Proceedings of the 8th International Symposium on Ectoparasites of Pets (ISEP)

May 8th – 11th, 2005
Hannover, Germany

www.isep-online.com
8th ISEP Program Committee

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The Past Meetings

1st 1991 17 to 19 June in Lexington, KY, USA
University of Kentucky and Kentucky Veterinary Medical Association
Chairperson: Fred Knapp
Program Committee: William Miller, Robert Young

2nd 1993 4 to 6 April in Lexington, KY, USA
University of Kentucky and Kentucky Veterinary Medical Association
Chairperson: Fred Knapp
Program Committee: Richard Hack, Don Labore, William Miller, Michael Potter, Robert Young

3rd 1995 2 to 4 April in College Station, TX, USA
Texas A&M University
Chairperson: Roger Meola
Program Committee: Bill Donahue, Richard Hack, Mike Potter, Lisa Rodriguez, Bob Sabol, Robert Young

4th 1997 6 to 8 April in Riverside, CA, USA
University of California, Riverside
Chairperson: Nancy Hinkle
Program Committee: Bill Donahue, Ann Donoghue, Mike Dryden

5th 1999 11 to 13 April in Fort Collins, CO, USA
Chairperson: Ann Donoghue
Program Committee: Mike Dryden, Richard Hack, Nancy Hinkle, Joanne Matsuda, Rex Thomas

6th 2001 12 to 15 May in Westport, Co. Mayo, Ireland
Biological Laboratories Europe Ltd
Chairperson: Martin Murphy

7th 2003 13 to 16 April in League City, Texas, USA
Stillmeadow, Inc., Sugar Land, Texas, USA
Chairperson: Bob Sabol, Mark S. Holbert, Jane Coburn, A. A. Perez de Leon,
Program Committee: Mike Dryden, Alberto B. Broce
FOREWORD

Dear colleagues,

on behalf of the Institute of Parasitology, University of Veterinary Medicine, I would like to welcome you all to the 8th International Symposium on Ectoparasites of Pets here in the city of Hannover.

Our university, founded in 1778, is one of the oldest veterinary schools in Europe known for its high standards in veterinary education and research. The city of Hannover was founded more than 1000 years ago and combines the relaxing atmosphere of green parks and lakes with an international flair of business and events. Hannover was host of the World Exhibition 2000, sees every year several 100,000 international guests who visit the world largest computer (CEBIT) and industrial (Hannover Messe) fairs and will be host for some of the top soccer teams during the Soccer World Championship in 2006. The city as well as our university therefore find their roots in history and tradition but aim into the future and feel ambitiously devoted to always meet the highest international standards.

After 2001 in Ireland, this is the second time that this symposium is held in Europe. We are very honoured to organise this meeting and welcome a large number of international attendees from different parts of the old and new world. You can be assured that we tried everything to make you feel home and organise an unforgettable event.

We thank all the participants for their valuable contributions and wish you all a successful meeting and a pleasant stay in Hannover.

Thomas Schnieder
Director, Institute of Parasitology, University of Veterinary Medicine
We kindly thank the following sponsors of the ISEP meeting in Hannover 2005:
ISEP 2005 in Hannover

Programme

Sunday 08th May 2005

15.00-20.30  Registration, Marriott Courtyard Hannover
             - Hotel check in and registration for the symposium -

19.00-23.30  Pfizer Welcome Reception, Marriott Courtyard Hannover
### Monday 09th May 2005

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<td>Breakfast for all hotel guests</td>
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<td>08.00-08.30</td>
<td>Registration for the symposium</td>
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<td>08.00-08.30</td>
<td>Welcome coffee Kindly supported by</td>
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<tr>
<td>08.30-08.50</td>
<td>Opening, Welcome of the Participants</td>
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<td>Housekeeping Remarks</td>
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#### Block 1: Epidemiology/Biology

**Moderator:** Michel Franc

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<td>Ectoparasites of Exotic Pets Keynote Speaker: John Chitty</td>
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<td>Biology of the afrotropical fleas Ctenocephalides felis strongylus (Jordan, 1925) : First results Yao P., N’Goran Kouakou E., Franc M.</td>
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<td>09.45-10.00</td>
<td>Qualitative and quantitative investigations on the flea population dynamics of dogs and cats in several areas of Germany Beck W., Boch K., Mackensen H., Wiegand B., Pfister K.</td>
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<td>Distribution of the chewing louse Werneckiella equi on horses Larsen K. S., Eydal M., Mencke N., Sigurðsson H.</td>
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<td>10.15-10.30</td>
<td>Evidence for an increased geographical distribution of Dermacentor reticulatus in Germany and detection of Rickettsia sp. RpA4 Dautel H., Dippel C., Oehme R., Hartelt K., Schettler E.</td>
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#### 10.30-11.15 Coffee break

#### Block 2: Vector-borne diseases / Ectoparasite-related diseases

**Moderator:** Maggie Fisher

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<td>Fleas and flea allergy dermatitis: the dermatologist’s view Keynote Speaker: Richard EW Halliwell</td>
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<td>14.00-14.30</td>
<td>Tick Transmitted Infectious Diseases of Companion Animals in North America Keynote Speaker: Ed Breitschwerdt</td>
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#### Block 3: Keynote Talk: Molecular Tools in Entomology

**Moderator:** von Samson-Himmelstjerna, Georg

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<td>How will molecular biology influence ectoparasite research? Keynote Speaker: Timothy Geary</td>
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| 14.30-14.45  | Cat fleas (Ctenocephalides felis) as transmitters of viruses: experiments with the feline leukemia virus (FeLV)  
Vobis M., Mehlhorn H., Mencke N. |
| 14.45-15.00  | Mapping dirofilarial (Dirofilaria inmitis and D. repens) infections in Europe  
Mortarino M., Rinaldi L., Cascone C., Cringoli G., Genchi C. |
| 15.00-15.45  | Coffee break                                                            |
| 15.45-16.00  | Prevalence of borreliosis in ixodid ticks in Northern Germany  
Stoverock M., Samson-Himmelstjerna G. von, Schnieder T., Epe C. |
| 16.00-16.15  | Flea hypersensitivity in cats: What can we learn from their basophils?  
Stuke K., Samson-Himmelstjerna G. von, Mencke N., Hansen O., Schnieder T., Leibold W. |

**Block 3:**

**Keynote Talk:**  
Molecular Tools in Entomology  
Kindly supported by

**Moderator:** von Samson-Himmelstjerna, Georg

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| 16.15-16.45  | How will molecular biology influence ectoparasite research?  
Keynote Speaker: Timothy Geary |

**18.00** | Bus Transfer to the Vet School Campus |

**18.30-23.30** | Merial Barbecue Night, Botanical Garden of the Vet School |

**23.30** | Bus Transfer to Marriott Courtyard Hannover |
Tuesday 10th May 2005

06.30-08.30  Breakfast for all hotel guests

08.00-08.30  Welcome coffee

Block 4: Keynotes about Vector-borne diseases II
Moderator: Schnieder, T.
08.30-09.00  Borrelia/Rickettsia EUR-perspective
    Keynote Speaker: Reinhard Straubinger
09.00-09.30  Tick Transmitted Infectious Diseases of Companion Animals in North America
    Keynote Speaker: Ed Breitschwerdt

Block 5: Ectoparasite Control 1
Moderator: Mike Rust
09.30-09.45  Imidacloprid 10 % and Moxidectin 2.5 % spot on (Advocate®) for treatment of
demodicosis in dogs
    Heine J., Krieger K., Fourie L., Dumont P., Radeloff I.
09.45-10.00  Imidacloprid 10 % and Moxidectin 2.5 % spot on (Advocate®) for treatment of
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    Krieger K., Heine J., Fourie L., Dumont P., Radeloff, I.
10.00-10.15  Efficacy of a formulation containing imidacloprid and moxidectin against naturally
acquired ear mite infestations (Psoroptes cuniculi) in rabbits
    Beck W., Hansen O., Gall Y., Pfister K.

10.15-10.45  Coffee break

10.45-11.00  Repellent Efficacy of Imidacloprid 10% / Permethrin 50% Spot-on (Advantix®)
    Against Stable Flies (Stomoxys calcitrans) on Dogs
    Stanneck D., Fourie L.J., Emle R., Krieger K.
11.00-11.15  Repellent Efficacy of a Imidacloprid/ Permethrin spot-on against sand flies
    (Phlebotomus papatasi, P. perniciosus and Lutzomyia longipalpis).
    Mencke N, Volf P., Volfova V., Stanneck D., Miró G., Gálvez R., Mateo M.,
    Montoya A., Molina R.
11.15-11.30  Efficacy of Imidacloprid against Tunga penetrans (sand flea, jigger flea)
    Mehlhorn H., Klimpel S., Heukelbach J., Mencke N.
11.30-11.45  Advocat™ also effective in reptiles and rodents
    Mehlhorn H., Schmahl G., Mevissein I., Mencke N.
11.45-12.00  The effect of permethrin, imidacloprid and their 5:1 mixture on behavioural and
chemoreceptor cell responses of Ixodes ricinus
    Kröber T., Turberg A., Guerin P.M.
12.00-12.15  How uninvited guests outstay their welcome – the tricks of ticks.
    Hannier S., Liversidge J., Sternberg J.M., Bowman A.S.

12.15-13.30  Lunch Break
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<td><strong>13.45-14.00</strong> The development of a method for in vitro testing Sand flies and Mosquitoes.insecticide susceptibility. Franc M.</td>
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<td><strong>14.00-14.15</strong> An in vitro assay for acaricides for hard ticks Kröber T., Guerin P.M.</td>
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<td><strong>14.15-14.30</strong> Methods to monitor the effects of acaricides on behavioural and chemoreceptor cell responses of <em>Ixodes ricinus</em> Kröber T., Guerin, P.M.</td>
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<td><strong>17.30-23.30</strong> Bayer HealthCare Night at the Zoo</td>
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<td>09.00-09.30</td>
<td>Therapy, control and prevention of flea infestation in companion animals</td>
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<td>Efficacy of a cyphenothrin (Gokilaht®) squeeze-on against fleas and ticks on dogs.</td>
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KEYNOTE PRESENTATIONS
Ectoparasites of Exotic Pets

John Chitty BVetMed CertZooMed MRCVS,
Strathmore Veterinary Clinic, London Road, Andover, Hants SP10 2PH, UK

1. AVIAN

Fleas
A wide variety of species of Siphonaptera may be found on many bird species (eg the European Chick Flea, *Ceratophyllus gallinae*) though they are seldom seen. Fleas in general are not host specific and it is likely that these flea species are not specific to an avian host species. Arnall and Keymer (1975) suggest that they may even transfer between avian and mammalian hosts.

The majority of the flea life-cycle is spent off the host around nest sites. A large build-up may occur where many birds nest (eg starlings in roof spaces (Cole (1997))). Large numbers may cause irritation and restlessness and it is possible that significant blood loss could occur in nestlings but there is little documented evidence for this.

One species is worthy of mention, *Echidnophaga gallinacea* the Sticktight Flea. This is common in the Tropics and Sub-Tropics but may be seen on imported birds (mainly poultry/game but also psittacines, raptors and pigeons). Unlike other flea species which regularly transfer between hosts, this species attaches firmly around the head. In severe cases hyperkeratinisation, irritation and anaemia may occur.

*Diagnosis:* Adult fleas on birds. More usually finding adult fleas and their eggs, larvae and pupae in nest sites.

Flies

**Hippoboscids**
a.k.a. Flattflies or louseflies
Related to keds. Many species found on birds including *Pseudolynchia* spp (*Pseudolynchia canariensis* (Pigeon Louse Fly)) and *Ornithomyia* spp. Not host specific. Some species are wingless, others able to fly. Some complete lifecycle on host while others spend time in nests/crevices and may lay eggs off the host. Blood-sucking.

These may cause pruritis and in severe cases may cause an anaemia (especially in young birds). Their main significance is in the spread of blood parasites (eg *Haemoproteus* spp and *Leucocytozoon* spp) and the transfer of mites and lice between individuals.

*Diagnosis:* easily recognised as large flies flattened dorso-ventrally

Myiasis
Invasion of diseased tissue by larvae of Calliphoridae (Blowflies), eg *Calliphora* (Bluebottle) and *Lucilia* (Greenbottle).

This is uncommon in UK birds as most nest and fledge before the main fly season (Malley & Whitbread (1996)). It is therefore only seen in extremely debilitated birds.

*Diagnosis:* Finding of typical larvae in wounds

*Therapy:* Cleaning and removal of larvae/eggs. Treatment of underlying conditions. Application of diluted ivermectin sprayed on to contaminated tissue and systemic dosing of ivermectin.

Mosquitoes (Culicidae)/ Gnats (Simulidiae)
Biting insects transmit various diseases:
- Mosquitoes – *Haemoproteus* spp, avipox virus (USA: Equine encephalomyelitis, West Nile Virus)
- Gnats – *Leucocytozoon* spp

These will rarely be seen on the birds.
Control: Avoidance of fly breeding areas when siting aviaries. Application of fipronil spray to areas of bare skin (especially the face).

“Bugs”
Related to the bedbug, *Cimex lectularius*. Order Hemiptera. Many species found on birds, including *Cimex* spp and *Oeciacus* spp. These are host-specific, eg pigeon has *Cimex columbarius*. Wingless; live and lay eggs in the nest environment. Nymphs and adults are blood-sucking and high levels of infestation may cause anaemia and debility, especially in young birds.

**Diagnosis**: finding adults, nymphs and larvae in the environment. Larger than mites and have six legs in all stages

**Lice**
Wingless insects, these are the most common avian ectoparasites. flattened dorso-ventrally. Only chewing/biting lice (Mallophaga) occur on birds with vast numbers described. Two orders of lice are found on birds, Amblycera (approx 1300 species described) and Ischnocera (2900 species described on birds from a total of ca 3060 species named in this order).

Lice appear to be host-specific and will cluster in various parts of the body with many species being specific for each niche (eg head and neck, topside/underside of wings, rump/tail). This may be reflected in their morphology, eg on pigeons, the slender louse (*Columbicola columbae*) on wings and the larger body louse (*Menopon latum*). They may be named by host, preferred site or morphology.

For a full review, see Smith (2001)
or, [http://darwin.zoology.gla.ac.uk/~vsmith/index_guide.html](http://darwin.zoology.gla.ac.uk/~vsmith/index_guide.html)

Lice are rarely linked to significant pathology. Heavy infestations may cause feather damage and irritation but, more importantly, are a sign of debility/poor husbandry. They can move directly between hosts or may “hitch lifts” on hippoboscid flies.

**Diagnosis**: easily seen on birds.

**Therapy**: environmental control with permethrin/pyriproxifen spray (“Indorex”, Virbac) very effective. This should be combined with regular fipronil applications and avoid bringing ticks into the aviary areas (Chitty (2000)).

**Ticks**
Hard ticks (*Ixodidae*) may feed on birds in the UK. However, soft ticks may be found on newly imported birds.

Large numbers may cause irritation, debility, anaemia and death. Transmit haemoproteozoa (eg *Aegyptionella* spp), arboviruses (eg Louping Ill (grouse)), *Borrelia* spp. (Kurtenbach et al (1999))

*Ixodes frontalis* has been associated with an intense and often fatal reaction around the head of the bird (Forbes and Simpson (1993), Knott (1993)). This may be due to an injected toxin (Phillips (1990)), tick-borne infection (see above), or a hypersensitivity reaction. A recent study has documented treatment and control strategies. It did not identify any pathogens (Monks et al; in press).

**Diagnosis**: easily seen on birds.

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**Ticks**

**Mites**
For a full review see Philips (1997)

**Dermanyssus**
aka. Red Mite/ Roost Mite
Free-living mite living in housing; breeds off the host and only feeds (blood) at night.
Primarily a parasite of poultry (D. gallinae) but will feed on any bird. Can cause intense irritation and restlessness as well as anaemia/debility if numbers large enough. May be fatal to young birds.

**Diagnosis:** mites active at night. May get on humans as well as birds. Examine birds/perches/etc at night. A white sheet placed in aviary/over cage at night may attract mites which can then be seen in the morning (Keymer (1982)).

**Therapy:** Environmental control essential but it should be realised that this is extremely difficult to achieve. Otherwise systemic ivermectin or topical fipronil can be regularly applied to birds in conjunction with environmental acaricides (eg permethrin/pyriproxifen). Ideally the birds should be treated and moved to a new environment and new birds should be treated before joining the group.

**Ornithonyssus**
aka Northern Fowl Mite
A poultry parasite (O. sylviarum) but also found on many other species. Similar to Dermanyssus but completes life-cycle on the host and feeds (blood) through the day as well. It is therefore associated with more irritation than red mite. Control is easier as the mite is an obligate parasite.

**Diagnosis:** Large mites may be found feeding on birds typically around the vent. Mites/eggs may be found on faecal examinations following ingestion during preening.

**Treatment** On-bird treatment (see Dermanyssus) sufficient

**Harvest Mite**

**Neotrombicula autumnalis**
Parasitic larval stage. Very unusual on birds. May provoke an intense reaction, including vesicle formation.

**Diagnosis:** mites easily identified on birds.

**Treatment** fipronil

**Feather Mites**
These live between the barbs on the ventral surface of feathers. The entire life-cycle is spent on the bird. As with lice, species appear host-specific and also prefer certain niches on the bird, eg. on the budgerigar, Protolichus lunula is found on wing and tail feather while Dubininia melopsittaci is found on smaller body feathers. Over 1400 species have been described. Most are not directly damaging to feathers (though Falculifer rostratus may damage feathers on the wings of pigeons) and light burdens generally cause no problems. It is proposed that mite burdens are kept low by the beating of the wings and that large numbers build-up when birds are too debilitated to flap wings (Atyeo & Gaud (1979)). In these situations mites may move off the feathers and onto the skin causing considerable irritation. This can result in loss of productivity in poultry.

**Diagnosis:** adult mites are easily seen as dark dots on feathers. They may be gathered on acetate strips. Discarded sheds of nymphs may be found in the plumulaceous barbs.

**Treatment** fipronil, high-cis permethrin, piperonyl/permethrin powder (Ridmite, Johnson), Piperonal/cedarwood oil/tea tree oil (Bla’t Off, Birdcare Co),

**Quill Mites**
Most species live and reproduce in quills where they feed on available secretions and detritus. The exception are Syringophilid mites which penetrate the quill and suck tissue fluid. In large numbers these may cause feathers to break easily and may predispose to follicle and pulp infections.

**Diagnosis:** appearance of damaged quills (opaque instead of transparent). Opening the quill and examining contents microscopically will reveal mites and eggs.

**Treatment** high-cis permethrin, fipronil
Quill Wall Mites
Laminosioptidae and Fainoctinae. These parasitise the developing primaries of a wide variety of species. They feed on the outer unkeratinised layers of the feather germ triggering hyperkeratosis of the sheath.

*Diagnosis:* Appearance of feathers. Scrapings of hyperkeratotic areas reveal mites.

*Treatment:* difficult! Ivermectin?

Skin Mites
Many species of mite may colonise avian skin. They may be considered in four groups:–

**Epidermoptid Mites:** eg. *Psittophagoides* (psittacines), *Passeroptes* (columbids and passerines) which live on the skin surface; *Michrlichus avus* (canary), *Proyalges* (passerines), *Myialges* (many) burrow into the cornified layer. These latter mites possess clawlike processes on the anterior legs enabling burrowing. These also enable the mite to cling onto hippoboscid mites and move between hosts. These may produce pruritus, crater lesions, scurf, and hyperkeratosis (aka. depluming itch; feather rot). Burrows may be seen as long winding lesions in the skin. *Microlichus* spp (canaries) live in feather bulbs producing congestion and swelling.

*Diagnosis:* typical signs, skin scrape, biopsy.

**Cnemidocoptid mites:** these invade follicles and the stratum corneum of the face and cere (*C. pilae* (psittacines, esp budgerigars)) or feet and legs (*C. pilae*, *C. jamaicensis* (passerines); *C. mutans* (poultry)).

The mites burrowing activity stimulates hyperplasia and hyperkeratosis. There may also be a heterophilic inflammation (Pass(1989)).

*Neocnemidocoptes gallinae* may produce lesions similar to “depluming itch” in poultry.

*Diagnosis:* (very) typical signs, skin scrapes.

**Harpyrhynchid mites:** Several species of *Harpyrhynchus* occur on psittacines birds. *H. serini* is found on canaries and *H. columbae* on pigeons. These attach to feather bases. In severe cases hyperkeratotic epidermal cysts may be produced. These appear pea-sized and white/yellow.

*Diagnosis:* signs, mites may be found inside cysts, eggs may be found on the calamus.

**Cheyletellid mites:** Rare but may produce lesions and a “mange” by burrowing in the stratum corneum. *Ornithocheyletia* spp are found on psittacines. Cheyletellid mite burrows in pigeons have been found to become colonised by a mould (*Micromonospora*) and the mite then feeds on the keratin breakdown products from the mould.

*Diagnosis:* skin scrape.

*Therapy:* ivermectin, moxidectin

**2. REPTILES**

**Flies**
Invasion of devitalized tissue by larvae of Calliphoridae is seen from time-to-time. In the UK this is usually in *Testudo* tortoises that spend the bulk of the summer outside. Abrasions around the vent or under the caudal plastron are frequently “struck”. Otherwise, for “indoor” reptiles, adequate fly control means that myiasis is rare.

**Biting flies** have been shown to cause debility due to stress and blood loss in smaller reptile species as well as acting as vectors for haemoproteozoa, microfilariae, or viruses (Lane and Mader (1996)). While the finding of haemoproteozoa is not uncommon in captive reptiles in the UK (many have been wild-caught or imported) it is rare to see spread of such diseases suggesting that biting flies are not a major problem in the UK.

**Bots.** Larvae may develop in subcutaneous tissues. The classic lesion is a a subcutaneous nodule opening to the surface. There is often a black crusty rim. Manual removal and, possibly surgery for infected cysts, must be employed.

**Fleas**
Fleas are unusual in reptiles. However, in experimental studies various mammalian fleas (Xenopsylla cheopis, Ctenocephalides felis, Ct canis, and X. gerbilli) will feed on reptile hosts (Barnard & Durden (2000)).

**Leeches**

These may be found on aquatic reptiles. In rare cases sufficient may be present to cause localized irritation while in very young animals anaemia may result from heavy infestations. Leeches attaching in the mouth may cause irritation resulting in secondary bacterial infection. Manual removal may cause more damage so it is best to use soaks (freshwater soaks for saltwater hosts and vice-versa) to persuade the leech to release.

**Ticks**

Hard tick of the genera Amblyomma, Hyalomma, Haemaphysalis, Aponomma, and Ixodes have been reported in a variety of species. However, it appears that many tick species are host-specific.

Soft ticks of the genera Argasidae and Ornithodoros are also found and, while some species are host-specific, many are not.

They are rarely found in sufficient numbers to cause anaemia (although this has been reported with Ixodes spp) but can damage the skin resulting in altered appearance and dysecdyis and can act as vectors for protozoan and viral diseases. Ornithodoros ticks have also been shown to transmit the filariid nematode, Macdonaldius oscei to snakes (Frank (1981)).

They often seek certain sites:
- All reptiles – cloaca, nostrils, eyes
- Snakes – olfactory pits
- Lizards – between digits, anterior axillae, elbow joints
- Chelonia – areas beween plastron and carapace (especially hard ticks)

*Treatment:* Manual removal is often necessary. Care must be taken always to remove the entire tick and so, given the sensitive areas to which they often attach, anaesthesia of the host is often necessary.

Topical fipronil or systemic ivermectin may also be used. Permethrin formulations have also been shown to be effective (Burridge et al (2003)).

NB. IVERMECTIN MUST NEVER BE USED IN CHELONIA!

**Mites**

Ophionyssus natricis. Found on snakes and (occasionally) lizards and lives under scales. Infestations may be severe enough to cause anaemia and debility. They also cause extreme irritation and affected animals may be seen to rub frequently and/or spend long periods of time soaking in water. Diagnosis is by observation of the mite on the skin; suspicion is often aroused by the altered behaviour of the host. They are usually found around the head and cloaca of the host.

Damage to scales may result in dysecdyis. However, the principal significance of this mite is in the transmission of disease, principally Inclusion Body Disease (IBD) virus in boids.

An excellent review of the biology of this mite may be found in Wozniac and deNardo (2000).

*Treatment:* the mite is capable of living off-host for large periods so environmental and on-host therapy is essential. Ivermectin or fipronil sprays or dichlorvos strips can be used in the environment. All organic materials must be discarded at this time. Ivermectin or fipronil can be used for the host.

Control is essential as this mite can rapidly colonise reptile collections especially as it appears highly mobile and due to the risks of disease transmission. All new animals should be quarantined and treated for mites, and the there is a good argument for regular environmental treatment.

**Trombiculid mites** may be seen on snakes and lizards. They generally colonise skin folds. As free-living adults do not survive in the captive environment, infestations do not build-up. The pathogenicity of the larvae is unknown (Lane & Mader (1996)).
Prostigmatid mites may be found under the scales of snakes (Ophioptidae) and in the cloacal mucosa of aquatic and semi-aquatic chelonia (Cloacaridae). They may cause localized irritation, but their definition as a true “parasite” is open to question (Klingenberg (2004)).

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www.missouri.edu/~vmicrorc/Byhost/Poultry.htm: a very useful web resource with separate sections on parasites of raptors, cage birds and ratites

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FLEAS AND FLEA ALLERGY DERMATITIS: 
THE DERMATOLOGIST’S VIEW

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Introduction:
Flea allergy dermatitis (FAD) is by far the most common skin disease affecting dogs and cats world-wide. Although the newer parasiticidal agents have enormously improved the ability of the veterinarian to manage the disease, only 10 years ago, difficulties with flea control led to serious welfare implications with many dogs and cats being euthanised.

Species of fleas involved
In most geographic locations, Ct. felis felis is the subspecies found most commonly on dogs and cats. Ct. canis is common on dogs in some parts of Europe (e.g. Ireland, but rare to absent in the USA. Echidnophagia gallinacea is an important parasite in some parts of the world. Pulex irritans and/or Pulex simulans, may also affect dogs, and less frequently cats. However they generally account for only around 1% of infestations.

Fleas whose natural hosts are birds (Ceratophyllus gallinae), rats (Xenopsylla cheopis), hedgehogs (Archeopsylla ernacei) and rabbits (Spylopsyllus cuniculi) will sometimes parasitise dogs and cats. These are the major cause of FAD in the more northern parts of Europe, where Ct. felis is rare to absent. In these situations control is readily effected.

Other hosts of Ct. felis
As Ct. felis is the major species involved, it is important for the dermatologist to be aware of the potential for introduction of this species to the local environment by wildlife. In this regard, ferrets, opossums, racoons and foxes may be of concern, whilst squirrels and rabbits are not ordinarily involved.

The development of FAD
It seems likely that all animals that suffer from dermatitis due to flea infestation are, in fact, allergic to the bites of the fleas. It is of great importance, therefore, to understand how FAD develops.

1. The flea allergen:
Despite the early work that implied that the flea antigen was a hapten (1) it is now known that there are a number of protein allergens in both saliva and allergenic extracts, with different dogs recognise differing allergens (2). The major allergen, Ctef1, is recognised by >90% of animals with FAD, and has been produced in recombinant form (3).

2. The induction of hypersensitivity.
Work undertaken in the laboratories of the author have shown that:
(i) All dogs can become allergic to fleas (2).
(ii) Atopic dogs are predisposed to developing flea allergy (2).
(iii) When dogs were exposed to the bites of 15 fleas for 15 minutes once or three times each week, they became allergic much quicker than did the dogs that were continually exposed, suggesting that intermittent exposure favours the development of FAD, whilst continual exposure was protective. However, when continually exposed dogs which are non-reactive are changed to intermittent exposure,
hyper-sensitivity develops (4). This finding was not confirmed by a later study which used different protocols (5).

(iv) The incidence of flea allergy diminishes somewhat with age, suggesting that spontaneous "desensitisation" may occur with time in some animals (2).

(v) Exposure to the bites of fleas early in life tends to lessen the chance of developing flea allergy later in life (2).

3. **The immunopathogenesis of flea allergy**
   This is complex and involves:
   (i) Immediate hyper-sensitivity, mediated by IgE (6).
   (ii) Delayed, cell-mediated hyper-sensitivity (6).
   (iii) Cutaneous basophil hypersensitivity (7).
   It is also possible that there may be contributions from late-phase IgE mediated pathways and from Arthus (IgG-mediated) reactions.

4. **The immunological nature of “non-reactivity”**.
   Animals continually exposed who do not have flea allergy have low to absent levels of IgE and IgG antibodies to flea allergen suggesting that they are at least partially immunologically tolerant (4, 8).

**Clinical signs of flea allergy**

**The dog:** Animals may present showing any or all of the following signs:

**Primary:**
- A papule appears within 15 minutes and persists for 48-72 hours.
- It may develop a small crust, but spreading lesions do not occur (cf bacterial folliculitis).
- Lesions preferentially involve the lower back, the inner and posterior thighs and the umbilical area.
- Lesions may generalise, and any area can be affected.
- In the case of *Echidnophagia gallinacea* (the "tick-tight" flea), localised involvement may occur.

**Secondary:**
- There is evidence of self-trauma, of seborrhoea and alopecia.
- Hyperpigmentation and lichenification may develop.
- Secondary bacterial folliculitis may develop, but is usually not sufficiently severe to necessitate treatment.

**The cat:** Cats may show any or all of the following signs, which are generally far less diagnostic than in the case of the dog:

**Primary:**
- A papule, which may be so small as to be difficult to recognise.
- The distribution in the cat is not so characteristic.
- There may be generalised pruritus with no specific distribution.

**Secondary:**
- Miliary dermatitis
- Hair loss from excessive licking
- Eosinophilic plaques, eosinophilic ulcers. and possibly also other manifestations of the eosinophilic granuloma complex.

**Diagnosis**

Fulfilment of all of the following criteria are necessary for a definitive diagnosis:
1. The presence of fleas and/or flea dirt.

2. Compatible clinical signs.

3. Demonstrated hypersensitivity.
   This is best achieved by the use of intradermal skin tests with aqueous flea antigen at 1/1000 W/V. Most animals show both immediate and delayed reactions, but some 15-30% of animals will show a delayed reaction only which is evident at 24-48 hours. It is thus important that, in the event of a negative immediate reaction, the patient is re-examined at 24-48 hours to observe for a possible delayed reaction. The latter may in fact have greater significance, in that in one study on cats, development of delayed hypersensitivity was associated with significant clinical signs following flea exposure (9).

Serological tests, offer an alternative, but these will not identify animals with the delayed component alone, and so some 15-30% of false negatives will occur.

4. Response to appropriate parasiticidal therapy.
   Here, it must be remembered that atopic dermatitis can co-exist with FAD, in which case a partial improvement only will result.

**Therapy**

**Parasiticidal therapy**
   This is the cornerstone of the approach, and the therapeutic plan must include consideration of all of the pets, the inside environment, and, if climatic conditions dictate, the outside environment. Specific choice of agents is beyond the scope of this presentation.

**Hyposensitization**
   Hyposensitization with the currently available aqueous products have not shown efficacy in either dogs or cats. On the other hand, "rush" hyposensitization with an experimental flea salivary antigen was effective (10). However the expense of production precludes the ready commercialisation of this approach. Use of recombinant allergens has yet to be assessed, but may offer promise.

**Anti-allergic therapy**
   This should be used as an adjunct to effective parasite control, and never as a substitute. Approaches include:

   **Corticosteroids** in short, tapered doses, are very effective.

   **Antihistamines** are not generally effective, although chlorphenarimine may be of use in cats. **Essential fatty acids** have not in general proved efficacious, although higher doses have some efficacy.

**Formulation of the therapeutic strategy**
   Important points that the clinician should remember are:

   - Every case is different, and may require a different, individualised approach.
   - The situation must be assessed carefully with a full history. The approach for FAD will be different than that for flea control in a non-allergic pet.
   - All in-contact pets must be treated.
   - The clinician must determine the likely level of infestation (i) on the pet and (ii) in the internal and (iii) external environment.
   - Therapy must be devised not only for the pet, but if significant environmental contamination is likely, also for the internal and external environment.
   - The likelihood of reinfection must be considered, and a decision made as to whether continued therapy is necessary.
• Corticosteroid therapy may be used, but should never replace effective parasite control.
• Finally, it is vital to communicate effectively to ensure client compliance.

A look to the future
Although FAD is relatively simple to control, assuming a clear understanding of flea biology and the use and properties of the newer products, it is inevitable that with time resistance will develop to the currently effective agents. This would refocus research on the possibilities of artificially inducing tolerance. One such study in cats employed oral dosing with antigen in young kittens. Although the treated animals had lower clinical scores following subsequent flea exposure, the results were not statistically significant (9). Attempts to deviate the immune response away from a Th2 towards a Th1 (e.g. via deoxyoligonucleotides (11)) may offer interesting possibilities, although without definitive evidence as to the relative pathogenicity of the component immunological pathways, a Th1 response could turn out to be as deleterious as is a Th2 response.

At all events, despite a great deal of progress in recent years, FAD is likely to engage the attention of researchers for many years to come.

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CANINE LEISHMANIOSIS: CHANGING THE PARADIGM

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Introduction

In last years most paradigms of infectious diseases have experienced a deep revision. We should not forget that the basis for the understanding, diagnosis and treatment of infectious diseases were established more than a century ago (Robert Koch’s postulates) and that in these years sciences as the immunology or the molecular biology were not born yet. Now the advances of these sciences have allowed deep changes in infectious diseases. First, the limits between infectious ad non-infectious diseases have become less defined. For instance, infectious agents have been demonstrated to be the cause of diseases considered for centuries as non-infectious. The role of Helicobacter pylori in the pathogenesis of gastric ulcers could be an example.

Second, the relationship between infection and disease has become more complex. The simple equation of infection=disease has been demonstrated wrong in many case. For instance, we know that not all dogs infected by Borrelia spp. develop Lyme’s disease; many infections run asymptomatic.

Finally, it seems that clinical cure is not always associated to the elimination of the infectious agent. When techniques of high sensibility (PCR, nested PCR) are used, the infectious agents can be detected years after the clinical cure. This fact has been demonstrated, for instance, in cases of tuberculosis in human beings.

Canine leishmaniosis constitutes an excellent example of all these changes. The way we used to understand the most important canine disease of the mediterranean area has deeply changed. A new paradigm, based on immunology and molecular biology results, is born. A new paradigm which has numerous implications in the diagnosis, treatment and control of the disease. The main purpose of this lecture will be to discuss this new paradigm and its implications.

The old paradigm and the change

Until now, key facts about canine leishmaniosis were:

1. The prevalence of the disease in the mediterranean area was 1-5% and the seroprevalence 5-15% (higher in some foci)

2. Most infected dogs develop the disease, sooner or later

3. Infected animals become seropositive

Two research lines have changed this paradigm. First, immunologists demonstrated, investigating the experimental infection of mice with L. major, that the immune response plays a key role in the evolution of the infection. In mice genetically
deficient in the cellular immune response (BALB/c, for instance) the infection progresses and a severe systemic disease appears. These mice develop a humoral immune response (Thelper-2, production of antibodies) which is inefficient in controlling the infection. Contrarily, mice belonging to other lines (C3H), control the infection by means of a cellular immune response (Thelper-1). In this last case CD4+ T cells are activated and produce gamma-interferon, which activates macrophages for the elimination of the parasites. Genetics, in consequence, is a key factor in the control of the immune response which is the key factor for the evolution of the disease.

Later on it was demonstrated that the situation in the dog was very similar to those described in mice: not all infected dogs develop the disease. Furthermore, dogs which developed the disease showed a humoral immune response, contrarily to the resistant dogs which showed a cellular immune response (similar to helper type-1). Dogs affected by the disease are strongly immunedepressed as can be demonstrated by lymphocyte proliferation tests or by the low production of cytokines by PBMCs after stimulation. The number of circulating CD4+ cells and the CD4+/CD8+ ratio drop during the disease.

A more recent paper demonstrates that besides immune response other resistance factors are important in controlling susceptibility to leishmaniosis in the dog. The authors have mapped and sequenced the canine RAMP1 gene (Slc11a1) and demonstrated that dogs susceptible to canine leishmaniosis have mutations in this gene which controls a ion transport protein involved in the control of intraphagosomal replication of parasites. This paper together with a previous study demonstrating that Ibizian hounds (a breed authoctonous of the Balearic islands) present a predominantly cellular and protective immune response against *Leishmania* infection have pointed out the major role that genetics play in the outcome of *Leishmania* infection in the dog.

At the same time, epidemiological studies showed that the incidence of the prevalence of the infection is much higher than the prevalence of the disease. For instance, a study performed in Mallorca using the PCR techniques on different tissues demonstrated that *Leishmania* infects 2 out of 3 dogs. In this study, most infected dogs showed no clinical signs. Similar studies performed in France and Portugal found similar results.

Finally, both research lines melted when it was demonstrated that infected but asymptomatic dogs had a cellular, effective cellular immune response, contrarily to symptomatic dogs which had a mainly humoral immune response (although the situation is not so polarised as it is in mice). In short, the new paradigm was born.

**The new paradigm**

1. Prevalence of infection is much higher than traditionally thought. In endemic areas probably over 50% of dogs become infected.

2. Most infected dogs do not develop the disease and remain free of clinical signs. Prevalence of the disease ranges between 1 and 10%.
3. Infected animals without clinical signs show a cellular immune response against Leishmania and usually are seronegative or weakly seropositive (borderline titres).

4. The infected and ill dogs show a humoral immune response but a weak cellular immune response.

5. A given dog can change from resistant to sensible to the disease and inversely. Drugs, infections, parasitic infestations, neoplasia, can induce the change.

**Implications of the new paradigm for the diagnosis of the disease**

1. The diagnosis of the disease is a complex task. The results of each technique have to be interpreted adequately. For instance, a positive PCR means, only, that the animal is infected (as a positive bone marrow smear). A positive means infection and humoral immune response, which usually is linked to development of clinical signs (especially if the titres are high).

2. The diagnosis, at the end, is always a clinical decision. Based on several analysis, but clinical. No one single test can establish a definitive diagnosis of leishmaniosis.

3. Diagnostic tests (serology, PCR, intradermal skin test with leishmanin) should be used when a dog show clinical signs compatible with the disease. The clinical behaviour to be followed in infected but clinically healthy dogs is, at the present moment uncertain. A periodic follow-up is, in any case, mandatory.

4. In most cases, several diagnostic techniques have to be combined to establish adequately the diagnosis. The techniques to be used in a given case depend on the clinical signs (for instance, a skin biopsy is usually very useful when cutaneous lesions are present).

5. In many patients the disease is associated with a hidden cause which has depressed the immune response (drug treatments, parasitism, infection, chronic diseases,…). In fact, scientific literature is full of case reports of leishmaniosis associated to different diseases (haemangiosarcoma, lymphoma, pemphigus foliaceus, ehrlichiosis,…). A plausible explanation would be that these dogs were chronically infected animals that developed leishmaniosis when an event (treatment, infection, neoplasia,…) change their immune response. Especially in middle-aged and old dogs affected by leishmaniosis the presence of hidden causes has always to be investigated.

**Implications for the treatment**

1. The combination of N-methyl-glucamine (40mg/kg/12 h; one month) and allopurinol 10-20mg/kg/12 h (at least one year) seems to be very effective in the control of canine leishmaniosis. Amphotericine B is a second option.

2. An alternative already in use in human medicine is miltefosine. Miltefosine is a phospholipid of high leishmanicid activity, which is given per os. Current clinical studies are trying to define the most covenant dosage and administration regime
for the dog (probably around 2-3 mg/kg/day). Main side effects are gastrointestinal.

3. Complete/definitive elimination of the infection is probably rare. Most dogs after the clinical cure remain infected.

4. As important as the treatment is to control the general condition of the patient and to detect hidden pathologies, infections, parasites,…..

5. Prognosis should be given on an individual basis. The recovery of the cellular immune response is the best indicator of good prognosis: increase in the number of circulating CD4+ and of the CD4+/CD8+ ratio, increase in the size of the intradermal skin test, decrease in the serum gamma-globulines, normalisation of the proteinogramme, decrease in the antibody titre,…..)
How will molecular biology influence ectoparasite research?

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Ectoparasite control is an important economic aspect of veterinary practice and remains a priority for pet owners and livestock producers. The presence of non-treated host animals (wild and domestic) and the seemingly inevitable rise and spread of drug resistance means that problems posed by ectoparasites can be managed but not eliminated. The availability of persistent, efficacious insecticides has wrongly minimized the need for continuing research into the biology of ectoparasites. Developments in molecular biology promise to revolutionize the kinds of research questions that can be asked in parasite systems. In the near future, the ability to detect insecticide resistant ectoparasites at low frequencies will help reduce the impact of these phenotypes on management. Genomics research will illuminate new targets for ectoparasite-specific chemotherapeutic control outside the roster of those targets relevant for agrochemical companies. Additional insights into the molecular bases for host-parasite restriction will be of interest for parasitologists and may reveal new ways to chemically or immunologically control ectoparasites on pets. Examples of possibilities in each of these areas will be given to illustrate potential research avenues. An important result of adopting new research tools may be a reinvigoration of basic (as opposed to clinical) research into the biology of ectoparasites, helping to ensure the appropriate training of the next generation of clinical ectoparasitologists.
Borrelia/Rickettsia EUR-perspective

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In Europe the most important tick-borne disease for man and animals is Lyme borreliosis. Five pathogenic Borrelia species for have been identified during the last years in Europe: *Borrelia burgdorferi* sensu stricto, *B. afzelii*, *B. garinii*, *B. lusitaniae*, and *B. valaisiana*. These slow-growing spirochetes may cause an *erythema migrans* (EM) around the site of tick attachment in humans and in man and animals unspecific flu-like symptoms within days or weeks after the infection. In addition acute inflammatory lesions in joints, heart, and the nervous system may be observed or renal failure due to an immune-complex-mediated event may develop weeks to months later, while in a few patients chronic alterations may be seen years after the infection. Epidemiological studies have shown that depending on the region under investigation up to 60% of ticks carry the infectious organisms and accordingly a large proportion of vertebrate hosts (approx. 20% of the dog population) had antigen contact.

**Ehrlichiosis** in man and animals is caused by a variety of *Ehrlichia* species. *Ehrlichia canis* causes monocytotropic ehrlichiosis in dogs with fever, anorexia, weight loss, hemorrhagic diathesis, CNS signs, and lymphadenomegaly. *Anaplasma phagocytophilum* (formerly *Ehrlichia equi*, *Ehrlichia phagocytophila*, HGE-agent) infects horses, dogs and humans (human granulocytic ehrlichiosis) and clinical signs include fever, anorexia, depression, lameness, lymphadenomegaly and limb edema. Less than 5% of the European tick populations carry *Ehrlichia* organisms.

**Babesiosis:** Members of the genus *Babesia* belong to a group of the *Apicomplexa* referred to as piroplasms. These organisms have two host life cycles involving a tick and a mammal. In the mammalian host the organisms reproduce asexually in the host's red blood cells. Clinical signs include fever, chills, fatigue, muscle pain, and anemia. In Europe most reported cases are due to *B. divergens* and occur in splenectomized patients. In a study from Switzerland, the overall prevalence of *Babesia* organisms in ticks was close to 4%, but varied with the location of origin (0.8 to 11%).

**Tick-borne Encephalitis (TBE)** is a communicable disease caused by a flavivirus and infected ticks are the main vectors. At least 10,000 human cases of TBE are referred to hospitals each year, yet the incidence of TBE so far is not fully recognized. The nervous system is affected, at least four clinical features of different severity are observed: meningitis, meningoencephalitis, meningoencephalomyelitis, meningoradiculoneuritis. In dogs with severe neurological signs, which were euthanized or died spontaneously, TBE-virus antigen was detected in their brains. The prevalence of TBE-virus in ticks from endemic areas of central Europe is estimated to be less than 1%.
Tick Transmitted Infectious Diseases of Companion Animals in North America

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Introduction

Despite substantial progress in our understanding of the disease manifestations caused by several tick-transmitted pathogens, numerous challenges continue to confront vector borne diseases researchers and the veterinary profession. Without question, veterinarians play a central role in the diagnosis, treatment and prevention of tick-transmitted infectious diseases of companion animals. Increasingly, veterinarians also play an important role in advising the public as to the zoonotic potential of pathogens that are transmitted by ticks to cats, dogs and human beings. Based upon scientific evidence, that has been generated during the past several decades, tick-transmitted pathogens can induce clinical manifestations ranging from acute fatal illness (i.e. anaplasmosis, babesiosis cytauxzoonosis, ehrlichiosis and Rocky Mountain spotted fever) to chronic debilitating disease states (ehrlichiosis, babesiosis borreliosis and bartonellosis). Therefore, minimizing or eliminating tick infestations in companion animals is perhaps of greater medical importance to the pet-owning public today, than during any previous time in history. In addition to facilitating improvements in the health care for companion animals, veterinarians are contributing in a substantial manner to the comparative medical understanding of these often times elusive infectious agents. During this discussion, I will attempt to highlight several of the factors that continue to challenge our current understanding of tick-transmitted infectious diseases.

Evolution and Tick Transmitted Infections

Recent data conceptually support the hypothesis that the common evolutionary history of Anaplasma, Bartonella, Borrelia and Ehrlichia species has resulted in a modern day complex of pathophysiological interactions among these organisms in animals and people. Following tick transmission, polymicrobial infections contribute to highly variable disease expression and increased severity of illness in both animal and human patients. For the clinician, confirming infection caused by a single tick borne pathogen can be very challenging, particularly when evaluating chronic as compared to acute illness. The microbiological confirmation of polymicrobial tick borne infections, particularly using current diagnostic modalities, can be much more difficult than confirming a solo infection.

Host Specificity and Tick Transmitted Infections

Although many tick borne infectious agents are more likely to be readily detected in one animal species, most organisms appear to be able to infect multiple animal species. Although first detected in horses in California in the 1070s, it has been recognized for some time that A. phagocytophilum can induce disease in cats, dogs, human beings. Anaplasma phagocytophilum can also infect numerous other wild animal species that serve as reservoir hosts. Bartonella vinsonii (berkhoffii), initially isolated from a dog with endocarditis in our laboratory, was subsequently isolated from a human with endocarditis in Europe. Infection with B. henselae, identified in the early 1990’s as the predominant cause of cat scratch disease (CSD) and bacillary angiomatosis and peliosis hepatis in immunocompromised individuals, is now known to be a much more prevalent infection in dogs than previously recognized. Evidence supporting tick transmission of Bartonella spp. is growing and it is
possible that the \textit{B. henselae} strains that infect dogs are transmitted by ticks as well as fleas. Similar to \textit{Anaplasma}, \textit{Borrelia} and \textit{Bartonella} spp., \textit{E. canis}, \textit{E. chaffeensis}, \textit{E. ewingii} and seemingly \textit{E. ruminantium} can infect both dogs and people. Importantly, organisms in these genera are transmitted worldwide to dogs and people by a diverse spectrum of tick species. Widespread variation in the number and types of tick-borne pathogens found in different geographic locations, further complicates the diagnosis of polymicrobial infections. The evolutionary interrelationships among these genera in disease expression are also supported by the molecular documentation of polymicrobial infection in cats, dogs and other animals, including man.

\textbf{Geographic Variation in the Prevalence of Tick-transmitted Pathogens}

Geographic variation in the prevalence of tick-transmitted pathogens presents an important challenge for veterinary clinicians. For example, in the northeastern United States, \textit{Ixodes scapularis} can transmit \textit{Borrelia burgdorferi}, \textit{Babesia microti}, \textit{Anaplasma phagocytophilum} (previously \textit{Ehrlichia equi}) and \textit{Bartonella vinsonii} (arupensis). In the southeastern United States, dogs are more frequently exposed to \textit{Dermacentor variabilis}, \textit{Amblyomma americanum} and \textit{R. sanguineus}, which could result in infection with \textit{E. canis}, \textit{E. ewingii}, \textit{E. chaffeensis}, \textit{Anaplasma}, \textit{platys}, \textit{Babesia canis}, \textit{B. vinsonii} (berkhoffii), \textit{R. rickettsii} and other less pathogenic spotted fever group rickettsiae, such as \textit{R. montana} and \textit{R. rhipicephali}. Therefore, it is becoming increasingly obvious that ticks in different North American regions or localities transmit different pathogens. Importantly, a given tick species may transmit a particular pathogen in one part of the world, but is not associated with transmission of the same organism in another part of the world. For example, \textit{Rhipicephalus sanguineus} transmits \textit{Rickettsia rickettsii} in South America and \textit{Rickettsia conorii} (the cause of Mediterranean spotted fever in people) in Europe, but is not believed to be associated with the transmission of \textit{R. rickettsii} in North America. As many tick-transmitted infections result in a prolonged subclinical course, a dog or cat might be infected in an endemic area, where veterinarians are very familiar with the disease manifestations. Unfortunately, the animal may become ill months to years later, after moving to an area in which the disease is not endemic and where veterinarians are far less familiar with the disease manifestations. This scenario is not unique to tick-borne pathogens, but is shared by other vector-borne pathogens, such as \textit{Leishmania infantum}. Leishmania infected dogs are transported from sand fly endemic regions in Europe to North America, where most veterinarians are very unfamiliar with the clinical or hematological manifestations of leishmaniasis.

Serological and molecular evidence indicates that simultaneous infection with multiple tick-borne pathogens may not be an unusual occurrence, particularly in dogs with extensive tick exposure. Simultaneous infection can increase the severity of disease manifestations or substantially alter the clinical presentation to the extent that a tick-transmitted pathogen is not suspected as a cause of the disease manifestations. As the number of documented tick-borne pathogens continues to increase and as molecular evidence of co-infection increases, the relative importance of tick control measures to the maintenance of a healthy pet has also become ever more obvious.

\textbf{Isolation or Molecular Detection of Tick-transmitted Pathogens}

Historically, studies from our research group have involved intracellular pathogens in the \textit{Genera Rickettsia}, \textit{Ehrlichia}, \textit{Babesia} and more recently, \textit{Bartonella}. In regard to the study of these obligate intracellular or in the case of \textit{Bartonella} sp., highly fastidious pathogens, clinical, as well as more basic research initiatives, have been hampered by difficulties associated with the in vitro culture of these organisms. The advent of molecular techniques that facilitate the detection of bacterial DNA in patient blood samples has begun to revolutionize the current understanding and medical practices related to the management of tick-transmitted infectious diseases. To a substantial degree, this molecular diagnostic revolution started with investigations related to \textit{Bartonella} sp. in HIV infected individuals in
North America. In recent years, we have come to better appreciate both the benefits and the limitations of molecular approaches for the detection of organism specific DNA in patient samples.

Causation and Infection with Tick-transmitted Pathogens

From an evolutionary perspective, it is obvious that ticks, tick-transmitted organisms, and animal and human hosts have developed a highly adapted form of interaction. The tick needs blood for nutrition; the bacterial, rickettsial and protozoal organisms need an intracellular environment to survive and immunologically, most hosts appear to be able to support chronic infection with many of these organisms without obvious deleterious effects. For this reason, establishing causation associated with tick-transmitted pathogens will remain a challenge for the foreseeable future. Seemingly disease expression would represent a strategic error on the part of the organism or the host. As recent serologic and molecular evidence indicates that co-infection in dogs with *Ehrlichia, Babesia, Rickettsia* and *Bartonella* spp. may be more frequent than previously realized, the extent to which infection with a *Bartonella* species influences the pathophysiology of ehrlichiosis, a disease of much longer historical venue, deserves critical reappraisal. For example, infection with *Bartonella* in dogs concurrently infected with *Ehrlichia canis* may contribute to the tendency to develop epistaxis. Historically, epistaxis has been attributed to ehrlichiosis, rather than bartonellosis. Of similar potential concern in human medicine is the finding of co-segregation of *Borrelia burgdorferi, Anaplasma phagocytophilum* (the cause of human anaplasmosis), *Babesia microti* and *Bartonella vinsonii (arupensis)* in *Ixodes scapularis* ticks in the northeastern and northcentral United States. A similar pattern of co-segregation has also been reported in *Ixodes ricinus* in Holland. As bartonella infection has been associated with reactive arthritis in children and polyarthritis in dogs, one might question as to whether simultaneous infection with *B. vinsonii (arupensis)* contributes to the pathogenesis of “Lyme arthritis” or could untreated bartonella infection explain cases of refractory arthritis in individuals diagnosed with chronic Lyme disease. Collectively, these recent observations also serve to illustrate the potential difficulty in establishing causation in dogs or people co-infected with multiple tick-transmitted pathogens. As certain *Borrelia, Ehrlichia, Babesia*, and *Bartonella* spp. can cause chronic, insidious infection in dogs, the relative role of each organism to the pathogenesis of specific disease manifestations in a sick, naturally infected dog will remain difficult to establish. Certainly, more recent evidence indicates that clinicians should screen for a panel of tick-transmitted pathogens when dealing with sick dogs with a history of tick exposure.

Concluding Remarks

Tick-transmitted infectious diseases will continue to challenge the creativity of the medical professions. Future research efforts must substantially improve our ability to detect the presence of tick-transmitted pathogens in our patients. For several tick-transmitted diseases, there is a serious need for better treatment modalities. The currently available treatments for diseases such as babesiosis, bartonellosis, ehrlichiosis or borreliosis, may only induce a state of remission, rather than eliciting a therapeutic cure. As the diagnosis and treatment of these diseases will remain challenging for the clinician and expensive for the client, development of a “tick pathogen vaccine”, that would prevent transmission of all or most tick-borne pathogens would seem to have great medical utility. In the interim, the use of products that will kill ticks prior to or shortly after attachment to the pet, will minimize the potential for the transmission of these pathogens.
Selected References From Our Research Group:


Innovations and Future Directions in the Control of Cat Fleas on Cats and Dogs

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Keywords: cat flea, Ctenocephalides felis, host-targeted treatments, insecticide resistance

Abstract: The cat flea, Ctenocephalides felis (Bouché), is the most important ectoparasite of cats and dogs worldwide. In the past 10 years, topical and oral applications of insecticides such as fipronil, imidacloprid, lufenuron, and most recently, selamectin, have revolutionized cat flea control. These therapies eliminate the need to treat indoor and outdoor environments and their use dramatically reduces the severity and incidence of flea allergic dermatitis. Extensive surveys have yet to reveal the development of insecticide resistance to imidacloprid in cat fleas. Recent molecular techniques provide the means to rapidly survey cat flea isolates for pyrethroid and dieldrin resistance. Many existing laboratory strains were positive for pyrethroid genes and a new susceptible strain needs to be developed. Extending the longevity of these effective host-targeted therapies and preventing resistance should be a major goal of the research and veterinary community.

The cat flea, Ctenocephalides felis (Bouché), is the primary ectoparasite of cats and dogs worldwide. In the past 10 years, flea control on companion animals has been revolutionized by systemic and topical insecticides such as lufenuron, fipronil, imidacloprid, and most recently, nitenpyram and selamectin. Prior to their introduction, most practitioners recommended a comprehensive treatment of the indoor and outdoor environments and the pet. Within just a few years after the introduction of these revolutionary treatments, the paradigm has shifted to advocating host-targeted strategies.

The objectives of this presentation are to review recent advances in host-targeted insecticides, consider the status of insecticide resistance, and propose that strategies be considered for the conservation of these effective new therapies. Some recent comprehensive reviews of cat flea biology and control (Rust and Dryden 1997, Krämer and Mencke 2001, Rust 2005) and of the new insecticides and their mode of action for controlling ectoparasites (Marsella 1999, Taylor 2001, Hovda and Hooser 2002) and flea allergic dermatitis (Carolliti and Jacobs 2000) have been published.

Host-Targeted Therapy. Even though shampoos, dips, and sprays with compounds such as cythioate, permethrin and synergized pyrethrins had been widely used as residual treatments on pets, these host-targeted therapies never altered the marketplace. Many of these are still widely sold in the over-the-counter market, but they do not provide outstanding control of fleas both on and off the animals. This revolutionary change to host-targeted therapies did not occur until our understanding of the biology of the cat flea and the importance of interrupting its life cycle was fully appreciated. Disruption of the flea life cycle at several stages was possible with the advent of new chemistries and a new strategy of flea control that began in 1995.

The avermectins are a group of fermentation products isolated from a strain of bacteria, Streptomyces avermitilis, possessing potent anthelmintic and insecticidal activity. Even though they have potent systemic activity against heartworms and larvae of cattle grubs, Zackson-Aiken (2001) showed that the commercialized compounds abamectin, ivermectin, milbemycin D, and selamectin did not have systemic activity against cat fleas in artificial membrane studies. However, topical formulations of selamectin provided nearly 100% kill of fleas within 36 h on dogs and 24 h on cats for cats and dogs (McTier et al.
2000a,b; Schenker et al. 2003). More importantly, in flea-infested environments selamectin provided cats and dogs protection in flea-infested environments for up to 3 months (Ratzhaupt 2000 a,b; 2002), its activity against activity against the immature stages of fleas contributing to this control.

Fipronil is a phenylpyrazole insecticide disrupts normal nerve function by blocking the GABA-gated chloride channels in neurons in the central nervous system, sharing a common binding site with cyclodiene and t-butylibicyclophosphorothionates. Monthly applications of fipronil “spot-on” on dogs provided about 98% control of fleas for 90 days (Medleau et al. 2002). Jacobs et al. (2001a) reported that in a simulated home environment topical applications provided outstanding control for 180 days. Dryden et al. (2000) reported that topical applications in a home environment provided > 97% reductions of fleas on the pet and > 98.6% reduction of fleas in the environment.

Imidacloprid is a chloronicotinyl insecticide acts as a competitive inhibitor at nicotinic acetylcholine receptors of the nervous system, resulting in the impairment of normal nerve function. Single topical applications of imidacloprid provided >95% control of fleas on cats and dogs for 28 to 37 days (Ritzhaupt 2000a, Liebisch and Reimann 2000). Dryden et al. (1999) reported that in home environments imidacloprid provided >97% reduction of fleas on pets and >98.6% reduction of fleas in the home. When applied to the pelage on animals, sufficient amounts of imidacloprid transfer to the immediate environment such as the pet’s blanket to prevent up to 74% adult development at 4 weeks (Jacobs et al. 2001b).

Nitenpyram, like imidacloprid, is a chloronicotinyl insecticide that acts on the nicotinic acetylcholine receptor channel (AChR). It is administered orally and is readily absorbed into the blood stream in 90 min and excreted in urine over 48 h. The minimal effective blood concentration to kill 100% of fleas feeding on the host is 0.5-0.9 ppm. Within 30 min, adult fleas are knocked down (Dobson et al. 2000, Rust et al. 2003) and by 6 h > 95 of the fleas were killed. Biologically activity doses of nitenpyram remained in the host's blood for 48 h (Rust et al. 2003).

A spot on application of 1 mg/kg pyriproxyfen on cats provided up to 9 weeks activity against flea eggs (Jacobs et al. 1996). Concentrations of pyriproxyfen applied to cat hair at 0.0001 mg/kg and in blood as low as 0.01 mg/L prevented 100% development of eggs (Stanneck et al. 2003). The dispersal of pyriproxyfen on the animal’s pelage remained above the efficacy level for 56 days. Pyriproxyfen was not toxic to adult fleas when fed on artificial membranes, but the eggs were not viable. Fecal blood containing pyriproxyfen inhibited larval development (Meola 2000).

Lufenuron is a systemic IGR that inhibits chitin synthesis during insect development by degenerating the epidermal cells of fleas needed for synthesis of molting fluid and chitin. Monthly oral administration of lufenuron to cats and dogs provided long-term control of fleas over a 3-year study (Dryden et al. 1998). Injectable formulations of lufenuron (10 mg a.i./kg body weight) provide 90% decrease in adults fleas emerging from eggs for 196 days after treatment, eliminating the need to dose animals monthly (Blagburn et al. 1999).

**Flea Allergy Dermatitis Studies.** One new concepts emerging from the use of these new oral and topical therapies is that Flea Allergy Dermatitis (FAD) caused by components of the flea saliva can be managed by these host-targeted therapies. The basic premise is if a treatment prevents fleas from feeding, then the source of allergen from the flea is eliminated. Applications of 0.07% deltamethrin shampoo prevented > 98% of fleas from feeding on the host during the first hour following infestation (McTier 2000b). Cat hair treated with as little as 0.025 ppm imidacloprid inhibited feeding of adult cat fleas (Rust et al. 2001). Of the insecticides tested permethrin showed the strongest anti-feeding activity for 7 days (Franc and Cadergues 1998).

Studies showed an improvement in FAD symptoms days after the administration of imidacloprid. Similarly, selamectin and fipronil significantly decreased pruritis and lesion scores in the treatment of canine FAD for at least 60 days (Prelaud et al. 2003). The overall treatment efficacy of fipronil in reducing FAD symptoms in cats was good to excellent in 34 of 40 cases (85%). After 30 days only 28% of the cats still had some pruritis. Topical
treatments of selamectin and fipronil reduced both pruritus and lesion scores in cats for at least 60 days.

Insecticide Resistance. In response to intensive applications of insecticides, cat fleas have shown a propensity to develop resistance, especially to the cyclodiene, carbamates, organophosphates and pyrethroids (Bossard et al. 1998, 2002). Field isolates continue to show reduced kill when exposed to carbaryl, chlorpyrifos, malathion, and synergized pyrethrins (Dryden et al. 1999). However, very limited information exists concerning the extent of resistance of cat fleas to the newer chemistries. A field isolate referred to as “Cottontail” was reportedly resistant to adulticides containing carbamates, organochlorines, and pyrethroids and showed “limited” resistance to fipronil. All of the IGR’s tested were effective. In another study, Payne et al. (2001) reported that fipronil sprays were very active on two field-collect strains of cat fleas, but another field-collected strain was less susceptible than laboratory strains when fleas were tested on 30-day-old deposits or fipronil residues on pets.

It is extremely important that a program be developed to extend the efficacy and longevity of the current therapeutic agents against cat fleas. Monitoring programs for insecticide resistance are the first important step in minimizing the likelihood of insecticide resistance. Bioassays must be developed for these new chemistries and their baseline levels of susceptibility established. Recent studies by Bass et al. (2004a,b) showed that many laboratory strains previously thought to be susceptible to insecticides have point mutations important for knockdown resistance (kdr) and cyclodene resistance. For example, 12 of 20 fleas from the UCR strain were homozygous for the resistant allele. This explains the lack of activity of permethrin and other pyrethroids against this strain in our laboratory over the past 20 years. To date there are no known universally susceptible strains of cat flea. It is imperative that a new laboratory susceptible strain be selected, maintained, and made available to researchers worldwide.

With the advent of these new chemistries for the control of cat fleas, the development of bioassays to test their biological activity is extremely important. The topical activity of 13 insecticides including nitenpyram, fipronil, imidacloprid, and deltamethrin on adult fleas showed that < 1 ng is required to kill a flea (Moyes and Gfellar 2001). Unfortunately, adult bioassays require large numbers of adult fleas (>300) and isolates must be maintained on hosts until sufficient numbers are available for testing. One advantage of conducting larval bioassays is that it is that the tests require reduced numbers of fleas and it is not necessary to maintain hosts and field-collected isolates of fleas (Rust et al. 2002). The LD_{50}’s of larval media treated with imidacloprid ranged between 1.13 and 2.04 ppm for four laboratory strains and a diagnostic dose of 3 ppm has been established to rapidly evaluate field-collected isolates for reduced susceptibility to imidacloprid (Rust et al. 2005). Other larval bioassays in round bottom tissue culture plates have been developed for fipronil and the IGRs, methoprene and pyriproxifen. As little as 100 ppm of methoprene or pyriproxifen delayed larval molting.

New molecular techniques have expanded our capabilities of surveying flea isolates for potential resistance alleles. Bass et al. (2004a) have developed a PCR-based diagnostic assay for detecting mutations responsible for kdr resistance to pyrethroids and DDT. A point mutation in the Rdl gene confers cyclodene resistance and cross resistance to fipronil (ffrench-Constant et al. 1993). A process (TaqMan) has been identified to find this gene in cat fleas and a field isolate in the United Kingdom carries putative resistance associated mutations of the Rdl gene (Daborn et al. 2004). Bass et al. (2004b) utilizing another process referred to as bi-PASA also identified the Rdl mutation in many laboratory and field strains. Bass et al. (2004b) tested three flea strains studied by Payne et al. (2001) and found that the least susceptible strain was homozygous for the resistant allele, and the most susceptible strain was homozygous for the susceptible or wild-type allele. These techniques are extremely powerful tools and need to be widely incorporated in our surveys of flea isolates.
Bioassays of some 435 field-collected isolates have yet to reveal any decrease in susceptibility to imidacloprid. Figure 1 shows the number of field isolates collected from 2001 to 2004 during each month. Fleas were collected every month of the year, but the greatest number of isolates collected occurred from August to October. The vast majority of the collections had > 40 eggs and were bioassayed (Fig. 2).
Greater than 100 isolates from the United States, United Kingdom and Germany were bioassayed each year (Fig. 3). The team research effort clearly demonstrates that it is possible to collect sufficient flea eggs to bioassay from cooperating veterinary clinics. Hopefully, this will be expanded in the future to include bioassays for the other insecticides.

One of the great challenges to the academic and veterinary community is developing control strategies that will help conserve these host-targeted therapies. The identification of potential isolates with resistance is the first step in developing such a comprehensive program. A monitoring program for imidacloprid exists, but comprehensive surveys for the other insecticides do not. As our understanding about the mode of action and development of resistance to these new chemistries in other insects increase, we must readily incorporate this in to our cat flea control programs. The stewardship of these host-targeted treatments is a collective responsibility of the research and veterinary community. Fortunately, industry and the veterinary community are in an ideal position to recommend and deliver flea control with an eye towards the management of insecticide resistance.

![Fig. 3. The number of isolates bioassayed and those valid isolates in which flea eggs hatched in the control.](image)

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Therapy, control and prevention of flea infestation in companion animals

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Fleas
Fleas are the primary ectoparasites of companion animals world-wide. Adult cat fleas (*Ctenocephalides felis felis* Bouche 1835) are aggressive feeders, consuming up to 15 times their body weight in blood every day. The cat flea is by far the most prominent ectoparasite, feeding on a wide variety of animals including cats and dogs, although it is not equally well adapted to all hosts. Concerning pets, particularly on cats and dogs, only a restricted number of flea species occur in large amounts with enough regularity to be considered important nuisance pests, these are besides the cat flea; *Ctenocephalides canis*, the dog flea; *Pulex irritans*, the human flea; and *Echidnophaga gallinacea* and *Ceratophyllus gallinae*, fleas found on poultry and *Archaeopsylla erinacei*, the hedgehog flea. In general, fleas threaten the health of humans and animals due to local bite reactions and transmission of diseases. The fact that fleas are major nuisance pests, a matter of public health, and a major cause of disease makes flea control a definite necessity. The annual expenditures by pet owners for flea control products remains at a high level and continues to increase from year to year. Furthermore, flea-related skin diseases account for a majority of cases reported in dermatological clinics and a high quantity of overall practice services.

Flea infestation, known as pulicosis, must not be overlooked as flea bites are associated with dermatological signs. Furthermore fleas can transmit pathogens like bacteria, viruses and cestodes. *C. felis* and *C. canis* play an important role as transmitter of a wide spectrum of diseases such as the dog tapeworm (*Dipylidium caninum*), other tapeworms such as *Hymenolepis nana*, *H. diminuta*, *H. citelli*, *H. microstoma* and *Dipetalonema reconditum*. Additionally, fleas are also reported to transmit the Friend Leucemia Virus and bacteria such as *Rickettsia typhi*, *Rickettsia* sp., *Yersinia pestis*, *Pasteurella* sp., *Brucella melitensis*, *Br. abortus*, *Br. suis* and *Bartonella henselae*. Regarding cat fleas as a vector for the etiologic agent of bubonic plague, the dog has also been shown to be capable of carrying *Yersinia pestis*. Human plague cases and even deaths associated with infected cats have been occasionally reported. The chances of contact with plague-infected fleas are increasing with humans and pets encroaching upon endemic wildlife plague cycles. Humans can become infected by their pets via pneumonic transfer, bites from infected rodent fleas residing temporarily upon the pets or possibly via cat flea transmission. Potential zoonotic pathogens such as the gram negative bacteria *Bartonella henselae*, the causative agent of cat scratch fever in humans is associated with flea infestations. In veterinary medicine, fleas are important as the primary cause of a dermatitis known as flea allergic dermatitis (FAD). The adult flea injects saliva into the host during their blood meal this accelerates immunological stimuli, leading to secondary infections of the skin and skin transformation.

Flea Control
Co-evolution occurred between fleas and their warm blooded hosts including man. Thus mankind developed strategies to fight flea infestations for centuries. Until the life cycle of fleas was described this approach was subject to a large variety of cultural believes. Fighting fleas was, for a long time, either elimination of an existing flea population on the host, a clear therapeutic approach, or pest control trying to reduce the amount of fleas in the environment. Throughout the last century a wide range of natural as well as synthetic compounds have been evaluated for flea control on animals. The numbers of compounds of the various chemical classes is enormous, thus one can only summarise the most important once. To make the picture even more complex, these compounds have been marketed in a large selection of formulations. From the early days with medicated soaps, shampoos, and
powders, to collars and sprays, to the most recent formulations of spot-on’s, injectables and oral medications.

Compounds for flea control:
The major aim of flea control in animal health was for a long time to eliminate the existing adult fleas on an animal at the time of treatment. This curative, or therapeutic effect was to provide relief to the flea-infested animal. In the early days of flea control in animal health there was no additional aim in prevention of reinfestation by breaking the flea life cycle or reducing the developmental stages in the environment. These early adulticidal compounds had to be applied frequently to control flea burden on an infested animal. Today adulticidal compounds have to fulfil two goals, first the complete removal of the existing flea burden, and second the persistent effect, to prevent reinfestation from the environment for a longer period.

One of the major factors of any adulticide is the rapid onset of the insecticidal efficacy, thus the speed of flea kill. Regardless the formulation, application and dosage, fast onset of efficacy is essential and thus requested for any modern flea product. Application of an adulticidal flea product with residual effects needs to have a fast speed of flea kill to eliminate an existing flea burden rapidly, to achieve killing of adults so there is not time to initiate reproduction (egg laying) and to kill fleas re-entering the host before they can start blood feeding.

The first chemical classes entering the companion animal market as flea control agents were members of the carbamates and organophosphates. Their mode of action was inhibition of the acetylcholinesterase. Fenthion, a organophosphate from the 1960ies was a systemically acting, while a product for dermal spot-on application for cats and dogs. Convenient spot-on application, while duration of flea efficacy and safety margin would not match today’s standards. Today’s flea control compounds are Fipronil a phenylpyrazole, selamectin a semisynthetic avermectin and insecticides of the new generation, imidacloprid and nitenpyram of the chloronicotinyl (syn. neonicotinoide) class. Compounds known as insect growth regulators mimic the insect hormones. IGR’s are either chitin synthesis inhibitors that act as molting inhibitors like Lufenuron, Triflumuron or Diflubenzuron, or juvenile hormone agonists acting as development inhibitors like Pyriproxyfen, Methoprene or Fenoxycarb. Limitations of the IGRs for flea control are their slow onset in disruption of the flea life cycle and lack of adulticidal effects in case of an existing flea burden on the animal. Thus IGRs need to be combined with adulticides in case of pets presented with an existing flea burden. In the past, proper flea control always required environmental flea control. Today environmental flea control, at least in well looked after pets, has decreased dramatically. However, the need for premise treatment in severe flea burden should not be neglected.

Flea infestation still is and will always be, especially in situations such as moderate climates, centralised heated houses and/ or multi-pet households, a problem for pet owners to seek veterinary advice. With the tremendous improvement in compounds developed by the pharmaceutical industry for flea control within the last 15 years, the necessity of the general practitioner has shifted towards flea control programs specially designed to meet the requirements of the individual pet. Thus the practising veterinarian needs a deep knowledge about flea biology and understand the efficacy and properties of the existing compounds to achieve flea control and subsequently customer satisfaction. Furthermore flea control today is one part of health management, in this respect parasite control management. Practitioners need to, as
suggested for e.g. vaccinations, direct their activity and recommendations to the special need for each pet and the pet owner. Fleas, thus become one important part of ectoparasite control. Flea, ticks, mosquitoes and other permanent and semi-permanent parasites need to be seen as parasites per se as well as vectors of pathogens causing serious diseases. In addition, mobility of people, esp. tourism has also increased the risk to acquire ectoparasites and thus transmitted diseases that may have not been diagnosed in that practice/ area/ country. Universities together with industry have the obligation to include their know how into continuous education programs for the practitioner, so flea control as part of parasite control can be adjusted to the current knowledge on the practice level.

Animal Health Industry
Derivatives from new chemical classes with insecticidal properties to be applied in animal health derive from limited sources. The major source remains the agro-industry and their efforts to search for new insecticides and acaricides. Discovery in this field may lead to spin-off into the animal health industry and the use as ectoparasiticide. The request from the animal health industry is for broad spectrum ectoparasitices, with efficacy against at least fleas and ticks. However, this may be in contrast with the primary agricultural indications. The focus in the animal health industry today is clear, development of such compounds is directed towards products to be used for companion animals, where farm animal indications may not profit, regardless their necessity. While new compound discoveries are limited, there is a trend in companion animal products towards combinations of compounds to broaden the spectrum of activity, or to broaden the indications or target animals in existing products. This may overcome the lack of new compounds for a short period of time, however one should not neglect the enormous capacity of insects, including fleas, in metabolic detoxification and genetic shifts in their susceptibility.

Further reading:
Biology of the afrotropical fleas Ctenocephalides felis strongylus (Jordan, 1925): First results

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Ctenocephalides felis (Bouché, 1835) complex is composed of two sub-species which are C. f. felis (Bouché, 1835) originating from palearctic regions and C. f. strongylus (Jordan, 1925) coming from afrotropical regions. The main part of the results available concerns C. f. felis. So we decided to carry out the breeding of C. f. strongylus in order to specify its biological parameters and to study its sensitivity of insecticide. C. f. strongylus was bred at National veterinary school of Toulouse (France) from a strain which was collected on dog (Abidjan/Côte d’Ivoire/10-10-2004). Now, we present the first results concerning the first part of life cycle, that is to say eggs hatching. Statistically, between 19°C and 29°C, the C. f. strongylus and C. f. felis eggs hatching rates are not different. Theses rates are between 88% and 97%.

Our first results indicate that there is a close link between the temperature and the speed of eggs hatching of two sub-species. Whatever, the temperature may be (between 19°C and 29°C), the first hatchings are observed two days after the laying of C. f. felis eggs. On the other hand, the C. f. strongylus eggs hatch two days after the laying only at 29°C and 27°C. During this experiment, 94% of C. f. strongylus eggs are hatched 6 days after the laying, and concerning C. f. felis, this rate represents 82% for the same time.
Qualitative and quantitative investigations on the flea population dynamics of dogs and cats in several areas of Germany

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From an ongoing country-wide study on the spectrum, the epidemiology and the population dynamics of flea infestations in dogs and cats, we present some preliminary results from the 3 areas of Karlsruhe, Nürnberg and Leipzig. Thereby, a total of 1914 dogs and 1838 cats from 12 different veterinary practices or clinics have been systematically examined between July 2003 and June 2004. All dogs and cats appearing for a clinical veterinary consultation on one regular working day per month per practice have been clinically examined over a period of one year. Dogs and cats were examined irrespective of any kind of prior therapeutic or prophylactic insecticidal treatment. The results show that a total of 99 dogs (5,13%) and 263 cats (14,33%) were infested, i.e. clearly, cats were more often flea-infested than dogs (p < 0.05). The highest infestation rates for dogs ($\bar{x}=7,87\%$) were detected between July and October, and for cats ($\bar{x}=21,14\%$) between July and September, the lowest infestation rates for dogs ($\bar{x}=2,88\%$) were investigated between November and May, and for cats ($\bar{x}=12,16\%$) between November and April (p < 0.05). Although the prevalences were generally higher during the summer months, no statistical differences were detectable when looking at the pattern between the four seasons, neither for dogs, nor for cats. Interestingly, the highest prevalences in dogs (9,9%) were detected in June 2004 and comparatively, in cats (23,86%) in August. The lowest detection rates in dogs were seen (1,28%) in April and in cats (7,26%) in January. The preliminary results did not indicate any tendency for a relationship between climatic conditions and flea infestation rates. Similarly, no differences of the infestations rates were detectable between urban and rural areas, 56% (dogs) and 46% (cats) of the infested pets originated from urban habitats. The flea species collected include *Ctenocephalides felis*, *Ctenocephalides canis*, *Archaeopsylla erinacei*, *Pulex irritans*, *Ceratophyllum gallinae*, etc. The overall frequencies reveal that *C. felis* was the most prominent species (81,5%), followed by *C. canis* (12,5%), *A. erinacei* (2,7%) and *P. irritans* (1,7%).

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How uninvited guests outstay their welcome – the tricks of ticks.

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Typically, arthropod ectoparasites such as mosquitoes, horseflies, tsetse and sandflies have a very short (> 2min) and transient association with their hosts. In such instances, there are relatively few host defence processes to overcome in order to obtain a full bloodmeal. In contrast, hard ticks remain attached for prolonged periods (up to 14 days) resulting in an opportunity for robust host defence processes such as haemostasis, inflammatory and immune responses to be mounted. The ability of ticks to overcome these obstacles resides in the plethora of pharmacological factors secreted in tick saliva, including anticoagulants, anti-inflammatories and immunosuppressants. We shall present our findings on a potent, specific salivary protein inhibitor of B-cells from the saliva of Ixodes ricinus demonstrated to inhibit pro- and anti-inflammatory cytokine production, early activation markers, and proliferation. Importantly, this salivary factor prevented a B-cell response to Borrelia burgdorferi outer-surface proteins A and C, essentially making Borrelia invisible to this arm of the immune response. The aim of our research programme is to understand the interaction of arthropods of medical and veterinary importance with their hosts and pathogens to make new control strategies apparent.
Distribution of the chewing louse Werneckiella equi on horses

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Two species of lice are found on horses namely the biting or chewing louse Werneckiella (Damalinia) equi, and the sucking louse Haemotopinus asini. However, although lice are a regular problem on horses only a few studies have been conducted to examine the biology of these lice. The present study was made in Iceland and demonstrated that W. equi is a common ectoparasite on Icelandic horses and was the only louse species found. Lice were found on all parts of the body of the horses. However, the main proportion of the W. equi population was found in the neck-mane area, on the ventral neck area and on the dorso-lateral trunk. The study demonstrated that the presence of typical clinical symptoms (e.g. alopecia) is not always associated with the presence of lice. Either low number of lice is present and the detection method (combing) did not detect these low numbers, or lice have been present while disappeared before clinical signs are present. Symptoms were seen on the horses at all levels of lice infestations. It was observed that dermatological lesions especially in the head area plus in the neck and mane area are a strong indication of the presence of lice.
Evidence for an increased geographical distribution of *Dermacentor reticulatus* in Germany and detection of *Rickettsia* sp. RpA4

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*Dermacentor reticulatus* is a hard tick, capable of transmitting several pathogens including *Babesia canis*. In Germany, only few foci of the tick have been known so far, including three *B. canis* areas.

In the course of a study on dogs (n=365) living at 171 sites in the Berlin and Brandenburg area, we found 11\% of the dogs to be infested by *D. reticulatus* and identified 26 areas where *D. reticulatus* must occur. We directly confirmed 7 sites by collecting ticks from the vegetation. All the locations have been previously unknown, suggesting, that *D. reticulatus* has expanded its range to the north.

In a further study, we screened heads of red deer (*Cervus elaphus elaphus*; n=203), roe deer (*Capreolus capreolus*; n=260) and fallow deer (*Dama dama*; n=258) shot in different federal states and regions of Germany during the autumn hunting season in 2004. Altogether, 23 (3.2\%) deer heads were infested by *D. reticulatus*, whereby red deer harboured significantly more ticks than roe- or fallow deer. Two autochthonous *D. reticulatus* locations already known in Saxony were confirmed by this study and we found at least 12 additional sites in Brandenburg, Saxony-Anhalt, Hesse and Bavaria. This suggests, that *D. reticulatus* is more common than previously thought, particularly in southern and eastern parts of Germany.

Ticks from the deer study (n=135) were investigated for the presence of *B. canis* and rickettsial DNA by PCR. Ticks were negative for *B. canis*, but we found more than 20\% of the specimens to be positive for *Rickettsia*. Sequencing showed 100\% identity with *Rickettsia* sp. RpA4, firstly described from a *Rhipicephalus* tick in Russia.
Cat fleas (Ctenocephalides felis) as transmitters of viruses: experiments with the feline leukemia virus (FeLV)

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FeLV belongs to the class of retroviruses and spreads through infected saliva, blood, urine, tears, feces and can also be spread by an infected queen to her kitten during gestation and by nursing. The various transmission ways arise the question, if there is another possible way of transmission, maybe through blood sucking ectoparasites like fleas. Fleas are generally known to transmit various pathogens, including bacteria (e.g. those initiating plague), tapeworms and also viruses (myxomatosis virus). In our study, we tested the vector potential of the cat flea Ctenocephalides felis for the FeLV. We fed cat fleas in an artificial feeding system with FeLV infected blood. Fleas were allowed to feed either for 5 or 24 h. Then fleas were transferred to uninfected blood feeding for a duration of another 5 or 24 h, respectively. The formerly uninfected blood was subsequently tested for FeLV material. In both cases, the virus was detected by nested PCR. The cat fleas therefore transmitted within the first 5 hours the virus from one blood source to another. In addition, FeLV was found in high amounts in the fleas feces. The virus was detectable in the fleas for up to 30 hours at room temperature after removal of the feeding source. In the feces, the amount of viruses decreased much slower, since after two weeks still half of the original amount of viruses was detected. Thus, fleas and their feces might be a possible source for virus transmission among cats.
Mapping dirofilarial (Dirofilaria immitis and D. repens) infections in Europe

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A study was carried out to map filarial worm infection in Europe with particular emphasis on Dirofilaria immitis and D. repens. Both species are transmitted by mosquitoes and are able to infect humans. A Geographical Information System based on thermal regimen was constructed in order to identify the areas potentially suitable for transmission, taking into account that the development of Dirofilaria larvae in the mosquito does not occur below the threshold temperature of 14°C. Furthermore, a bionomic model of Dirofilaria in the mosquitoes, which calculates the moving cumulative Heartworm Development Units, was applied using the available temperature data to assess the theoretic transmission timing of Dirofilaria infection. The results show that the earliest infection risk decade occurs in Spain (Murcia station on March 21st), the latest risk decade occurs in Spain too (Monteventoso station on November 21th). The longest risk period occurs in Spain (March 21st – November 11th), the shortest risk period.
Prevalence of borreliosis in ixodid ticks in Northern Germany

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The detection of spirochetes of the genus *Borrelia*, causative agent of tick borreliosis, is performed either with dark field microscopy or PCR. The establishment of PCR on base of ITS sequences or on base of the rPOB gen sequence is described. For validation of this PCR method and for collecting recent prevalence data regarding the transmission risk, selected localisations in Northern Germany were examined last year. A total of 1148 ticks were collected and processed to PCR, using the *internal transcribed spacer*-Region (ITS) of *Borrelia* spp. Additionally, the positive samples were differentiated using rPOB-PCR. The ticks were flagged on public greens in Hamburg, Hannover and Kassel. A total of 204 ticks were diagnosed positive corresponding to a prevalence of 17.9 %. Ticks from Hannover (n = 436) and Kassel (n = 358) revealed prevalences of 21.9 % each, ticks from Hamburg of 8.5 % (n = 354). 18 ticks showed multiple *Borrelia* infections. Prevalence data of nymphs showed to be lower (11.2%) than the prevalence in adult ticks (25.2, % (p=<0.001). The quantitative analysis with real time PCR showed a mean number of 7424 *Borrelia*, in nymph stages a mean of 2076. All few larval tick stages flagged showed negative results in PCR. With exception of *B. lusitaniae* and *B. bissettii* all other species, described to be present in Europe, could be found.
Flea hypersensitivity in cats: What can we learn from their basophils?

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Type I hypersensitive reactions are of central importance in the development of flea allergy dermatitis (FAD). Typically, in type I hypersensitivity reactions allergen-specific antibodies bind to receptors on mast cells and basophilic granulocytes, thus sensitising them. Following allergen exposure, via the membrane-bound antibodies the cellular Fc-receptors are cross-linked, resulting in a series of biochemical reactions within these cells, causing the release of various inflammatory mediators, such as histamine. Based on allergen-induced in vitro degranulation and histamine release of basophils, a functional in vitro test (FIT) for horses had been developed enabling a sensible qualitative and quantitative monitoring of an individual functional sensitisation for type I allergy in the horse.

The aim of this project was to adapt the FIT to cats and to use it for studying the degree and kinetics of sensitisation of cats against *C. felis*. Fourteen cats were tested for their sensitisation status prior to flea exposition repeatedly. Subsequently they were infested with *C. felis* under controlled conditions and FIT tested every two weeks over a period of seven months. Additionally, intradermal testing (IDT) was performed in weeks 4, 12 and 28 after first flea exposure.

The results indicate different reaction patterns to one allergen preparation of *C. felis*: Four cats reacted constantly positively; others (n = 4) never developed a measurable degree of sensitisation; and some (n = 6) that were negative in the beginning, became sensitised during the course of flea exposition. IDT showed always clear agreement with FIT results.
Imidacloprid 10 % and Moxidectin 2.5 % spot on (Advocate®) for treatment of demodicosis in dogs

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Canine demodicosis occurs as localised or generalised demodicosis. The localised demodicosis is usually a self limiting benign disease whereas the generalised demodicosis is one of the most severe canine skin diseases that is difficult to treat. For treatment of demodicosis in Europe amitraz washings or the daily oral administration of milbemycin oxime are approved; in addition, macrocyclic lactones are used, un-approved for this indication.

In a first study we included 18 dogs with generalised demodicosis. All dogs were treated 2 to 4 times at a 4 week interval with a dose volume of 0.1 ml Advocate Spot-on per kg b.w. At study end the average reduction in mite counts was 98 %. Clinical symptoms improved accordingly in all dogs after treatment. Body weight increased and overall condition improved markedly.

A second study was conducted to assess the efficacy of Advocate Spot-on in dogs under European field conditions. The study was designed as a multicenter, controlled, randomised, blinded field study including 25 veterinary practices in Albania, France and Germany. Dogs were treated 2 to 4 times at a 4 week interval with Advocate Spot-on (min. 0.1 ml per kg b.w.) or were treated daily orally with milbemycin oxime (0.5 to 2 mg/kg b.w.). At study end no Demodex mites could be detected in 26 of 30 dogs treated with Advocate Spot-on and in 29 of 33 dogs treated with milbemycin oxime. Dogs in both groups showed a similar clinical improved.
Imidacloprid 10 % and Moxidectin 2.5 % spot on (Advocate®) for treatment of sarcoptic mange in dogs

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The combination product Imidacloprid 10% and Moxidectin 2.5% solution has been approved recently by the EU authorities for topical treatment and/or prevention of various endo- and ectoparasitic diseases in dogs. The efficacy against mange infections was investigated in a controlled, randomized and blinded study in South Africa with 30 mainly cross breed domestic dogs (14 ♂ and 16 ♀) naturally infected with Sarcoptes scabiei. The dogs were treated twice, 4 weeks apart, with either the investigational product, at 0.1 ml/kg body weight, or with Selamectin (12%), at 0.05 ml/kg body weight. Efficacy evaluation was based on mite counts in skin scrapings supported by clinical signs associated with canine sarcoptic mange. From day +22 and onwards no mites were found in any of the treated dogs and within 9 weeks after the initial treatment almost all clinical symptoms disappeared.

An analogous study design was implemented in a European multicentre field study with 58 dogs conducted in Germany, France, UK and Albania. Examinations were conducted before treatment and at days 14, 28 and 56 after the first treatment. Efficacy evaluation was based on a non inferiority test comparing the mite counts and the clinical resolution in the two groups on day 56 with a non inferiority limit of 20%. All dogs were parasitologically cured at day 56 and the proportion of dogs either improved or cured was 96.3 % in both groups. No adverse drug reaction occurred in any of the treated animals.
Efficacy of a formulation containing imidacloprid and moxidectin against naturally acquired ear mite infestations (Psoroptes cuniculi) in rabbits

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The purpose of this study was to evaluate the efficacy of a topical formulation containing imidacloprid and moxidectin for eradication of Psoroptes cuniculi in rabbits. Fourteen adult rabbits from a rabbit husbandry were enrolled in the study. On each rabbit, 40 mg imidacloprid and 4 mg moxidectin were applied monthly as spot-on on days 0, 30, and 60. No other treatment or environmental decontamination was performed during the trial. On days 0, 30, 60, and 90, all rabbits were examined, epidermal debris was collected from both auricular areas and the external ear canal for microscopic examination. Clinical signs had subsided by day 30 in all 14 rabbits and no signs of recurrence were apparent in the following weeks. All epidermal samples were negative by day 90. No adverse reactions were observed. Under the conditions of our study, topical formulation of imidacloprid and moxidectin was a practical and well-tolerated means of treatment for ear mange in rabbits.
Repellent Efficacy of Imidacloprid 10% / Permethrin 50% Spot-on (Advantix®) Against Stable Flies (Stomoxys calcitrans) on Dogs

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The stable fly Stomoxys calcitrans is known to cause fly-bite dermatitis in prick-eared dogs. The objective of this blinded, negative controlled laboratory GCP-study was to evaluate the repellent and insecticidal efficacy of Imidacloprid 10% w/v / Permethrin 50% w/v Spot-on (Advantix®, Bayer HealthCare) against this parasite. Thirty-two dogs were allocated to two groups of 16 dogs each. One group was treated on day 0 with 0.1ml/kg b.w. of Advantix® spot-on, the other group served as untreated negative control. The dogs were exposed to ~25 fasted S. calcitrans flies for 30 minutes on days +1, +8, +15/+18, +22 and +29. The flies were subsequently collected and blood feeding and survival assessed. Repellent and insecticidal efficacy of Advantix® was calculated compared to the control group. Efficacy in prevention of blood feeding (equivalent to repellent efficacy) was 94.6% (d+1), 86.0% (d+8), 91.7% (d+15), 85.9% (d+22) and 82.5% (d+29). Efficacy in inducing mortality was 77.8% (d+1) and 81.8% (d+8), decreasing to 19.6% (d+22). These values are in line with the high repellent efficacy values reported for Advantix® against other ectoparasites such as ticks and sand flies.

In conclusion, Advantix® offered a high protection to dogs against stable fly bites over a period of four weeks. The risk of fly-bite dermatitis would thus be significantly reduced when the product is applied regularly throughout the fly season.
Repellent Efficacy of a Imidacloprid/ Permethrin spot-on against sand flies (Phlebotomus papatasi, P. perniciosus and Lutzomyia longipalpis.)


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Imidacloprid 10%w/v and permethrin 50%w/v spot-on was tested in three laboratory GCP-studies of identical design to evaluate the repellent and insecticidal efficacy against sand flies on dogs. The results against Phlebotomus papatasi, P. perniciosus and Lutzomyia longipalpis, the vectors of Leishmania infantum causing canine leishmaniosis, will be reported and compared. The repellent efficacy criterion was based on the feeding rate of sand fly females, the insecticidal efficacy on the survival rate 24 hours post exposure. In total, 40 beagle dogs were anaesthetised and exposed to sand fly females each for a period of 1.5 hours, weekly for four weeks. Against P. papatasi the repellent efficacy was 94.6% (d 1), 93.3% (d 8), 80.3% (d 15), 72.8% (d 22) and 55.8% (d 29). Due to the high repellent effect, the insecticidal efficacy was rather low and decreasing from 60.0% (d 1) to 29.3% (d 29). The repellent efficacy against P. perniciosus and L. longipalpis exceeded the 90% efficacy margin for three weeks after treatment and decreased thereafter. The insecticidal efficacy against L. longipalpis was higher in comparison to P. papatasi. These studies conducted under controlled laboratory conditions clearly demonstrated the discrepancy in sensitivity to insecticides between these three sand fly species. The high repellent potential of the imidacloprid/ permethrin (Advantix®) against sand flies was demonstrated and was effective to protect dogs from sand fly bites.
Efficacy of Imidacloprid against Tunga penetrans (sand flea, jigger flea)

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Tungiasis is endemic in many South American and African countries. The females of the jigger flea *Tunga penetrans* penetrate into the skin of many hosts including man, dogs and farm animals, such as pigs. Feet are the predominant delection sites, and infection leads to severe inflammation and pain. In field studies we investigated the behaviour of sand fleas prior to penetration into the skin. We have shown that both male and female sand fleas roam through the haircoat and suck blood after infestation of the mammalian host (e.g. dogs), similar to the cat flea. Several hours after this initial blood meal, the engorged females enter the host’s skin, and mating occurs. The male fleas do not penetrate permanently into the skin of the host. The observed behaviour gives an important opportunity using insecticides to prevent sand flea infestation. Protection of dogs against infestation by killing female sand fleas prior to permanent skin penetration, will reduce severe pathology. In field experiments in the surroundings of Fortaleza (Northeast Brazil) dogs were treated with imidacloprid (Advantage®) or the combination of imidacloprid/permethrin (Advantix®) once following label instructions. Dogs were examined weekly for 4 weeks, and number and stage of parasites were documented. Dogs were protected for 28 days from new infestations with *Tunga penetrans*. New biological and efficacy data of the field study will be presented.
Advocat™ also effective in reptiles and rodents

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The active ingredients of the products Canine and Feline Advocat™ - a combination of imidacloprid and moxidectin - were registered for cats and dogs to control nematodes such as Toxocara, Toxascaris, Ancylostoma, Uncinaria, Dirofilaria and fleas, were tested also in reptiles and rodents, which were held in increasing numbers in many households as pet animals. A pour-on application was used in our experiments in a similar mg/kg bodyweight concentration as in cats and dogs. It was seen in both - reptiles and rodents - that intestinal worms (nematodes) were killed as well as experimentally applied fleas (in rodents). In reptiles the products were applied at places, where the skin was rather thin (e.g. armpits).
The effect of permethrin, imidacloprid and their 5:1 mixture on behavioural and chemoreceptor cell responses of Ixodes ricinus

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Two pesticides, the neonicotinoid imidacloprid and the pyrethroid permethrin, have been tested in interference with arrestment and in interference with chemoreceptor cell response in assays with I. ricinus. Permethrin showed pronounced dose dependent effects on the arrestment behaviour of I. ricinus on filter paper treated with its own faeces. Surprisingly, imidacloprid also disrupted the arrestment of the ticks on faeces. Imidacloprid on its own, not known as a very active acaricide, was about one tenth as active as permethrin. The response to different doses of permethrin was shifted to slightly lower concentrations in presence of imidacloprid. The observed effects of imidacloprid in the arrestment assay were confirmed in the electrophysiological assay. Both permethrin and imidacloprid disrupted the response to guanine by receptor cells in I. ricinus tarsal chemosensilla: The response of the receptor cells to the faeces constituent guanine is characterised by bursts of action potentials following exposure of the sensory cells to permethrin or imidacloprid. The lowest effective median concentration of the 5:1 mixture of permethrin and imidacloprid that caused such bursts was about 100x lower than with either of the compounds alone.
The evaluation of deltamethrin and permethrin in an vitro method developed for testing the efficacy of insecticides on Sand flies.

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The ENVT method (impregnated paper cones) was used to evaluate the LD50 and the LD90 of insecticides after 1 hour contact with Culex pipiens and Phlebotomus perniciosus females. The cone templates were either impregnated with acetone alone or with an acetone solution of either deltaméthrine (DMT) or permethrin (PMT), allowed to dry and then formed into the cones. The filter paper sealing discs were also treated in the same way. The concentrations were 0.88, 1.75, 3.5, 7, 14, 28 and 56 mg DMT/m² and 12.5, 25, 50, 10, 200, 400, 800 mg PMT/m². For each concentration 3 replicates of 25 Culex and 3 replicates of 10 Phlebotomus were tested. The mortality criteria was the WHO criteria: The results analysis was performed with the Win Non Lin version 4.01 logiciel (Pharsight, Mountain View 94040 California). Using this method the LD50 of DMT is 3.03 mg /m² (S.e. 0.43) on Phlebotomus, and 5.75 mg /m² (0.63) on Culex. In the same conditions LD50 of PMT is 68.05 mg /m² (2.50) on Phlebotomus, and 39.05 mg /m² (2.50) on Culex. The LD90 of DMT is respectively 15.95 mg /m² (3.83) on Phlebotomus, and 58.92 mg /m² (13.61) on Culex. The LD90 of PMT is respectively 264.29mg /m² (53.83) on Phlebotomus, and 99.60 mg /m² (10.08) on Culex. This method provides a useful tool for the rapid comparison of the relative efficacy on insecticides against insects using minimal handling of these flies. The authors express their gratitude to R. Curtis and B.and M. Killick-Kendrick for their assistance.
The development of a method for in vitro testing Sand flies and Mosquitoes. Insecticide susceptibility.

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A method was developed for insecticides susceptibility testing of mosquitoes and Sand flies using sustained contact with insecticide impregnated papers for 24 hours. Whatman filter paper were cut into templates, which formed a cone when suitably folded. They were impregnated with acetone (control) or with an acetone solution of either deltamethrin (DMT) or permethrin (PMT), allowed to dry and then formed into the cones. Filter paper sealing discs were treated in the same way. Cones were placed inside a plastic container 25 female Culex pipiens or 10 Female Phlebotomus perniciosus introduced and the cone sealed with a filter paper disc and the container cap. All the insects were alive after 24 hours in the control group. Using this method the effect of DMT at between 0.88mg/m2 and 56mg/m2 and PMT at between 12.5mg/m2 and 800mg/m2 was evaluated in a series of repeat tests for 24 hours. DMT produced 97 to 100% mortality on mosquitoes (WHO criteria: incoordinated+moribund+dead) at all rates tested and PM The, advantage of this method over the WHO protocols were 4: only one insect manipulation, permanent contact with insecticide during the trial (in the WHO system the mesh is not impregnated with insecticide), lower cost, ease of field use.
An in vitro assay for acaricides for hard ticks

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Animal husbandry could not be practised over large areas of the planet without acaricides. Prevention of tick bite reduces blood loss and transmission of diseases during the long blood meal. Reliance on pesticides contributes to the development of tick resistance against the major acaricide classes. This drives the quest for new molecules that target physiological processes crucial to tick survival. In vivo trials involve repetitions because of inherent variations between host animals, requiring large amounts of test products and ticks for such experiments. An in vitro alternative should permit testing a product's ability to restrict attachment and feeding by ticks at precise doses. Here we describe an in vitro feeding system where the European tick Ixodes ricinus feeds on blood through a cellulose rayon-reinforced silicone membrane. The membrane shore hardness is modified to imitate the elastic retraction forces of skin that assures closing of tick penetration sites on the membrane to prevent bleeding.
Methods to monitor the effects of acaricides on behavioural and chemoreceptor cell responses of Ixodes ricinus

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Tick ectoparasites of vertebrates utilise a variety of infochemicals for host finding and acceptance, intraspecific aggregation and mating responses. Individual *I. ricinus* adults readily arrest on filter paper strips impregnated with their own faeces. The faecal constituents guanine and xanthine also cause arrestment. Mixtures of these products induce arrestment of *I. ricinus* at doses 100x lower than the lowest active dose of either product presented alone. These responses are mediated by gustatory cells in terminal-pore sensilla on the first leg tarsi of *I. ricinus* since electrophysiological recordings show that a saline extract of faeces activates these receptor cells. Two cells in these sensilla respond in a dose dependent manner to guanine. So conspecific faeces are implicated in aggregation responses of *I. ricinus* and these responses can be used for testing compounds to control ticks. Addition of an acaricide to the faeces extract inhibits the arrestment response of *I. ricinus*. Furthermore, presentation of an acaricide in the electrode used to stimulate the gustatory receptor cells interrupts the normal response to guanine. The behavioural and electrophysiological assays described have proven useful to screen for compounds interfering with arrestment behaviour of *I. ricinus*. 
Efficacy of a cyphenothrin (Gokilaht\textsuperscript{R}) squeeze-on against fleas and ticks on dogs.

Miller, T.\textsuperscript{1}, Sharp, M.\textsuperscript{2}, Nouvel, L.\textsuperscript{3}, Stichler, C.\textsuperscript{4}.

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Efficacy of a cyphenothrin squeeze-on was evaluated on dogs against fleas and ticks. Two registered products, Meriel's Frontline Plus for Dogs (fipronyl) and Hartz Mountain Advanced Care Flea and Tick Drops Plus (phenothrin) served as positive controls. Efficacy against fleas reached 100\% by 24 hours for the cyphenothrin squeeze-on, by 48 hours for fipronyl but not until the 9\textsuperscript{th} day for phenothrin. Group efficacy against pre-existing tick burdens reached 100\% by 48 hours for cyphenothrin, by the 7\textsuperscript{th} day for dogs treated with fipronyl but did not attain 100\% for the dogs treated with phenothrin. Dogs treated with cyphenothrin were free of fleas and ticks for one month and individual efficacy values were 90\% or better against new fleas and ticks for 7 weeks. Dogs treated with fipronyl were mostly free of new fleas and ticks for 2 weeks, and individual efficacy values were 90\% or better for 7 weeks (fleas) and 6 weeks (ticks). Only once were all phenothrin-treated dogs free of ticks (day 9) and individual values of 90\% were recorded for up to 4 weeks (fleas) and 5 weeks (ticks). There were statistically significant differences in flea and tick burdens between the three groups of treated dogs. Efficacy was higher for dogs treated with cyphenothrin. Differences were statistically significant for about half of the comparisons. Fipronyl was statistically more effective than phenothrin but only for about a third of the comparisons.
Efficacy of a cyphenothrin (Gokilaht R) squeeze-on against fleas, ticks and mosquitoes on dogs.

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4 Nouvel Inc., P. O. Box 261248 Plano, TX 75026, USA,
5 Sergeant's Pet Care Products Inc., 1637 S. 158th Plaza, suite 100, Omaha, NE 68130, USA

A cyphenothrin squeeze-on was evaluated on dogs for speed of kill/repellency against new infestations of fleas and ticks, for efficacy against the nymphs of the Lyme Disease vector tick and for potential to prevent feeding of two species of mosquito that are known vectors of West Nile Virus. Efficacy was 100% against fleas for all treated dogs by one hour and against Dermacentor variabilis for 5 of 6 treated dogs by 3 hours. In a standard test for efficacy against Ixodes scapularis nymphs, by exposing them in vitro to hair clipped from dogs on the 8th day after treatment, all nymphs were dead by 48 hours for 5 of 6 treated dogs. Hair clipped on the 36th day was also lethal (only 0-10% survived) to most nymphs. Dogs were exposed to Culex quinquefasciatus mosquitoes on the 8th and 41st days and to Aedes albopictus mosquitoes on the 22nd day after treatment. There was no evidence of repellency but only 2 of 99 female Culex were able to feed at 8 days and only 2 of 77 female Aedes fed on the 22nd day. Efficacy for Culex on the 41st day declined since about half the females were able to feed, compared with the level of feeding on untreated dogs.
Development of a Diflubenzuron (Dimilin) Equine Feed-thru Larvicide to Control House Flies (Musca domestica) and Stable Flies (Stomoxys calcitrans) in Manure of Treated Horses

Douglas H. Ross\textsuperscript{1} and Robert G. Pennington\textsuperscript{2}

\textsuperscript{1}Farnam Companies, Inc., Phoenix, Arizona, USA, and \textsuperscript{2}ECTO Development Corporation, Excelsior Springs, Missouri, USA.

This report summarizes the development of a new equine feed-thru larvicide with the IGR diflubenzuron (Dimilin\textsuperscript{\textregistered}) to prevent house fly (Musca domestica) and stable fly (Stomoxys calcitrans) emergence from the manure of treated horses. All studies used 2 groups of horses, untreated controls and horses receiving diflubenzuron. Manure was collected pretreatment from all horses to determine its suitability for fly development. On study Days 0 thru 7, “treated” horses were fed diflubenzuron pellets (0.16 – 0.24%) at the test dose(s), top-dressed on their morning ration. Untreated horses received only their normal ration. On Day 7 fresh manure samples were collected from all horses for fly bioassays. For both fly species, 4 replicates (45 – 60 g each) of manure from each horse from each collection date were bioassayed. Either 30 – 50 eggs or 30 – 50 1\textsuperscript{st} instar larvae of house flies or stable flies were used per replicate. Manure was placed in plastic cups and eggs or larvae added. Cups were held in climate controlled rooms [26°C (79°F) and 60 – 65% relative humidity] until adult flies had emerged and died, and adult flies were counted and percent control (emergence inhibition) for each treatment calculated using Abbott’s formula. Doses of 0.08 and 0.10 mg/kg BW were effective against stable flies, but inconsistent against house flies. The minimum effective dose, to consistently achieve 90 – 100% emergence inhibition, was determined to be 0.13 mg diflubenzuron/kg BW/day.
Efficacy Evaluation of an Equine Fly Repellent Product (Mosquito Halt) Against Mosquitoes on Horses

William B. Warner\(^1\), Adalberto A. Pérez de León\(^2\) and Douglas H. Ross\(^1\)

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This study was conducted to determine the efficacy of a single application of Mosquito Halt Repellent Spray against mosquitoes on horses. The test insect, Aedes albopictus, is a mosquito known to carry West Nile Virus (WNV) in nature, and proven experimentally to be a competent and efficient WNV vector to horses. A tent structure with vinyl walls was assembled to hold two infestation chambers in a semi-controlled indoor environment. Eight horses were randomly assigned to either the control (Group I) or treatment (Group II) groups. Mosquito Halt was applied once to Group II horses (240 mL/horse). Mosquito infestations were conducted on each horse for 6 consecutive days. For each infestation a horse was placed in a chamber, and 200 female Ae. albopictus were released into the chamber. After a 60-minute exposure, all mosquitoes were collected from the chamber. Dead and live mosquitoes were collected and enumerated separately to determine dead vs. live counts, blood feeding status, daily average mosquito mortality and blood feeding rates. Average mosquito mortality for the treated group did not reach 90% in this study. However, the mean efficacy (repellency) of Mosquito Halt, measured by blood feeding reduction, was >97% 2 hours after dosing and still > 91% the day following treatment. Repellency declined to 62% by Day 6. Mosquito Halt provided substantial control of blood feeding by mosquito vectors of West Nile Virus when used according to label directions.
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