

Fleas:

Theory and Application of Modern Flea Control

Michael W. Dryden, *DVM, MS, PhD, DACVM*

University Distinguished Professor

College of Veterinary Medicine

Kansas State University

Manhattan KS



Fleas¹⁻³

- > 2200 species and subspecies worldwide
- > 250 species and subspecies in North America
 - 95% of species occur on mammals & 5% on birds – rarely some species occur on both.
 - Only a few species regularly parasitize dogs and cats.

II. Prevalence

- ***Ctenocephalides felis* - (cat flea)**
 - Most prevalent species on dogs and cats in most countries
- **Other species that occur on dogs & cats in NA.**
 - *Ctenocephalides canis* (dog flea)
 - *Echidnophaga gallinacea* (poultry sticktight flea)
 - *Pulex simulans* (a flea of small & medium sized mammals)

1. Dryden M, Rust M. The Cat Flea - Biology, Ecology and Control. Vet Parasitol 1994;52:1-19.
2. Rust M, Dryden M. The biology, ecology and management of the cat flea. Ann Rev Entomol 1997;42:451-473
3. Blagburn BL, Dryden MW. Biology, treatment and control of flea and tick infestations. Vet. Clin. N. Am. 39(6):1173-1200, 2009.

Flea Infestations

- By the time a pet owner notices fleas, immature flea stages have been developing in the home for 1-2 months.^{4,5}
 - This “bio-mass” of immature flea stages provides an ongoing source of new adult fleas that will continually reinfest pets^{1,2}

4. Chin A, Lunn P, Dryden M. Persistent flea infestations in dogs and cats controlled with monthly topical applications of fipronil and methoprene. *Aust Vet Pract* 2005;35(3):89-96.

5. Dryden MW. How you and your clients can win the flea control battle. *Vet. Med. Supplement* March: 17-26, 2009.



Within 24 hours of pets acquiring fleas, females are laying eggs. If you have fleas on a dog or cat, this biomass is in the carpet, cracks or grooves in hardwood floors or outdoors in shaded habitats.⁵

5. Dryden MW. How you and your clients can win the flea control battle. *Vet. Med.* Supplement March: 17-26, 2009.

Eliminate immature stages in premises

- Historically we treated the premises directly.⁶
 - Application of insecticides and IGRs into the carpet and yard.
 - Tried to kill emerging fleas and prevent development of eggs & larvae.
- Premises treatments were necessary to break the flea lifecycle.
 - Prior to 1995 topical products (dips, sprays, collars etc..) had no substantial residual activity.⁷
- Premises treatments were difficult to conduct, time consuming, expensive, environmentally unfriendly and often ineffective.

6. Dryden M, Bennett G, Neal J. Concepts of Flea Control. *Comp An Pract* 19(4-5):11-22, 1989.

Eliminate immature stages in premises

- With modern topical and systemic residual flea products control of infestations in the premises is achieved by **preventing reproduction**.^{4,5}
 1. Use of highly effective residual adulticides that kill most newly acquired fleas before they begin reproduction (killing fleas within 24 hrs after jumping on treated pet).
 2. Use of insect growth regulators or insecticides with ovicidal activity to kill any eggs that are produced.
- If you can not reproduce as a species you go extinct.
 - Termed “Breaking the life cycle at the host level”

4. Chin A, Lunn P, Dryden M. Persistent flea infestations in dogs and cats controlled with monthly topical applications of fipronil and methoprene. *Aust Vet Pract* 2005;35(3):89-96.

5. Dryden MW. How you and your clients can win the flea control battle. *Vet. Med. Supplement* March: 17-26, 2009.



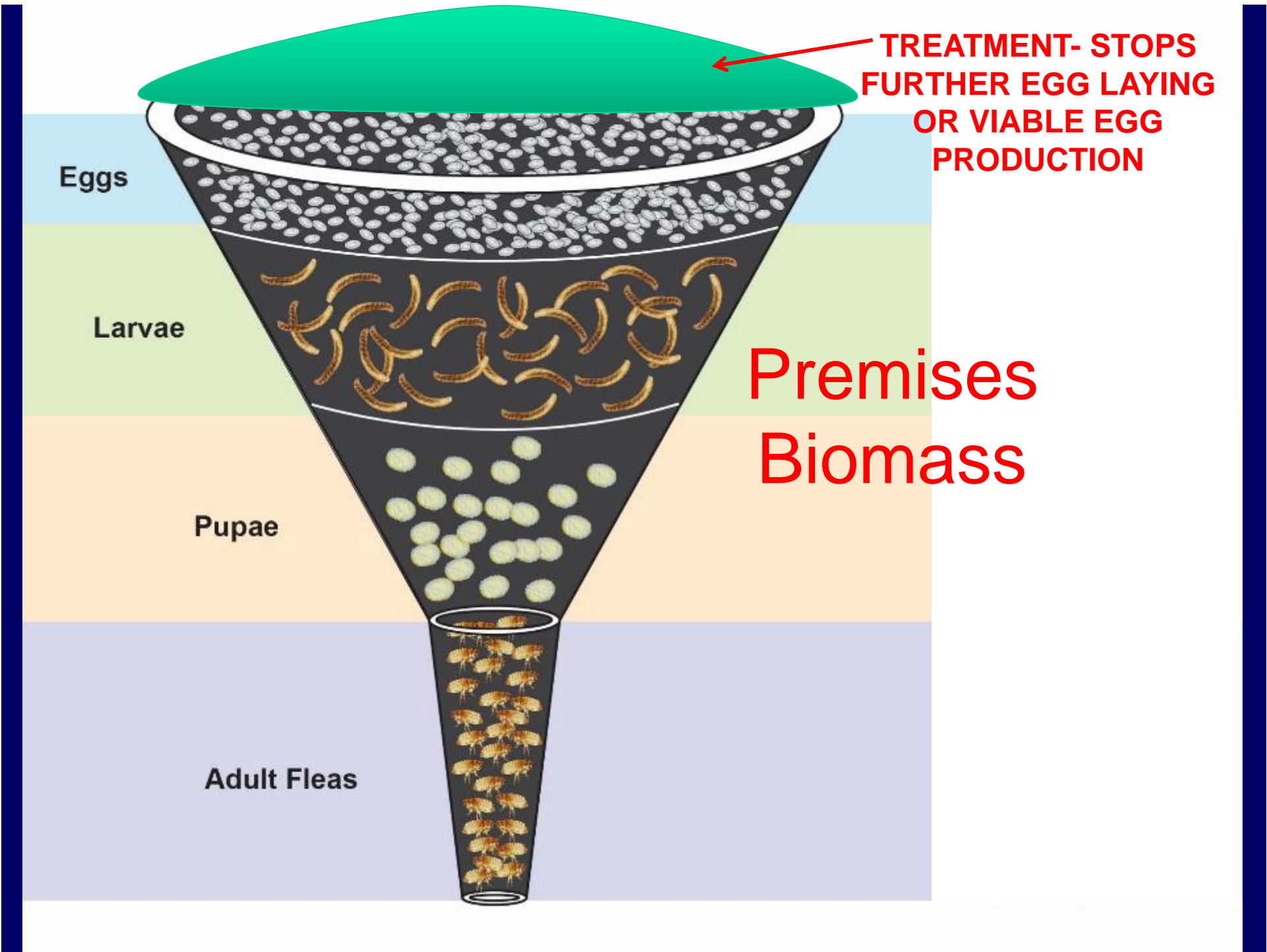
Within 24 hours female fleas begin laying eggs and can produce 40 – 50 eggs each day.⁷

7. Dryden MW: Host association, on-host longevity and egg production of *Ctenocephalides felis felis*. *Vet Parasitol* 1989;34:117-122.

Residual Adulticides

- Speed of kill⁸
 - Initial speed of kill
 - Residual speed of kill
 - Killing newly acquired fleas rapidly enough
 - To prevent flea reproduction
 - To markedly reduce injection of salivary proteins and minimize or eliminate FAD
 - To provide client satisfaction (fewer fleas observed)

8. Dryden, MW. Spotlight on Research: How residual speed of kill affects flea control in dogs and cats. 2014:1-4. Vet Med 109(7).



**TREATMENT- STOPS
FURTHER EGG LAYING
OR VIABLE EGG
PRODUCTION**

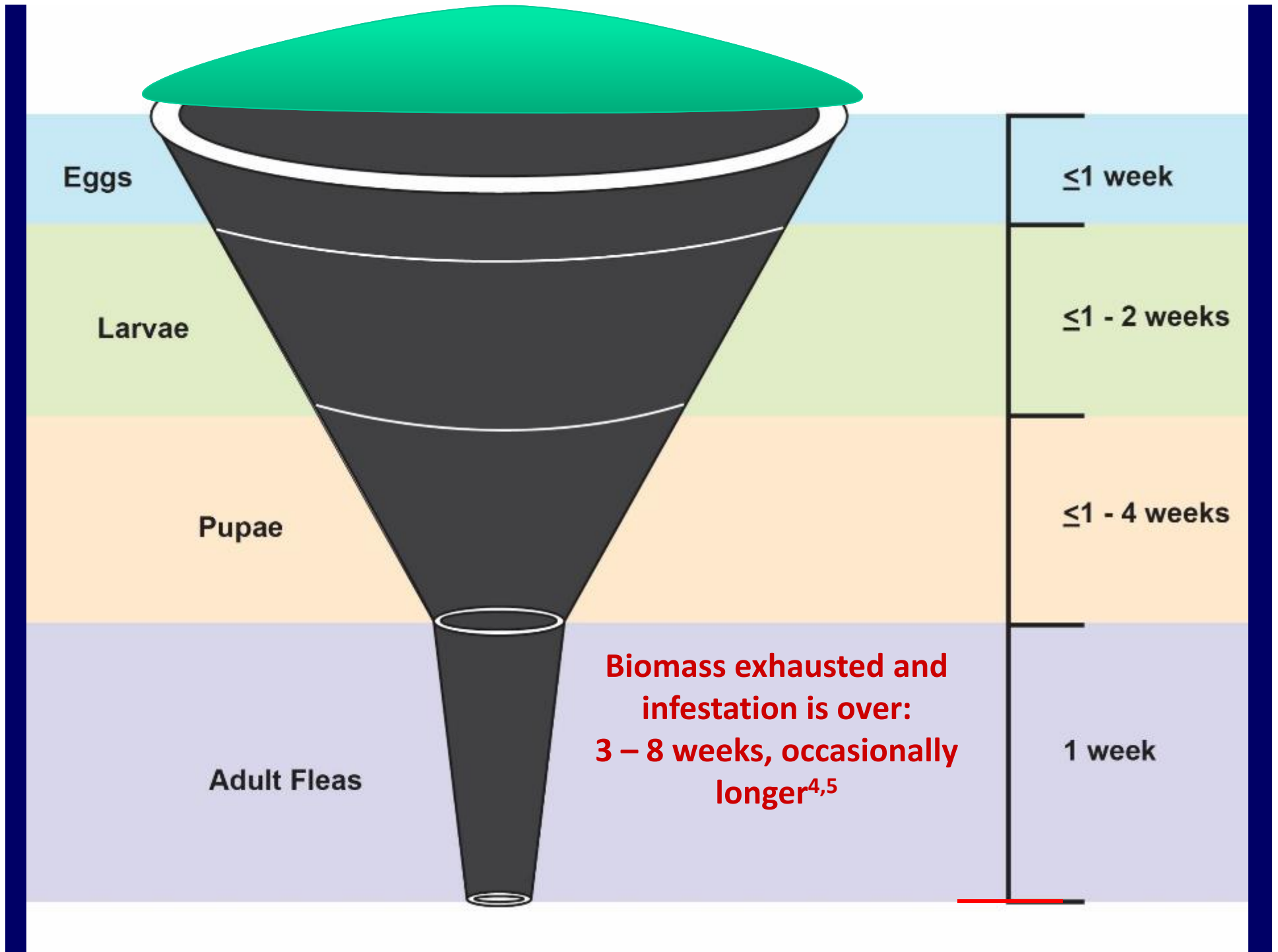
Eggs

Larvae

Pupae

Adult Fleas

**Premises
Biomass**



How “K-State Field Studies” are conducted^{9,10}

- Clinical cases and field research projects in Manhattan KS & Tampa FL from 1990 - 2014.
- K-State Flea Team members visit each home to conduct selection, evaluations & all treatments.
- Homes are randomly assigned to treatment groups.
- **Numbers of fleas on pets** assessed using visual area counts
- **Numbers of adult fleas in homes** assessed by the use of intermittent light-flea traps
 - days 0, 7, 14, 21, and once between days 28–30, 40-45, & 54-60 & *occasional up to 90 days.*

9. Dryden M, Carithers D, McBride A, Riggs B, Smith L, Davenport J, Smith V, Payne P, Gross S. A comparison of flea control measurement methods for tracking flea populations in highly infested private residences in Tampa FL, following topical treatment of pets with FRONTLINE® Plus (fipronil/(S)-methoprene). Intern. J. Appl. Res. Vet. Med. 9:356-367,2011

10. Dryden MW, Payne PA, Smith V, Chwala M, Jones E, Davenport J, Fadl G, Martinez-Perez de Zeiders MF, Heaney K, Ford P, Sun F. Evaluation of indoxacarb and fipronil (s)-methoprene topical spot-on formulations to control flea populations in naturally infested dogs and cats in private residences in Tampa FL. USA. Parasites & Vectors 2013, 6:366 (28 December 2013)

Materials and Methods

Flea Population Assessment Techniques

- **Numbers of fleas on pets⁶** assessed using visual area counts on days 0, 7, 14, 21, and once between days 28 – 30, 40-45, & 54-60.
 - 1) dorsal midline, 2) tail head, 3) left lateral thorax, 4) right lateral thorax, and 5) inguinal region and counting fleas for up to 1 minute at each location.
 - Maximum of 50 fleas/ area or 250 total
 - Estimates 23.5% of total flea burden



11. Dryden M, Boyer J, Smith V. Techniques for estimating on animal populations of *Ctenocephalides felis* (Siphonaptera: Pulicidae). J. Med. Entomol. 31:631-624, 1994

Intermittent light-flea traps^{12,13}



12. Dryden M, Broce A. Development of a flea trap for collecting newly emerged *Ctenocephalides felis* (Siphonaptera: Pulicidae) in homes. *J. Med. Entomol.* 30:901-906, 1993.

13. Müller GC, Dryden MW, Revay EE, Kravchenko VD, Broce AC, Hampton K, Junnila A, Schlein Y. Understanding attraction stimuli of *Ctenocephalides felis* for non-chemical control methods. *Med. Vet. Entomol.* 25(4):413-420. 2011.

Materials and Methods

Flea Population Assessment Techniques

- **Premises Infestation**

- Assessed using intermittent light-flea traps on the same day that flea numbers on pets assessed.

- One trap is placed in each of 2 rooms for 16 to 24 hours; room selection based on time spent in room by pets or observation of fleas in the room by owners. Traps are placed in the same location at each counting period.

- Typically traps are placed once weekly for 16 – 24 hours.

- For clinical cases traps often placed in homes continuously

- ***Premises flea traps used to evaluate flea development & emergence in a home.^{9,10,12,13}***

Materials and Methods

Flea Population Assessment Techniques

- **Premises Infestation**
 - Fleas collected on the adhesive pads of the traps are enumerated and identified as to characteristics (e.g.: fed, unfed, gravid) and as to species.
 - In addition, the gender of fleas collected on light traps for each counting period, for each household, is determined.

Field Evaluations

- The Great Unknowns!
 - *How long will it take for this biomass to complete its development?*
 - *How much flea biomass (eggs, larvae, pupae) is in the environment?*
 - *Is there an ongoing source of flea eggs?*
 - *Either product is not stopping viable reproduction or there is an untreated animal in the home*

Field Evaluations

- The Great Unknowns!
 - *How long will it take for this biomass to complete its development?*
 - *How much flea biomass (eggs, larvae, pupae) is in the environment?*
 - *Is there an ongoing source of flea eggs?*
 - *Either product is not stopping viable reproduction or there is an untreated animal in the home*

Manhattan KS – Summer 2003

- Home with three adults and two children (both under 6 yrs old).
- Five cats
- Three cats upstairs
- Two cats lived in the basement with grandmother.
- Owners and Social worker complaining of flea bites



Flea Treatment

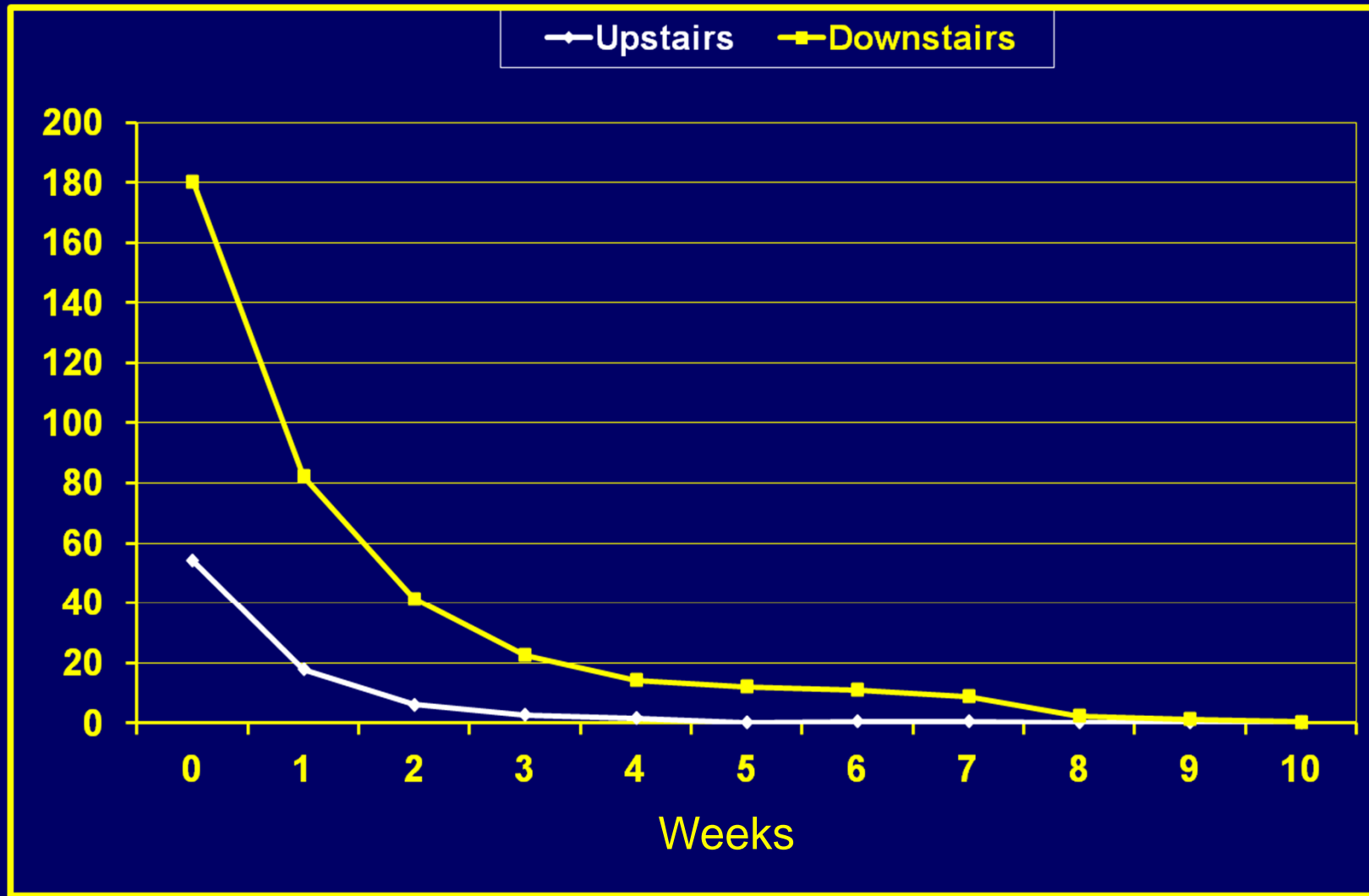
- Cats
 - Product application once monthly to all cats
 - Treatment days 11Jul; 12Aug; 15Sep
- KSU Intermittent Light Flea traps^{12,13}
 - used continuously
 - 2 upstairs
 - 2 downstairs

12. Dryden M, Broce A. Development of a flea trap for collecting newly emerged *Ctenocephalides felis* (Siphonaptera: Pulicidae) in homes. *J. Med. Entomol.* 30:901-906, 1993.

13. Müller GC, Dryden MW, Revay EE, Kravchenko VD, Broce AC, Hampton K, Junnila A, Schlein Y. Understanding attraction stimuli of *Ctenocephalides felis* for non-chemical control methods. *Med. Vet. Entomol.* 25(4):413-420. 2011.



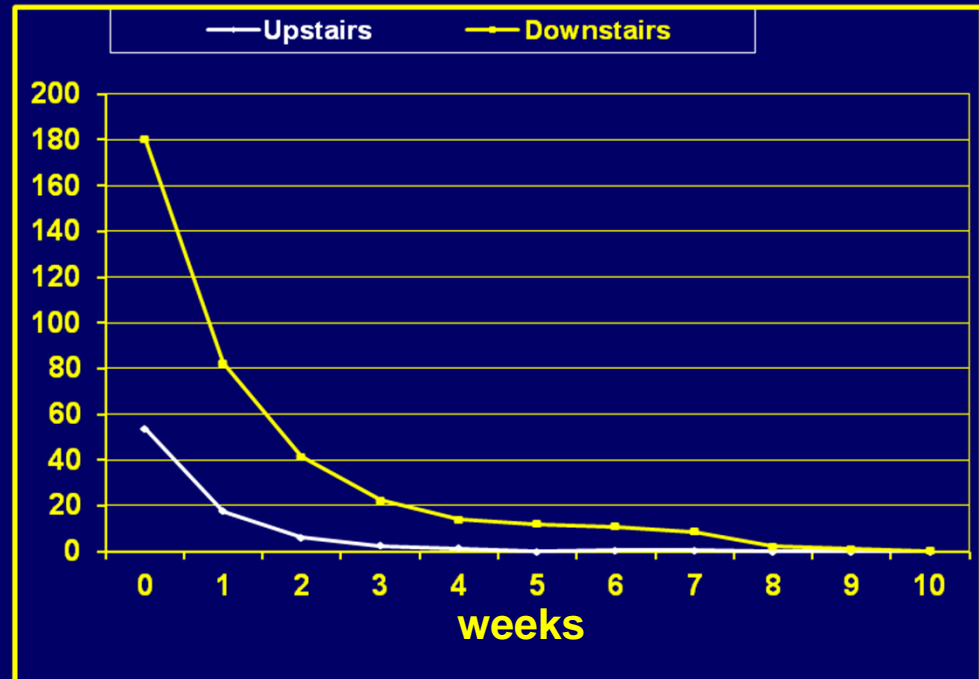
Flea Trap Counts – Fleas Trapped / Day



Why are more fleas emerging in the basement?

- Relative humidity in the microenvironment is primary determining factor in flea populations.
- Flea larvae are weak link in the life-cycle chain.
- Susceptible to heat and desiccation^{1,2}
 - Minimal larva survival if R.H. <50%.

Flea Trap Counts: Fleas Trapped / Day

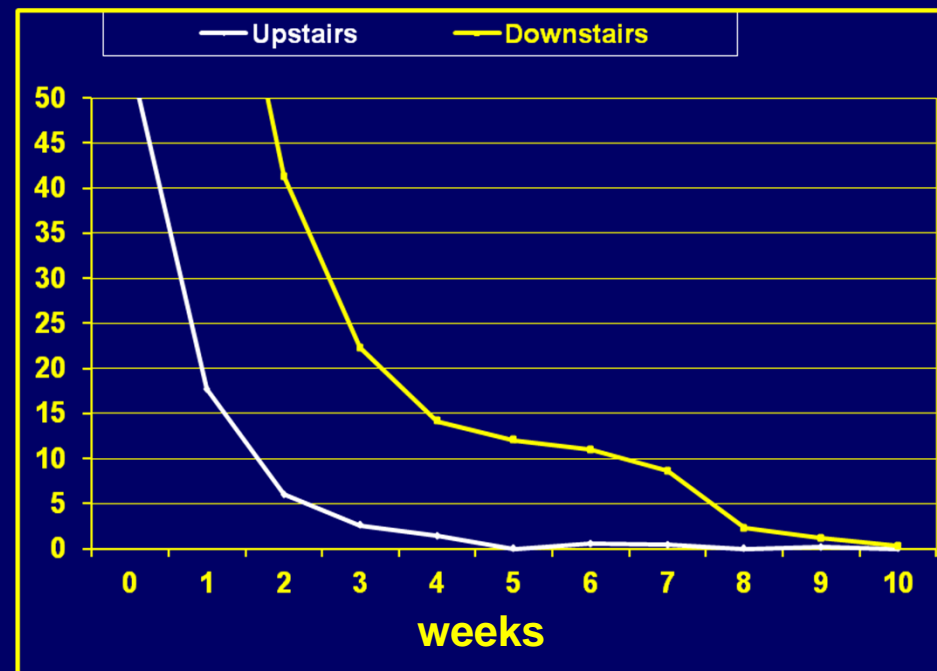


1. Dryden M, Rust M. The Cat Flea - Biology, Ecology and Control. Vet Parasitol 1994;52:1-19.
2. Rust M, Dryden M. The biology, ecology and management of the cat flea. Ann Rev Entomol 1997;42:451-473.3

Why did it take twice as long to eliminate fleas downstairs?

- Rate of flea development is temperature dependent.^{1,2}

Flea Trap Counts – Fleas Trapped / Day

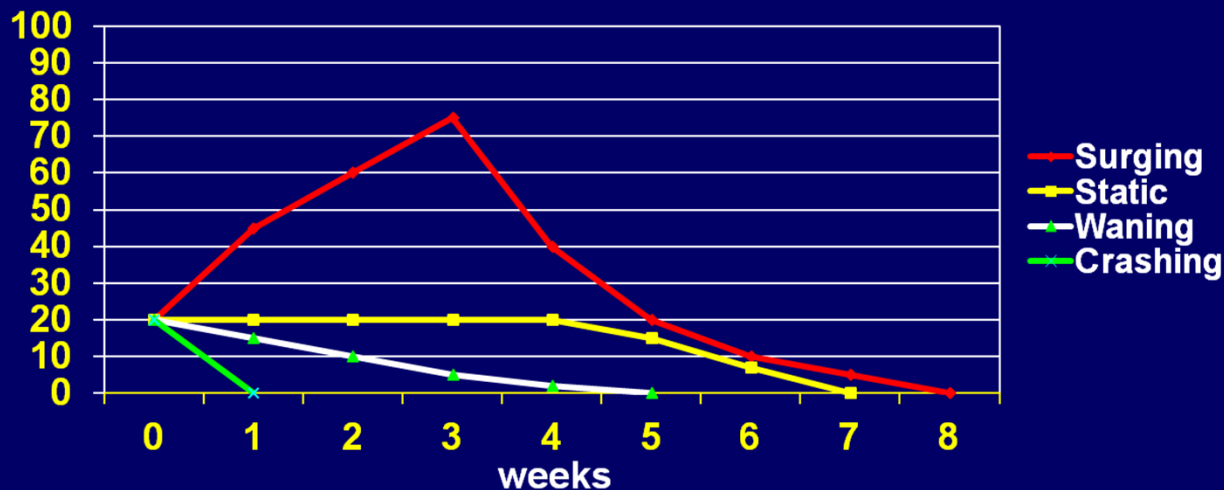


1. Dryden M, Rust M. The Cat Flea - Biology, Ecology and Control. Vet Parasitol 1994;52:1-19.
2. Rust M, Dryden M. The biology, ecology and management of the cat flea. Ann Rev Entomol 1997;42:451-473.3

Field Evaluations

- The Great Unknowns!
 - *How long will it take for this biomass to complete its development?*
 - *How much flea biomass (eggs, larvae, pupae) is in the environment?*
 - *Is there an ongoing source of flea eggs?*
 - *Either product is not stopping viable reproduction or there is an untreated animal in the home*

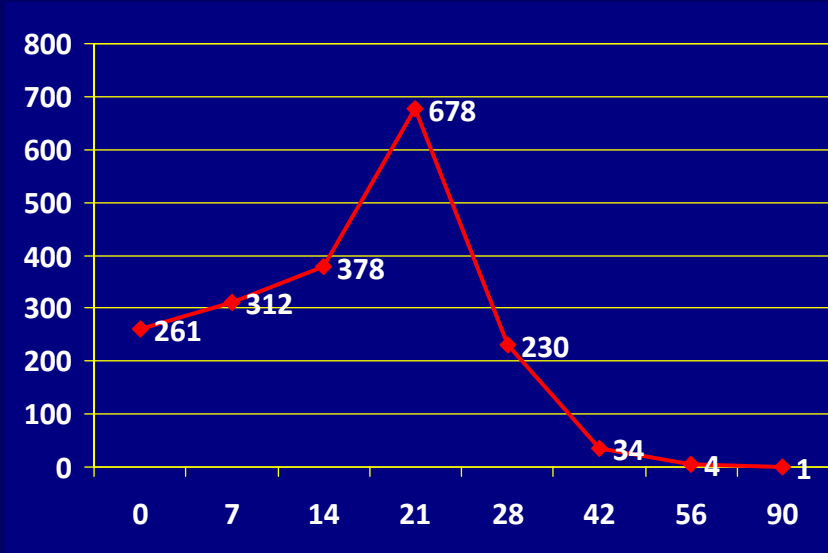
- Red-line homes^{5,9}
 - Red-line homes are houses where premises trap flea counts increase $\geq 20\%$ over day 0 trap counts within 1 to 4 weeks post-treatment.



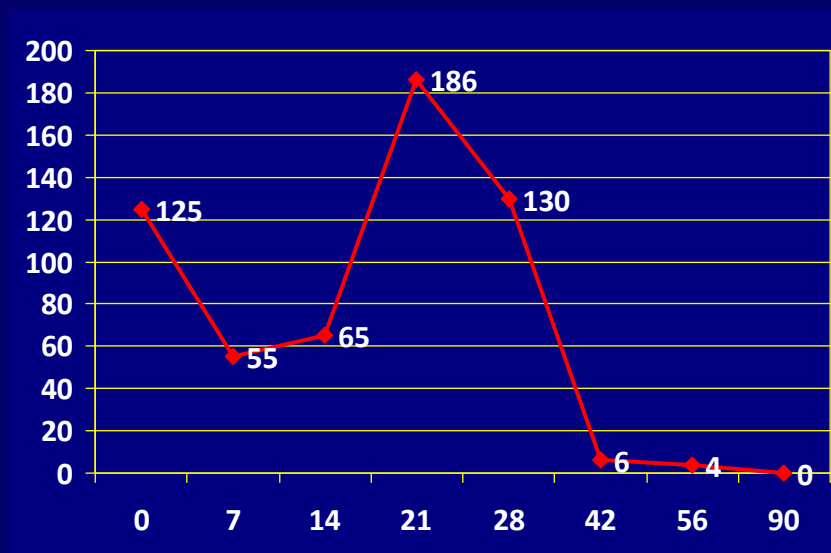
5. Dryden MW. How you and your clients can win the flea control battle. Vet. Med. Supplement March: 17-26, 2009.
 9. Dryden M, Carithers D, McBride A, Riggs B, Smith L, Davenport J, Smith V, Payne P, Gross S. A comparison of flea control measurement methods for tracking flea populations in highly infested private residences in Tampa FL, following topical treatment of pets with FRONTLINE® Plus (fipronil/(S)-methoprene). Intern. J. Appl. Res. Vet. Med. 9:356-367,2011

Classic Red Line Home²

flea trap counts

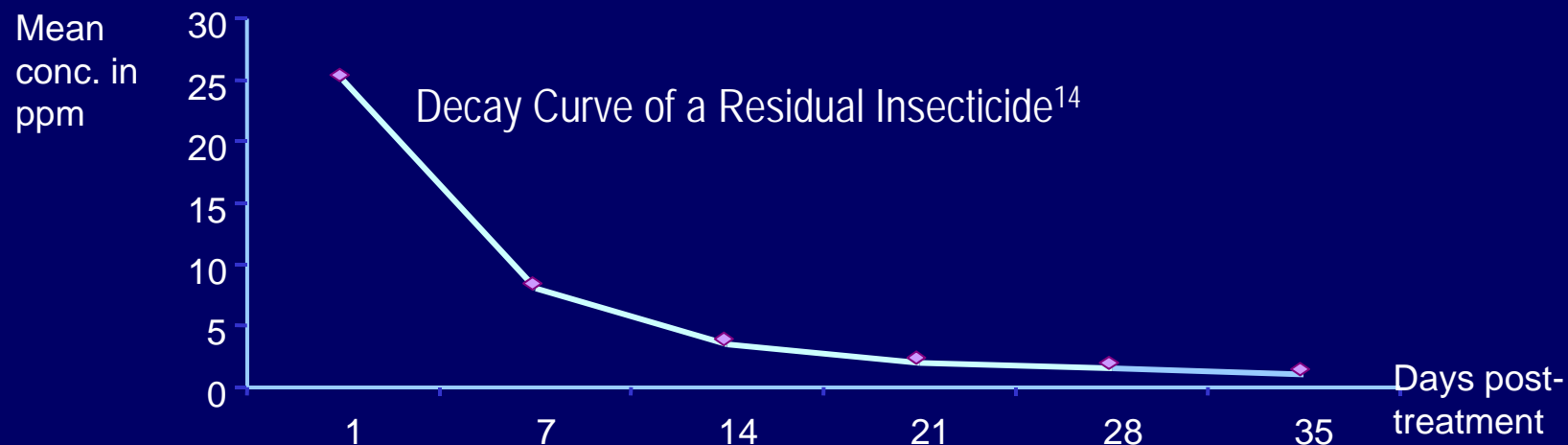


dog area flea counts



1 dog in home treated with fipronil (s)-methoprene on days 0, 30 & 60
May – July 2000

- Residual insecticide concentrations
 - Due to naturally decreasing insecticide concentrations the rate of flea kill slows throughout the month following application.¹⁴⁻¹⁶



- Speed of flea kill is directly proportional to insecticide concentration.

14. Kramer F, Mencke N. Flea Biology and Control: The Biology of the Cat Flea, Control and Prevention with Imidacloprid in Small Animals. Berlin: Springer-Verlag; 2001,104.

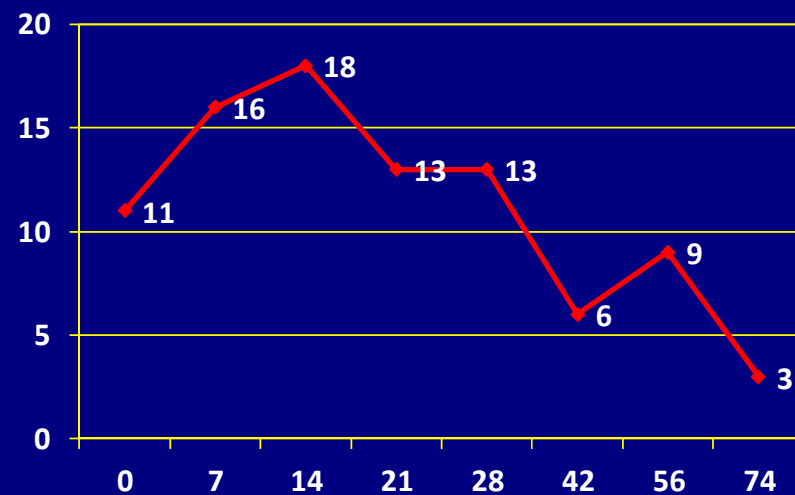
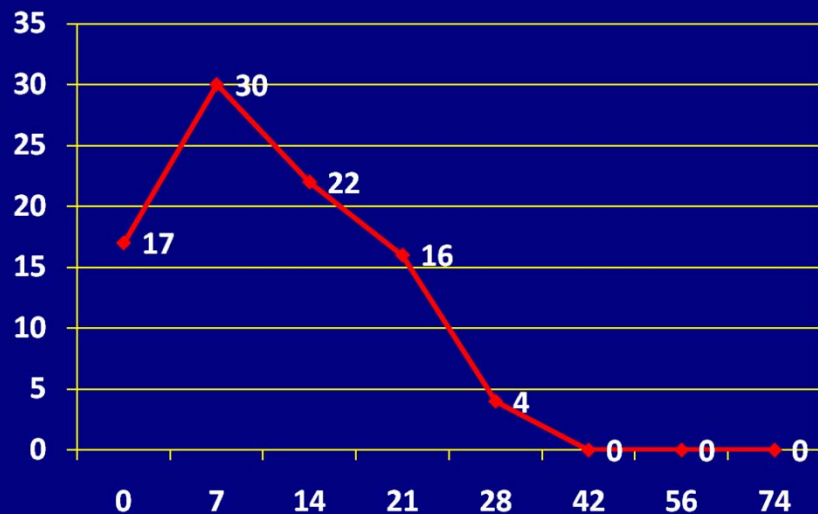
15. Dryden MW, Payne PA, Smith V, Heaney K, Sun F. Efficacy of indoxacarb applied to cats against the adult cat flea, *Ctenocephalides felis*, flea eggs and adult flea emergence. *Parasites & Vectors* 6:126, 2013

16. Dryden MW. Flea and tick control in the 21st century, challenges and opportunities. *Vet Dermatol* 20: 435–440, 2009

Flea counts

Trap (premises)

Pet



1 dog in home treated with dinotefuran-permethrin-pyriproxyfen on days 0, 30 & 60

Client DH

- 4 dogs: Zoe, Molly, George & Shya
- *Enrolled 22May2013*



Client DH

	Flea counts						
	0*	7	14	21	28-30*	40-45	54-60
Zoe	10						
Molly	53						
George	6						
Shya	12						
Traps	22						

*treated topically with indoxacarb (Activyl®)

Client DH

	Flea counts						
	0*	7	14	21	28-30*	40-45	54-60
Zoe	10	0	0	0			
Molly	53	1	0	2			
George	6	1	0	1			
Shya	12	1	0	1			
Traps	22						

*treated topically with indoxacarb (Activyl®)

Client DH

	Flea counts						
	0*	7	14	21	28-30*	40-45	54-60
Zoe	10	0	0	0	47		
Molly	53	1	0	2	3		
George	6	1	0	1	3		
Shya	12	1	0	1	5		
Traps	22						

*treated topically with indoxacarb (Activyl®)

Client DH

	Flea counts						
	0*	7	14	21	28-30*	40-45	54-60
Zoe	10	0	0	0	47		
Molly	53	1	0	2	3		
George	6	1	0	1	3		
Shya	12	1	0	1	5		
Traps	22	13	5	3	397		

Red-line home



*treated topically with indoxacarb (Activyl®)

Client DH

	Flea counts						
	0*	7	14	21	28-30*	40-45	54-60
Zoe	10	0	0	0	47	0	0
Molly	53	1	0	2	3	0	0
George	6	1	0	1	3	0	0
Shya	12	1	0	1	5	2	3
Traps	22	13	5	3	397	9	1

Red-line home

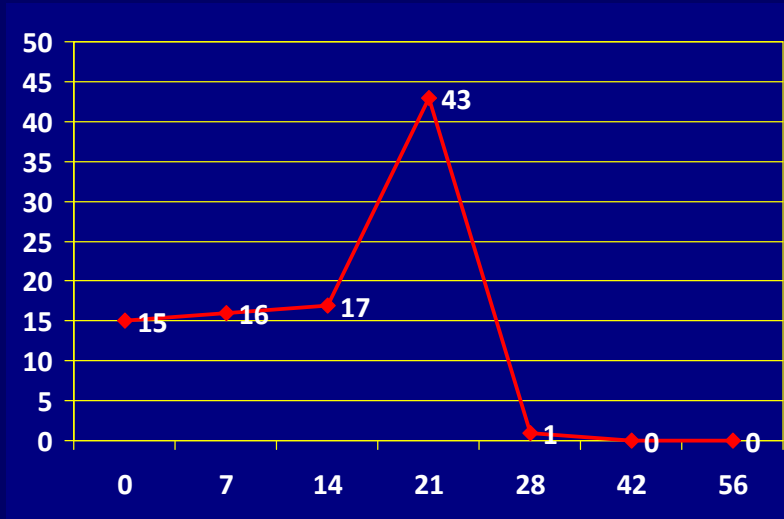


*treated topically with indoxacarb (Activyl®)

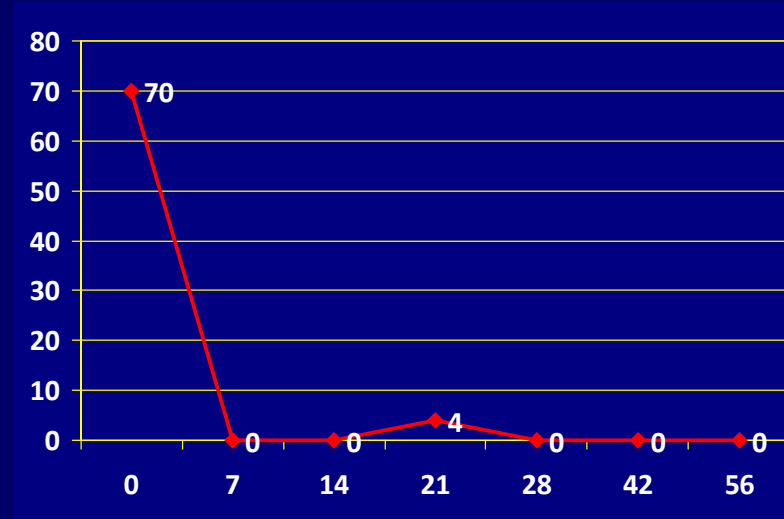
Red Line Home – Tampa 2014

Afoxolaner

flea trap counts



dog area flea counts



1 dog in home (LR:17-27) administered afoxolaner chewable tablets on days 0, 30 & 60

Note minimal to no corresponding increase in flea counts on dog

Field Evaluations

- The Great Unknowns!
 - *How long will it take for this biomass to complete its development?*
 - *How much flea biomass (eggs, larvae, pupae) is in the environment?*
 - *Is there an ongoing source of flea eggs?*
 - *Either product is not stopping viable reproduction or there is an untreated animal in the home*

Flea Population Assessment Techniques

- Premises Infestation
 - Continued collection of emerging un-fed fleas in premises traps
 - Gender ratios?
 - Why do we care about the male and female ratios of fleas collected in premises flea traps?



Protandry versus Protogyny

Use of gender emergence rates to evaluate cessation of flea reproduction

- Protandry
 - tendency for males to emerge before females, and it is common in insects with discrete, nonoverlapping generations in which females mate once only soon after emergence.
- Protogyny
 - tendency for females to emerge before males. Is much less common than protandry in insects and often occurs where females mate with multiple males.
- We determined in study published in 1994 that *C. felis* undergoes protogyny.¹⁷
 - as a flea population “ages” it becomes more male

17. Dryden M, Smith V. Cat flea (Siphonaptera: Pulicidae) cocoon formation and development of naked flea pupae. J. Med. Entomol. 31(2):272-277, 1994.

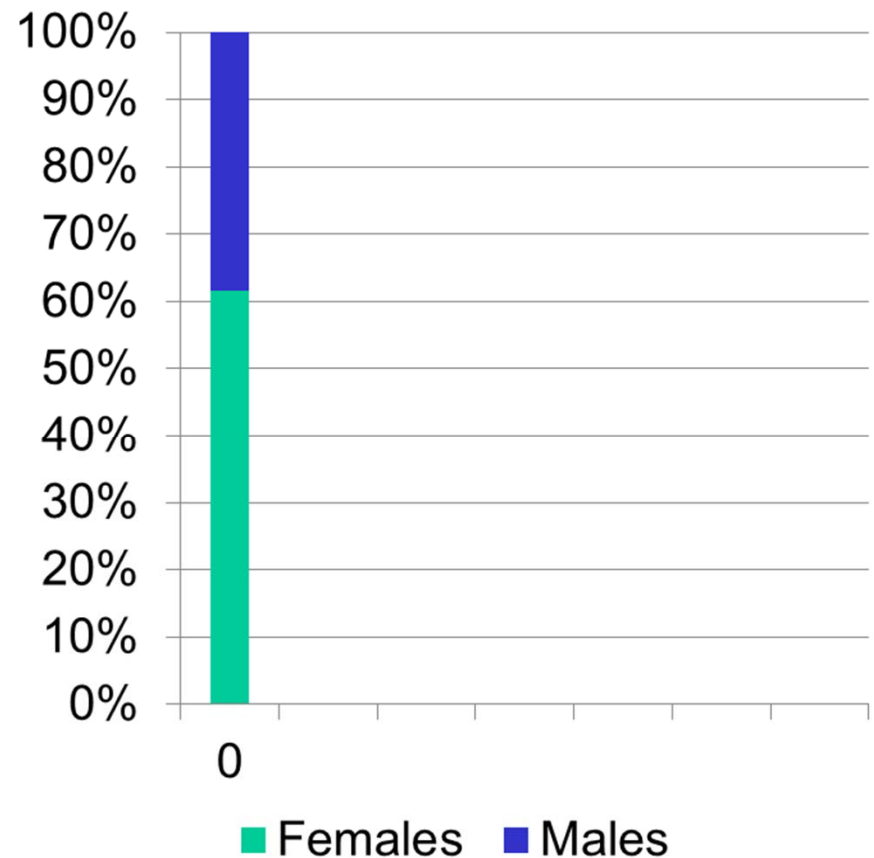
Efficacy in the field and flea gender

Flea counts

	Flea counts						
	0*	7	14	21	28*	45	60
pet	192						
traps	125						

2013 Home AF:
Product A

% of females and males in population collected in flea traps



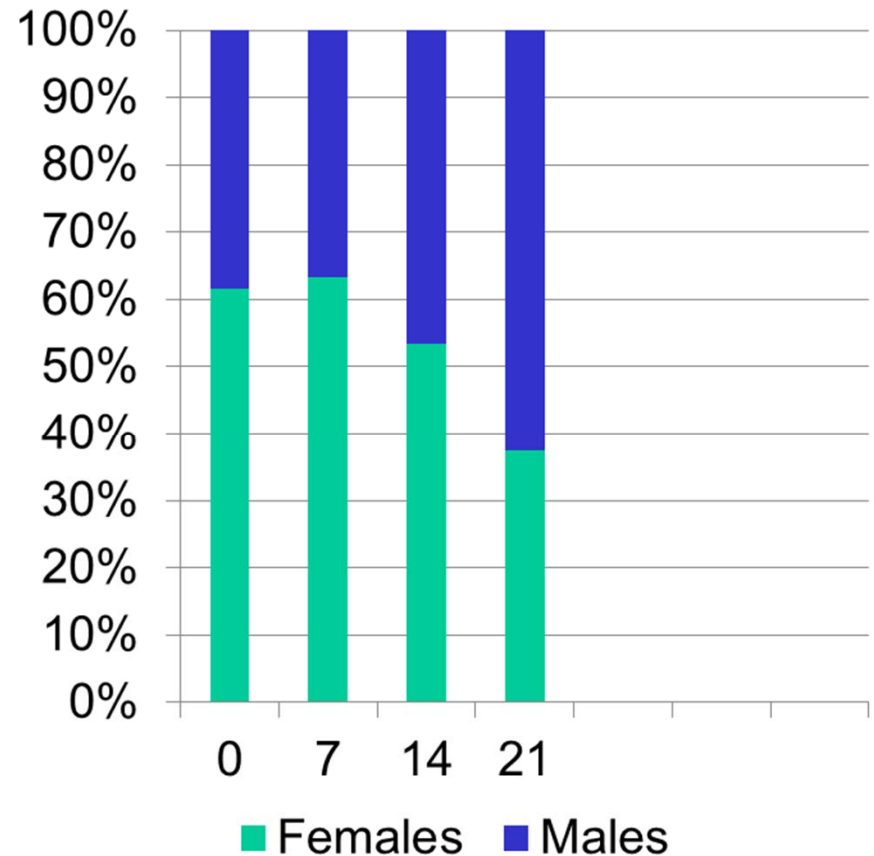
Efficacy in the field and flea gender

Flea counts

	Flea counts						
	0*	7	14	21	28*	45	60
pet	192	0	2	3			
traps	125	31	15	16			

2013 Home AF:
Product A

% of females and males in population collected in flea traps



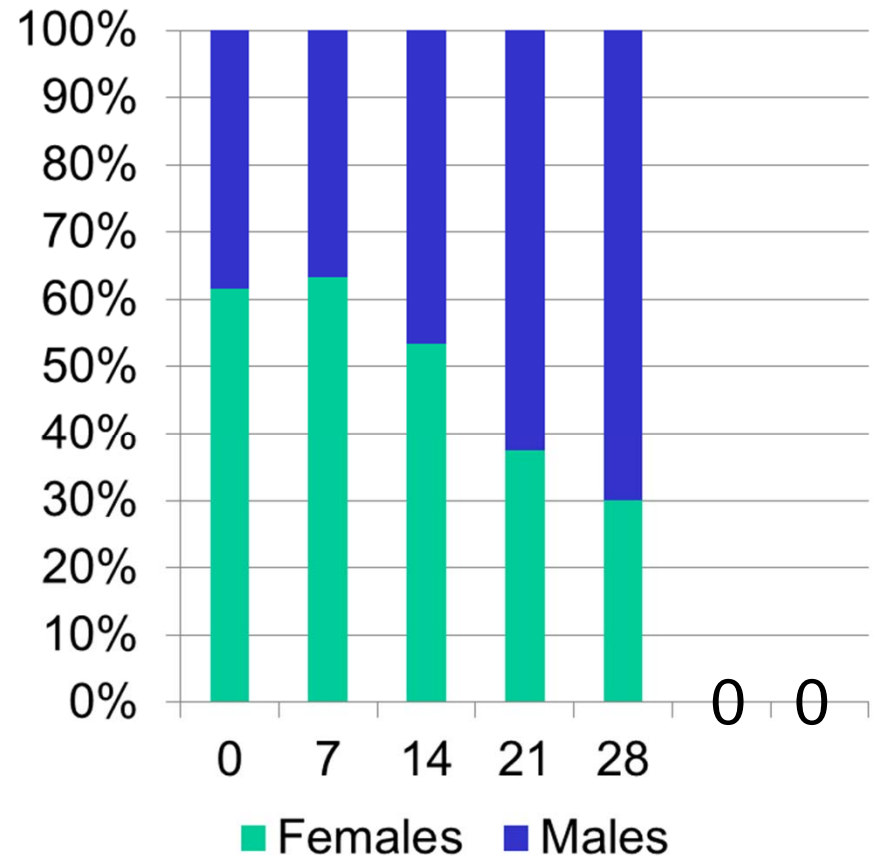
Efficacy in the field and flea gender

Flea counts

	Flea counts						
	0*	7	14	21	28*	45	60
pet	192	0	2	3	10	0	0
traps	125	31	15	16	4	0	0

2013 Home AF:
Product A

% of females and males in population collected in flea traps



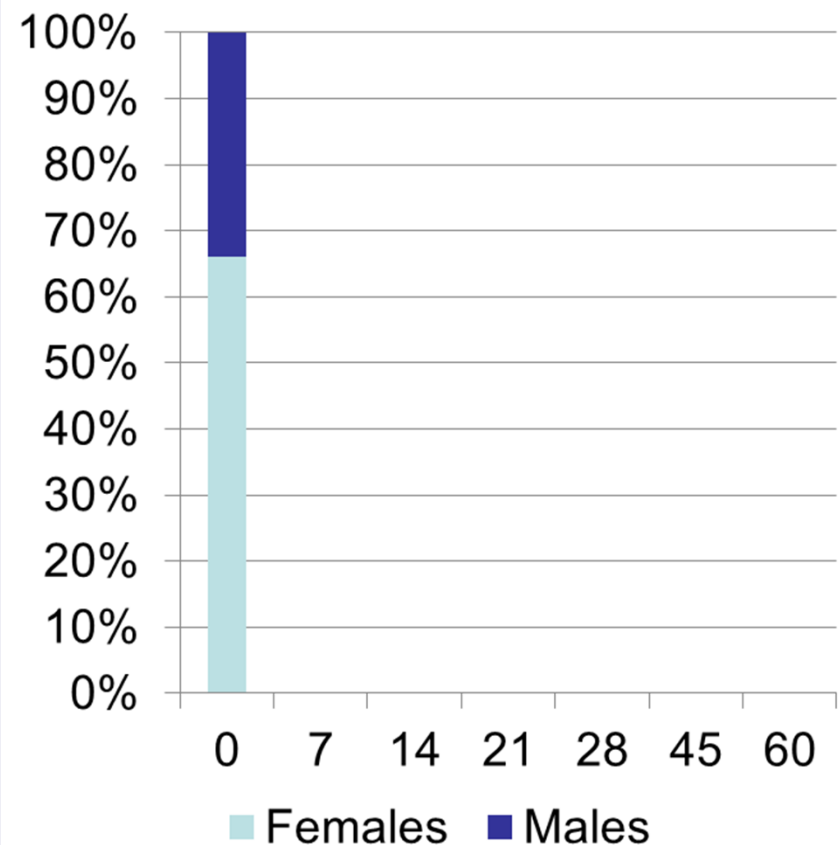
Efficacy in the field and flea gender

Flea counts

	Flea counts						
	0*	7	14	21	28*	45	60
pets	177						
	113						
	13						
	11						
traps	59						

2013 Home KJ:
Product B

% of females and males in population collected in flea traps



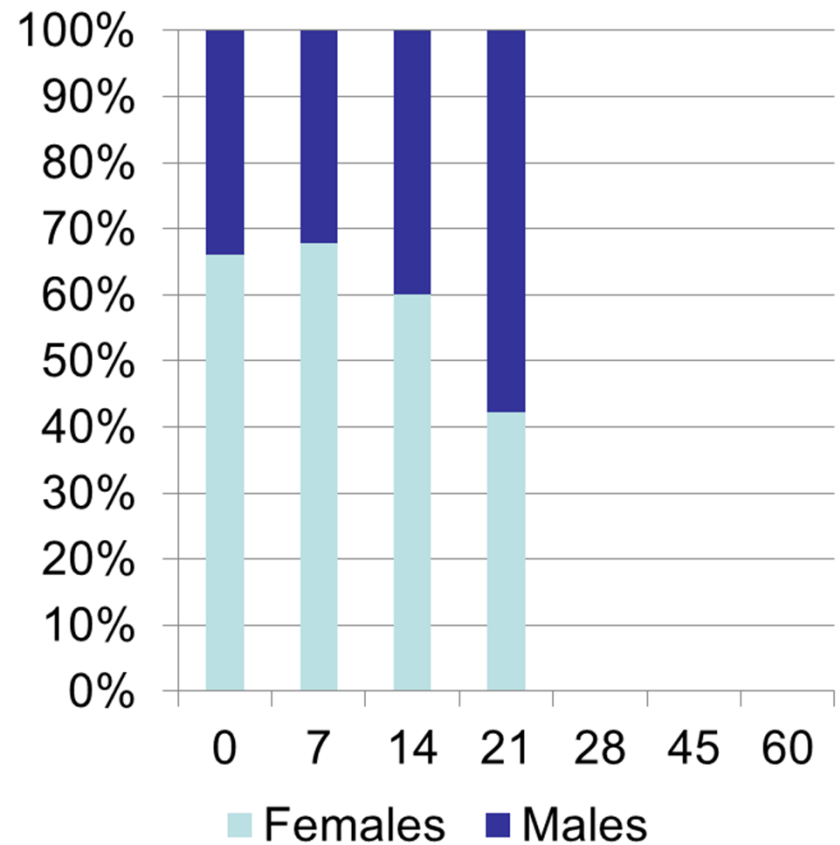
Efficacy in the field and flea gender

Flea counts

	Flea counts						
	0*	7	14	21	28*	45	60
pets	177	14	0	0			
	113	17	8	3			
	13	0	0	0			
	11	1	0	0			
traps	59	29	10	24			

2013 Home KJ:
Product B

% of females and males in population collected in flea traps



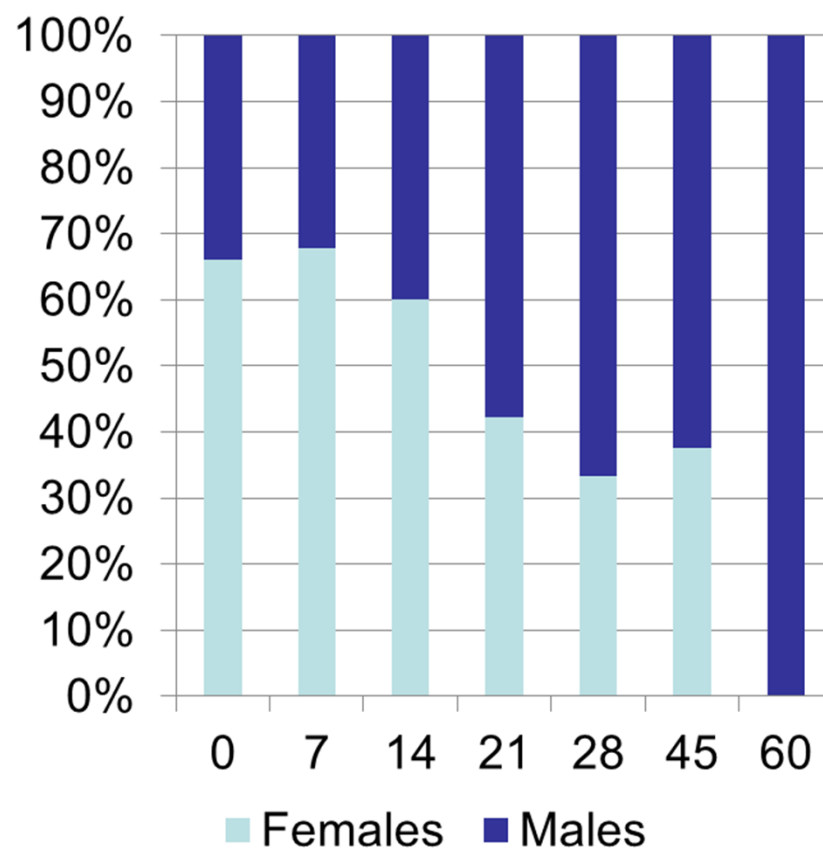
Efficacy in the field and flea gender

Flea counts

	Flea counts						
	0*	7	14	21	28*	45	60
pets	177	14	0	0	4	0	0
	113	17	8	3	7	2	0
	13	0	0	0	-	0	0
	11	1	0	0	0	0	0
traps	59	29	10	24	3	8	2

2013 Home KJ
Product B

% of females and males in population collected in flea traps

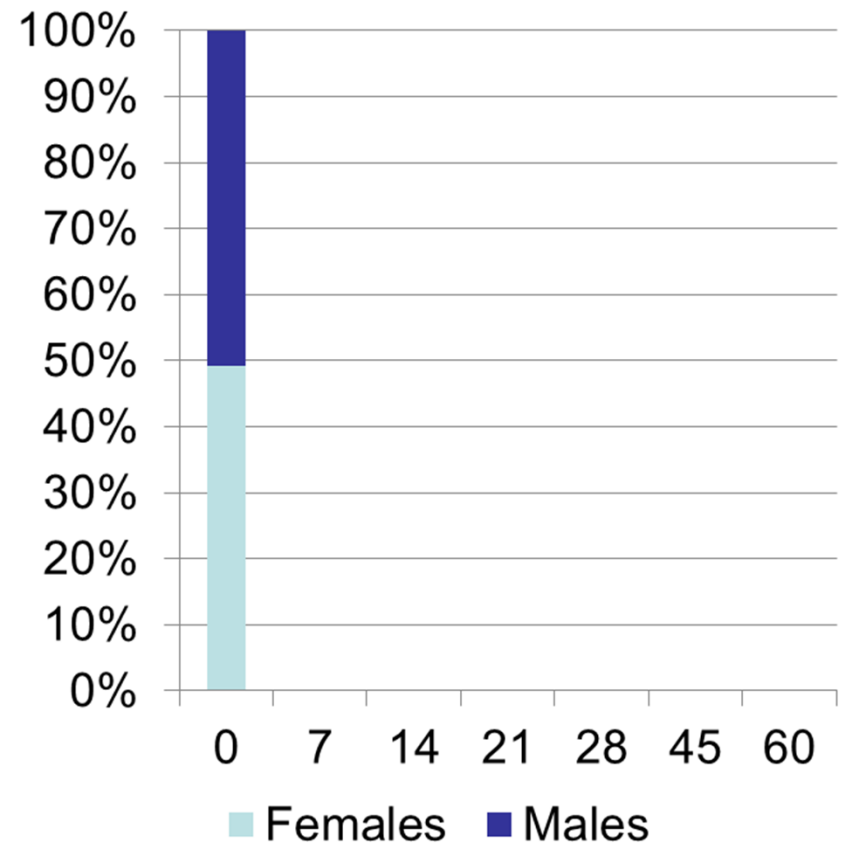


Efficacy in the field and flea gender

Flea counts

	Flea counts						
	0*	7	14	21	28*	45	60
pet	250						
traps	122						

% of females and males in population collected in flea traps



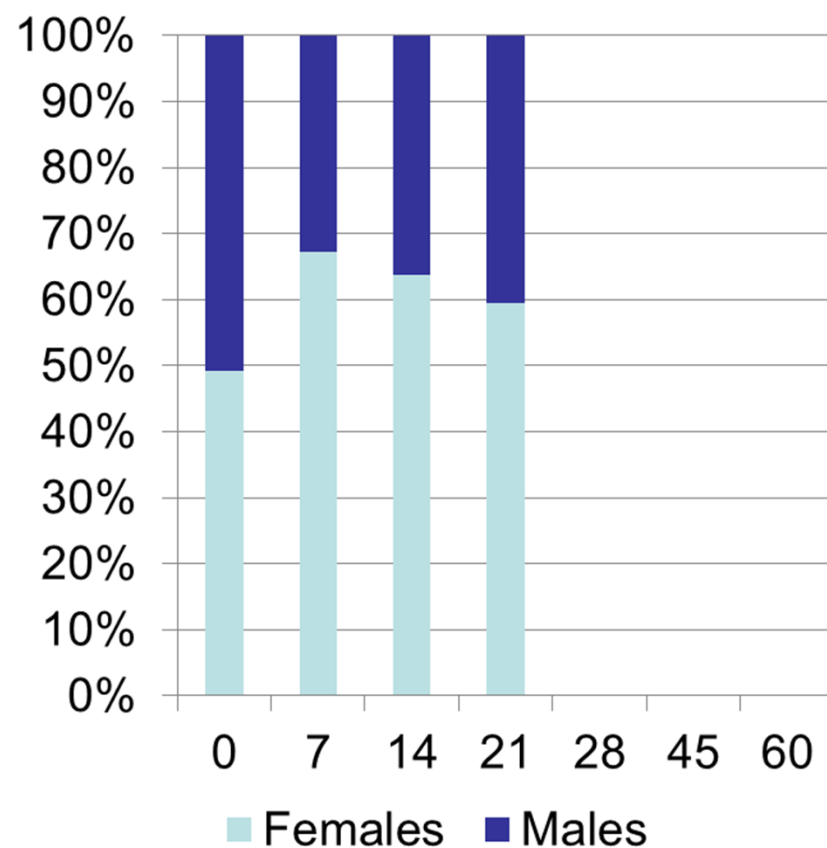
2013 Home MG
Product C

Efficacy in the field and flea gender

Flea counts

	Flea counts						
	0*	7	14	21	28*	45	60
pet	250	10	15	123			
traps	122	55	56	37			

% of females and males in population collected in flea traps



2013 Home MG
Product C

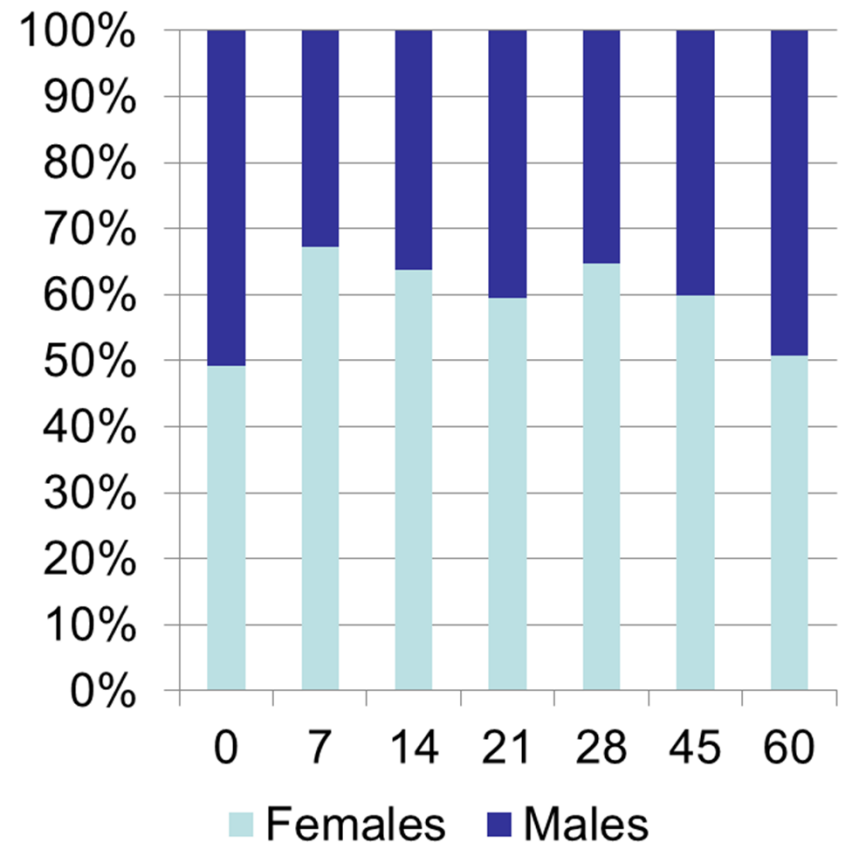
Efficacy in the field and flea gender

Flea counts

	Flea counts						
	0*	7	14	21	28*	45	60
pet	250	10	15	123	198	53	74
traps	122	55	56	37	166	102	77

2013 Home MG
Product C

% of females and males in population collected in flea traps



Field Evaluations

- *Is there an ongoing source of flea eggs?*
 - *Either product is not stopping viable reproduction or there is an untreated animal in the home*
 - + *Excessive bathing*
 - + *Improper administration*
 - + *Not treating all flea hosts*
 - + *Visitor pets*
 - + *Product failure/resistance*
 - + *Etc...*



Lessons from in-home investigations

- In cases in which it appears products are not fully effective, careful investigation may reveal the cause.
 - Numerous “red-line” homes
 - Outdoor sources of infestation
 - Untreated visitor animals
 - Improper administration
 - Too frequent bathing
 - Residual speed of kill is critically important
 - Etc...

Residual Adulticides

- Speed of kill⁸
 - Initial speed of kill
 - Residual speed of kill
 - Killing newly acquired fleas rapidly enough
 - To prevent flea reproduction
 - To markedly reduce injection of salivary proteins and minimize or eliminate FAD
 - To provide client satisfaction (fewer fleas observed)

8. Dryden, MW. Spotlight on Research: How residual speed of kill affects flea control in dogs and cats. 2014:1-4. Vet Med 109(7).

Fleas and FAD

- Classic working hypothesis of Flea Allergy Dermatitis (FAD)^{18,19}
 - A single flea bite will produce a clinical reaction in a hypersensitive animal and the animal will react for up to two weeks.
 - But is this accurate?
 - If this is accurate, then flea products must kill fleas before they can bite & feed in order to manage FAD.

18. Kissileff A. Relationship of dog fleas to dermatitis. *Small Animal Clinician* 1962; 2: 132–5.

19. Dryden MW. Flea and tick control in the 21st century, challenges and opportunities. *Vet. Dermatol.* 20, 435–440, 2009.

C. felis and FAD

- What do we know about flea feeding?²⁰⁻²³
 - Feed in seconds to minutes; Between 90 - 95% feed within 5 minutes to 1 hour depending upon strain, age post-emergence and type of analysis.
 - Female fleas consume 10x body weight in blood the 1st 24 hours resident on the host and consume 15x their body weight daily thereafter.^{20,23}

20. Dryden M, Gaafar S. Blood Consumption by the Cat Flea, *Ctenocephalides felis felis* (Siphonaptera: Pulicidae). *J. Med. Entomol.* 28:394-400, 1991
21. Cadiergues MC, et al. First bloodmeal of *Ctenocephalides felis felis* (Siphonaptera: Pulicidae) on cats: time to initiation and duration of feeding. *Journal of Medical Entomology* 2000; 37: 634–6.
22. Dryden M, Wilkerson M, Payne P, Bagladi-Swanson M. Evaluation of the efficacy of lufenuron-nitenpyram and imidacloprid to control Flea Allergy Dermatitis and Flea Populations in a simulated home environment Study. *Am. Assoc. Vet. Parasitol.* 48th Annual Meeting. July 19-22, 2003 Denver CO. P60
23. McCoy C, et al. Flea blood feeding patterns in cats treated with oral nitenpyram and the topical insecticides imidacloprid, fipronil and selamectin. *Veterinary Parasitology* 2008; 156(3-4):293-301

Feeding challenge

- Dogs exposed to ~25 fleas that were 1- 3 days post emergence.
- 15mm diameter glass tube covered by gauze.
- Placement:
 - inguinal region of the dog and fleas allowed to feed for 5 minutes.
 - Fleas were then analyzed using a commercial occult blood test (Quik Cult fecal occult blood test strips) to reveal ingested blood



22. Dryden M, Wilkerson M, Payne P, Bagladi-Swanson M. Evaluation of the efficacy of lufenuron-nitenpyram and imidacloprid to control Flea Allergy Dermatitis and Flea Populations in a simulated home environment Study. Am. Assoc. Vet. Parasitol. 48th Annual Meeting. July 19-22, 2003 Denver CO. P60



placement in inguinal region



Fleas feeding

Provocative challenge – feeding

- Fleas fed rapidly through the gauze with feces being excreted within 2 to 5 minutes.
 - Feces were excreted from one flea in 82 seconds (1:22)
- 514 fleas were placed on the 20 dogs
 - 89.8% (462) tested positive for blood after the 5 minute feeding challenge.

**Gauze before and after feeding challenge with
25 fleas for 5 minutes.**



C. felis and FAD

- Can topical insecticides truly stop this rapid feeding?
 - Studies indicate that topical insecticides often can not kill all fleas prior to them initiating feeding.^{19,23,24}
 - Certain permethrin formulations with specific flea strains have demonstrated reductions in feeding, but with other flea strains permethrin offers little efficacy.^{19,24}
 - In fact some of these topical insecticides can not even kill fast enough to stop egg production which requires at least 24 hours of blood feeding.^{19,25}

19. Dryden MW. Flea and tick control in the 21st century, challenges and opportunities. *Vet. Dermatol.* 20, 435–440, 2009.

23. McCoy C, et al. Flea blood feeding patterns in cats treated with oral nitenpyram and the topical insecticides imidacloprid, fipronil and selamectin. *Veterinary Parasitology* 2008; 156(3-4):293-301

24. Franc, M; Cadiergues, MC .Antifeeding effect of several insecticidal formulations against *Ctenocephalides felis* on cats. *PARASITE-JOURNAL DE LA SOCIETE FRANCAISE DE PARASITOLOGIE* 5(1): 83-86, 1998

25. Dryden M, et al. Efficacy of selamectin and fipronil / (S)-methoprene spot-on formulations applied to cats against the adult cat flea, *Ctenocephalides felis*, flea eggs and adult flea emergence. *Veterinary Therapeutics* 2007; 8: 255–62.

***C. felis* and FAD**

- However, while the topical insecticides can not stop flea bites and fleas must bite to acquire systemically active compounds, numerous studies have clearly shown that these compounds (fipronil, fluralaner, imidacloprid, nitenpyram, permethrin, selamectin, spinosad) have had a positive clinical effect on dogs and cats with FAD.^{22, 26-34}

C. felis and FAD

26. Genchi C, Traldi PG, Bianciardi PP. Efficacy of imidacloprid on dogs and cats with natural infestations of fleas, with special emphasis on flea hypersensitivity. *Vet Ther.* 2000 Spring;1(2):71-80.
27. Medleau L, Clekis T, McArthur TR, Alva R, Barrick RA, Jeannin P, Irwin J. Evaluation of fipronil spot-on in the treatment of flea allergic dermatitis in dogs. *J Small Anim Pract.* 2003 Feb;44(2):71-5.
28. Dickin SK, et al. Efficacy of selamectin in the treatment and control of clinical signs of flea allergy dermatitis in dogs and cats experimentally infested with fleas. *Journal of the American Veterinary Medical Association* 2003; 223: 639–44.
29. Medleau L, et al. Evaluation of fipronil spot-on in the treatment of flea allergic dermatitis in dogs. *Journal of Small Animal Practice* 2003; 44: 71–5.
30. Hellmann K, et al. Evaluation of the efficacy and safety of a novel formulation of metaflumizone plus amitraz in dogs naturally infested with fleas and ticks in Europe. *Veterinary Parasitology* 2007; 150: 239–45.
31. Robertson-Plouch C, et al. Clinical field study of the safety and efficacy of spinosad chewable tablets for controlling fleas on dogs. *Veterinary Therapeutics* 2008; 9: 26–36.
32. Dryden MW, Ryan WG, Bell M, Rumschlag AJ, Young LM, Snyder DE. Assessment of owner-administered monthly treatments with oral spinosad or topical spot-on fipronil/(S)-methoprene in controlling fleas and associated pruritus in dogs. *Vet Parasitol.* 2013 Jan 31;191(3-4):340-6.
33. Fisara P, Sargent RM, Shipstone M, von Berky A, von Berky J. An open, self-controlled study on the efficacy of topical indoxacarb for eliminating fleas and clinical signs of flea-allergy dermatitis in client-owned dogs in Queensland, Australia. *Vet Dermatol.* 2014 Jun;25(3):195-8.
34. Meadows C, Guerino F, Sun F. A randomized, blinded, controlled USA field study to assess the use of fluralaner tablets in controlling canine flea infestations. *Parasit Vectors.* 2014 Aug 16;7:375.

Fleas and FAD – A Shifting Paradigm

- The classic working hypothesis likely is not accurate!!!
 - FAD is likely related to the degree of hypersensitivity of the individual, number of fleas & amount of antigen injected.¹⁹
 - It appears that the role of insecticides in managing FAD is related to a decrease in prolonged flea feeding and thereby the amount of salivary protein delivered to the pet and in the long-term reduction of flea numbers.¹⁹
 - What is important is how rapidly a compound can kill newly acquired fleas!
 - Products residual speed of kill
- What is clearly evident is that both topical and systemically active compounds can provide rapid cessation of feeding and rapid flea death, thus effectively managing FAD.

Situations that may require treatment of the environment⁶



FAD, human flea bites or massive infestations



6. Dryden M, Bennett G, Neal J. Concepts of Flea Control. *Comp An Pract* 19(4-5):11-22, 1989.

Premises Treatments

- Eliminate fleas more rapidly, provide animal relief and provide home owner relief from flea bites.
 - **Mechanical control**^{2,6}
 - Wash bedding, Vacuum - discard bag, steam clean, wash area rugs, flea traps etc.



Key with premises treatments:
BIO-MASS REDUCTION

2. Rust M, Dryden M. The biology, ecology and management of the cat flea. *Ann Rev Entomol* 1997;42:451-473

6. Dryden M, Bennett G, Neal J. Concepts of Flea Control. *Comp An Pract* 19(4-5):11-22, 1989.



Dyson “Animal” Vacuum Test

	Control		V1		V2	
	# recovered after vacuuming from 100 eggs & 50 larvae ^a					
Trials	Eggs	larvae	Eggs	larvae	Eggs	larvae
1	74	44	48	18	45	35
2	80	40	54	35	55	25
3	98	42	60	30	41	23
Geomean	83.40	41.97	53.78	26.64	46.64	27.20
Reduction			35.5%	36.5%	44.1%	35.2%

Carpet - medium pile nylon carpet - 1 sq ft.

control = no vacuum

V1 = vacuumed once up/back

V2 = vacuumed twice up/back

^aEggs & larvae scattered across carpet: carpet lightly brushed & allowed to sit for 10 minutes. Following vacuuming carpet inverted for 4 hours and then vigorously tapped to dislodge remaining eggs

Flea Trap^{12,13}

www.Myfleatrap.com



12. Dryden M, Broce A. Development of a flea trap for collecting newly emerged *Ctenocephalides felis* (Siphonaptera: Pulicidae) in homes. *J. Med. Entomol.* 30:901-906, 1993.

13. Müller GC, Dryden MW, Revay EE, Kravchenko VD, Broce AC, Hampton K, Junnila A, Schlein Y. Understanding attraction stimuli of *Ctenocephalides felis* for non-chemical control methods. *Med. Vet. Entomol.* 25(4):413-420. 2011.

Premises Treatments

- Premises treatment^{2,6}
 - Sprays, directed aerosols, total release aerosols & Pest Control Services
 - Adulticide (pyrethroids) & IGR (methoprene or pyriproxifen)
 - Two applications 7 to 10 days apart
 - Outdoors: imidacloprid-cyfluthrin, esfenvalerate, permethrin) every 7 – 10 days.

2. Rust M, Dryden M. The biology, ecology and management of the cat flea. Ann Rev Entomol 1997;42:451-473

6. Dryden M, Bennett G, Neal J. Concepts of Flea Control. Comp An Pract 19(4-5):11-22, 1989.

