex minutus*, four species of cestodes were found in *Sorex araneus*, two species of trematodes were found in *Neomys fodiens*, and one species of cestode in *Talpa europaea*. The prevalence of infection was 86.96% in Soricidae and 7.69% in Talpidae

Conclusion: All of the platyhelminths tended to occupy a specific site in the host gastrointestinal tract. The cestodes *Neoscrjabinolepis schaldybini* and *Molluscotaenia crasiscolex* were the dominant platyhelminth species. Trematode species were recorded from *Neomys fodiens* and *Sorex minutus* only in Šakiai district in wet places where molluscs are abundant.

ANTHROPOGENIC PRESSURE INFLUENCES ON IXODES TICK POPULATIONS

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Objective: About 3000 *Ixodes* ticks previously collected and fixed in 70% ethanol, and 3000 examined as live specimens, were investigated for detection of exoskeleton abnormalities. Ticks were collected from different parts of their area within a nine years period (1990-1999) by flagging.

Materials and Methods: Abnormalities were detected using a stereomicroscope.

Dark field microscopy, IFA and PCR methods were used to detect infections. Every specimen was investigated to determine the type of infection by different pathogens (e.g. *Borrelia*, *Ehrlichia* and tick-borne encephalitis virus). Types of abnormalities were described previously (Alekseev & Dubinina, 1996).

Results: The minimal level of abnormalities (10%) was found in protected areas (Zhiguli Preserve, Russia and Kingelund Forest, Denmark). The maximum (50%) was observed in the Cherepovets area (Vologda Region, Russia). The activity of anomalous ticks differed from that of normal ones, and their infection rate was higher than that of normal ticks.

Conclusion: The amount of exoskeleton abnormalities in *Ixodes ricinus* and *Ixodes*

persulcatus tick populations greatly depends on anthropogenic pressure. Anomalous ticks differed from normal ones in many parameters and were more susceptible to infection. Exoskeleton abnormality research might be one of the reliable ways of biomonitoring. Further study of abnormality-causing agents is needed.

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References

Alekseev AN, Dubinina HV. Some aspects of mite (Oppiidae) and tick (Ixodidae) pathology as a result of antropogenic pressure. *Acarology* IX. Columbus, Ohio 1996; 1: 117-20

NEWS

Minutes from the SSP Board telephone meeting 28. November, 2000:

Present: Tellervo Valtonen, Jorun Tharaldsen, Ingela Krantz, Karl Skirnisson, Mats Wahlgren and Maria Vang Johansen

Reporter: Maria

Agenda for the meeting:

- 1) *Report from the meeting in St Petersburg (Tellervo)*
- 2) *Next SSP meeting including connected nematode meeting, The history of SSP presentation by Jørn Andreassen and young scientist support (Mats).*
- 3) *Financial status of SSP and new members. Each local treasure should report.*
- 4) *New president for SSP to be selected in Stockholm in 2001 (Tellervo).*
- 5) *Report from the General Assembly of the European Federation of Parasitologists (Karl).*
- 6) *Information on new initiatives on parasitological courses in Denmark (Maria)*
- 7) *Other issues.*

Ad 1) Tellervo informed that the joint meeting of The Russian Soc. for Parasitology and SSP in St Petersburg in July 2000, had been very successful, with many interesting speeches and discussions and very well organised. A total of 121 people from 25 countries participated. Jorun informed that the next issue of the Bulletin containing the abstracts (150 pages) will be finished shortly and 2/3 of the publication expenses will be covered by extra mural funding.

Ad 2) Planning of the 20th SSP meeting to be held in Stockholm in 2001 is going very well. The meeting will be held at the Karolinska Institute in Stockholm. As the SSP meeting is planned in connection with a special meeting on 'free-living and parasitic nematodes' (organised by Hans P. Fagerholm) as well as a course on 'antigen variation', many speakers can contribute without payment. Hans Peter has now got funding for his meeting. The 2nd announcement will come out soon. It was agreed to ask Jørn Andreassen (Denmark) to give an anniversary-talk about the 30 years of SSP at the meeting in Stockholm, although the actual anniversary is in 2002. Karl told that he had poster presented the 1st announcement of the SSP meeting 2001 at the EMOP meeting in Poland this summer. It was decided that the meeting should be announced in Parasitology Today, Journal of Helminthology, SSP Bulletin and also communicated to national parasitological and tropical medicine societies (Norwegian Vet. Ass., Swedish Trop.Soc. etc.). Mats will take action on the international announcements. Mats also informed about a very informal meeting among Swedish parasitologists last week. Eighty persons participated, but no abstracts were provided. Mats will give Jorun a short report from the meeting for the Bulletin.

Ad 3) In order to get an updated list of our members Tor and Maria should communicate as soon as possible. Before acceptance of new members the candidate should be presented to the board and their names published in the Bulletin. The financial status is:

Norway: 15,000 Norwegian Kr.

Denmark: 9,290 Danish Kr. (26 persons paid in 2000)

Iceland: 2,900 Norwegian Kr. (6 persons paid in 2000)

Sweden: 2,000 Swedish Kr.

Finland: 4,300 Fmk (26 persons paid in 2000)

Ingela reported that there had been some problems with the Swedish giro account, but she would look in to this.

It was agreed upon that the SSP meetings have to be self-supporting and that SSP in connection with meetings only provide money for travel and attendance stipends for young scientists. The membership fee is 25 EURO for ordinary members and 10 EURO for students.

Ad 4) The board discussed possible new candidates to replace the president and the treasurer of SSP from autumn 2001.

Ad 5) Karl reported from the board meeting of the European Federation of Parasitologist (EFP) in Poznan in Poland in September this year where he represented SSP. 19 societies of the 29 member societies were present at the meeting. The new board of EFP were elected as follows:

President: R. Houin from Creteil in France, (*Echinococcus*)

Secretary: Y. Gtiriz from Izmir in Turkey, (*Echinococcus*)

Treasurer: J. Sluimers from Rotterdam in the Netherlands (*Giardia*)

Vice-president: H. Wedrychowicz from Warshaw in Poland (DNA Vaccination)

Additional board members are:

J. Corba from the Slovak Academy of Sciences in Kosice (*Echinococcus*)

Andrey Alekseev from Saint Petersburg (ectoparasites)

Tor Bakke from Oslo.

The fourth candidate, Kolarova from the Czech Republic parasitological Society only got 7 votes and was not elected.

Auditor is C. Holland from Dublin in Ireland.

Finally it was accepted by all representatives that the next EMOP will be organized during the third week of July in 2004 in Valencia in Spain. No other candidates asked to organize this meeting but the British Society had also shown some interest in some preliminary stages.

Ad 6) Maria informed that a 2-year Master programme in parasitology is being planned at the Royal Veterinary and Agricultural University (KVL) in Copenhagen. The course will be in English and be announced internationally. Additionally, a 3-week summer course in parasitic zoonoses will be announced in the beginning of next year. The summer course has been sponsored by NOVA. Maria will give more details as soon as possible to Jorun for the Bulletin. Jorun asked for written information for the Bulletin about the 2 new research professorships in parasitology at KVL as well as information about the new leader of the Danish Centre for Experimental Parasitology, Darwin Murrell. Maria answered that she had asked the relevant people to write about it. She will remind them again.

Ad 7) Tellervo mentioned that a one-week course in 'advances in parasite ecology' will be offered at the International Summer School at University of Jyvaskyla, Finland next autumn.

Mats informed about 2 new books he is involved in that are coming out soon. One is about 'parasites of the Nordic areas' and the other is a 'Method book in malaria research'.

Jorun informed that parasitic zoonoses are currently receiving a lot of attention in Norway and a recent meeting on the issue attracted 120 participants.

Tellervo told that the Baltic Society for Parasitology had asked SSP to make a joint meeting in 2003 in Vilnius. It was then discussed whether our regular meetings (which should be in Norway in 2003) should be held in a Nordic country or whether it could be a part of a joint meeting outside the Nordic countries. The board all agreed that

there would be no problem in holding the meeting in Vilnius, but it was an issue to be decided at the General Assembly. Tellervo will write to the Baltic society with a copy to Maria.

29.11.00 Maria Vang Johansen

Book information

Methods in Malaria Research is a collection of a variety of protocols in malaria research. The book contains 73 pages of protocols and was edited by Martha Schlichterle and Mats Wahlgren (Karolinska Institutet, Stockholm Sweden), Hedvig Perlmann (Stockholm University, Sweden) and Artur Scherf (Institut Pasteur, Paris, France). Protocols were contributed as a collaborative effort from labs of the editors as well as the MR4 at ATCC (Manassas; Virginia, USA) and KEMRI/CGMRC / Wellcome Trust Research Unit (Kilifi, Kenya).

The book aims to be an all-round collection of practical protocols that students and researchers of malaria can use as they conduct their research. Some of the highlights include methods in: the handling of parasites (such as culturing, freezing, thawing, staining, purification, micromanipulation, fixation, sampling of blood in the field), immunochemistry (surface iodination and metabolic labeling), serology (immunofluorescence, ELISA, agglutination assay), cellular methods (parasite antigen preparations, T-cell proliferation assay, cytokine RT-PCR), molecular biology (gDNA preparation, RNA- and Northern preparations, cDNA library construction, single cell RT-PCR, PCR species identification, pulsed-field gel electrophoresis, recombinant protein expression, transfection protocols).

To make future editions of this book of protocols even more complete, we hope that our readers will want to contribute their own well working methods. A criterion we have set to include a protocol, is that it be well-tried by the lab or person contributing it. We aim to maintain this idea in the future and thus wish for the book to be a living document of practical malaria methodology.

Methods in Malaria Research is now available as an internet pdf-document on the following address:

http://www.malaria.mr4.org/mr4pages/MR4_Protocols.html

Parasitological activities in Sweden

The second Swedish Parasitology Meeting (SPAM) was held at the Swedish Institute of Infectious Disease Control in Stockholm on the 17th of November. The initiative to meet among parasitologists in Sweden had come from the Veterinary parasitologists in Uppsala and the first meeting was held 1999 in Uppsala. This year was an

expanded version of SPAM where we had talks, among others, about the infectious biology of giardia, malaria, scabies, toxoplasma, and the genome sequencing project of *Trypanosoma cruzi* which is taking place at Uppsala University.

Mats Wahlgren

Parasitological activities in Norway

A course in Serious, Contagious Diseases in Animals was held in Oslo, September 3-8, 2000, jointly organized by the Norwegian School of Veterinary Science, the National Veterinary Institute, VESO, the Faculty of Veterinary Science of the University of Pretoria and the Onderstepoort Veterinary Institute of South Africa. There were participants from Denmark, Sweden, Italy/Ethiopia and Norway.

This course also included a session on zoonotic parasitic diseases, with a lecture by T. Krecek (An African perspective), and J. Tharaldsen (Nordic Perspective).

The Norwegian Zoonosis Centre organized a one-day **Seminar on parasitic Zoonoses** at the National Veterinary Institute, Oslo, November 8, 2000. The seminar was very well attended, with more than 120 participants.

Jorun Tharaldsen

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. If possible, computer made figures should also be included, but good print-outs should be provided with the manuscript. Otherwise 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 should 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:

Austin B, Austin DA. Bacterial fish pathogens: disease in farmed and wild fish. Chichester: Ellis Horwood, 1987

McFerran JB, McNulty MS, eds. Acute virus infections of poultry: a seminar in the CEC programme, Brussels 1985. Dordrecht: Martinus Nijhoff, 1986. (Current topics in veterinary medicine and animal science 37)

Sosialdepartementet. Tsjernobyl-ulykken: Rapport fra Helsedirektoratets rådgivende faggruppe. Oslo: Universitetsforlaget, 1987 (Norges offentlige utredninger NOU 1987: 1)

Thornhill JA. Renal endocrinology. In: Drazner FH, ed. Small animal endocrinology. New York: Churchill Livingstone, 1987: 315-39

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In the interest of speed, no proofs will be sent to authors. It is therefore of vital importance that the manuscripts are carefully checked before submission.

BULLETIN OF THE SCANDINAVIAN SOCIETY FOR PARASITOLOGY

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