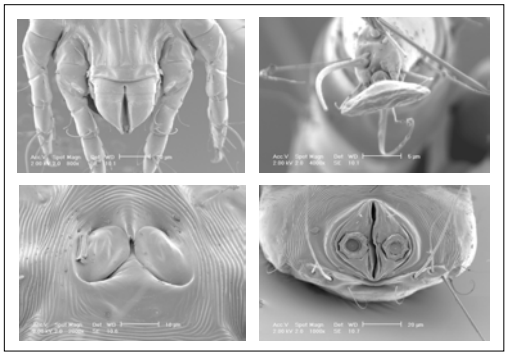
The LECTUS Mite Population Model

developed in conjunction with Dr Brian Leung, Visiting Fellow at University of Cambridge Department Zoology



Outline

Reporting on:

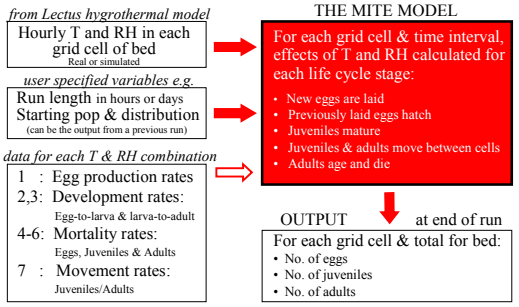
- Development of the Lectus population model
  A spatially explicit life cycle transient population dynamics model
- Testing it against steady state data
  Including brief mention of the simpler BED3 population model
- Testing it against transient data
  Preliminary findings
- Limitations of the model and further work required

Modelling Simplifications

We have considered:

- Only one species: *Dermatophagoides pteronyssinus*, the most common dust mite species in UK homes.
- Only the bed habitat (and primarily the mattress), the most common habitat for DP.
- The bed to be a closed system with no immigration or emigration & an excess supply of food
- Larvae & nymphs lumped together as "juveniles"
- No allergen production

Diagram of Lectus population model



Two of the available data sets (for DP)

1: Number of eggs per female **Red** = Gamal Eddin 1983 **Bold** = Arlian 1990

	Temperature									
RH	10	15	16	20	23	25	30	35	35	40
50						11				
55						23.7				
60						44.5				
65						70				
70						106				
75		80			90.2	**68.4**	123	80	28	**48**	13.3
80							148				
85							88.4				
90							10				
95							4				
100											

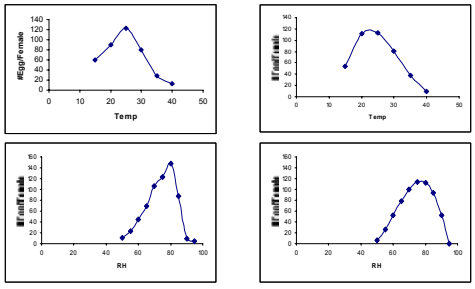
2: Development time of eggs to larvae (DAYS) Blue = Colloff; Red = Gamal Eddin 1983; **Bold** = Arlian 1990

	Temperature														
RH	10°C	15°C	15°C	16°C	20°C	20°C	23°C	25°C	25°C	30°C	30°C	32°C	35°C	35°C	35	40°C
50									16.2							
55	180	59			9.7			6.2	14	5			4.2			
60	155	42			9.2			6	12.1	4.8			4.2			
65	120	37			9.1			5.8	10	4.4			3.9			
70	135	29			7.9			5.1	9.2	4.1			4			
75	145	32	19.3	**26.6**	7.9	12.2	**8.1**	4.5	8.3	3.9	6.6	**4.5**	3.9	5.4	**3.9**	4
80	150	33			8			5	7.2	3.7			3.7			
85	160	38			9			5.2	8	4			3.6			
90	150	42			9.8			6	10	4			3.5			
95	150	44			9.5			5	14	4.1			3.4			
100	175	45			10.5			5.2		4.2			3.9			

NB: all steady state data

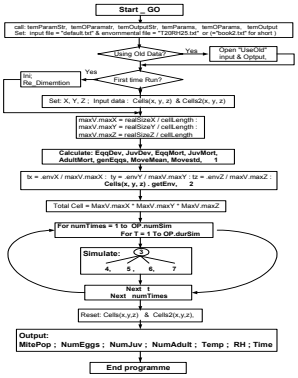
Curve fitting

Eggs/female: data simulated

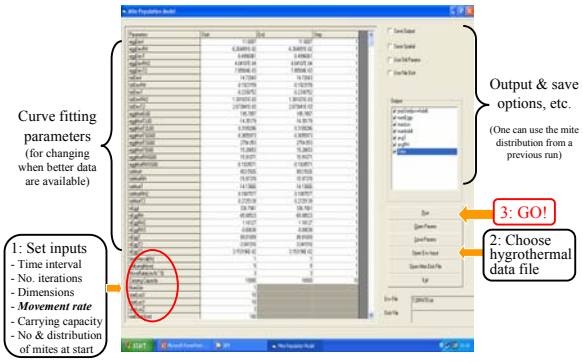


Eggs/female = $336.7 - 65.1RH + 1.16RH^2 - 0.00638RH^3 + 89.0T - 3.04T^2 + 0.03T^3$

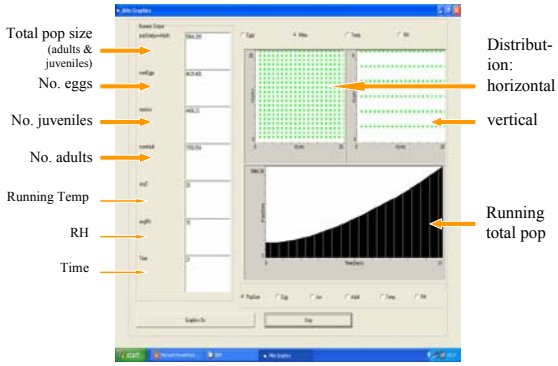
Flow Chart of the Population Model



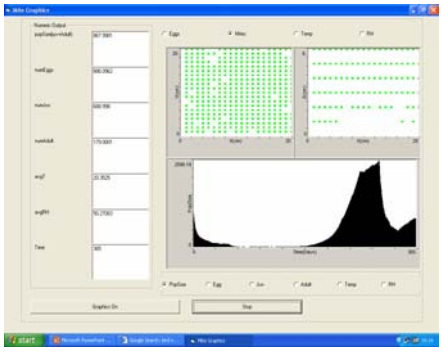
User interface: inputs



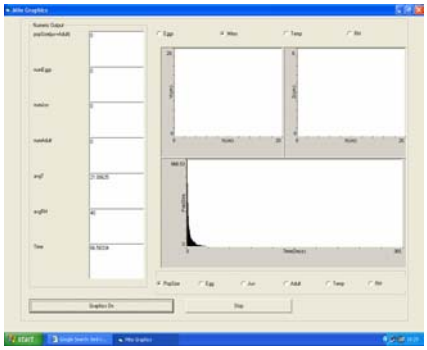
User interface: Model outputs



Example: a relatively damp house



Example: a dry house

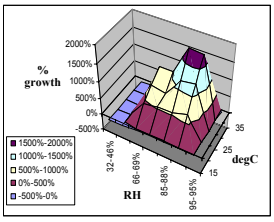


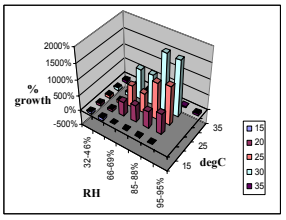
Testing against steady state conditions: 1

Experimental data collection

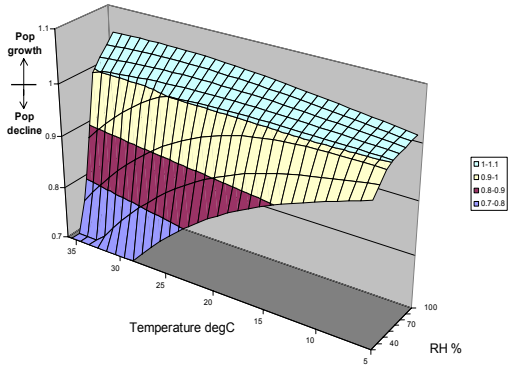
Population growth of DP mites held at different combinations of RH and T for 3 weeks (1161 at start)

RH	Temperature degC				
	15	20	25	30	35
32-46%	-84%	-84%	-100%	-100%	-100%
46-53%	-85%	-67%	-100%	-100%	-100%
66-69%	-17%	450%	698%	970%	-100%
68-82%	-5%	526%	624%	970%	-8%
85-88%	-20%	544%	1153%	1802%	290%
84-87%	-3%	663%	1236%	1766%	44%
95-95%					-63%





Cunningham's model: 3-D chart



The BED3 Population Model

Cunningham curve fitted population data to derive a model relating mite growth/decline with RH and T. We have done the same, using this new data, based on a new concept - **Hygrothermal Population Equilibrium (HPE)** - *defined as:*

- For a specified temperature, the RH at which a mite population is stable, neither growing nor declining

It is analogous to CEH_T *(Critical Equilibrium Humidity), except that it relates not to individual mites and their supracoxal glands, but to overall population dynamics.*

More later …..

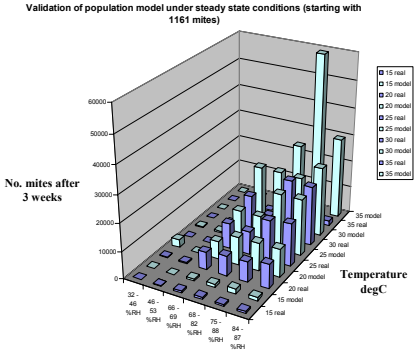
Testing against steady state conditions: 2

Model predictions vs. experimental data

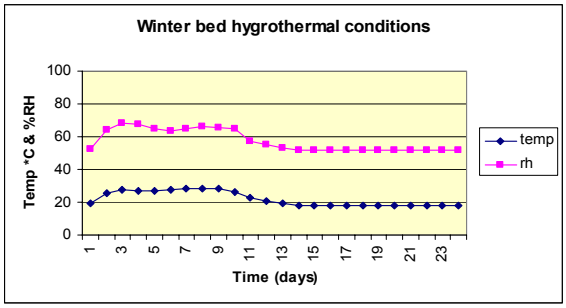
Key: **130** no mites after 3 weeks (av. of 3 replicates)
73 population predicted by model after 3 weeks
33.4 actual monitored av. RH

RH	15°C Starting pop 1161	20°C Starting pop 1161	25°C Starting pop 1161	30°C Starting pop 1161	35°C Starting pop 1164
32 – 41%	**191** **107** 33.4	**183** **2,779** 32.4	**0** **349** 34.4	**0** **0** 40.6	**0** **0** 32.5
46-53%	**170** **0** 46.2	**385** **0** 46	**0** **540** 50.4	**0** **327** 53.3	**0** **0** 40
66-69%	**964** **1,046** 63	**6,389** **6436** 68.5	**9,264** **10,419** 66.6	**12,417** **20,091** 69.5	**0** **293** 55
68-82%	**1,107** **1,692** 66	**7,265** **10,125** 82	**8,408** **10,385** 68.6	***12,417*** **20,091** 70	**1,068** **23,763** 71
85-88%	**930** **2,739** 75	**7,478** **10,265** 85.6	**14,549** **20,641** 85.4	**22,088** **19,566** 88.1	**4,531** **59,082** 79
84-87%	**1,121** **1,878** 87	**8,864** **10,265** 84.4	**15,510** **20,641** 85.4	**21,659** **25,190** 86.6	**1,677** **29,541** 83
94.5%					**431** **0** 94.5

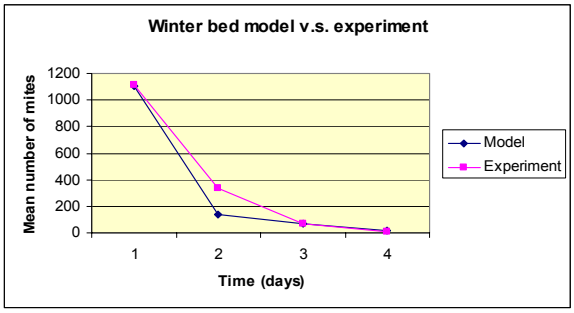
Testing against steady state conditions 3



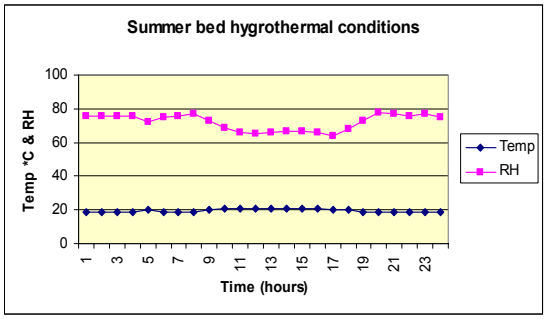
Simulating transient conditions: 1



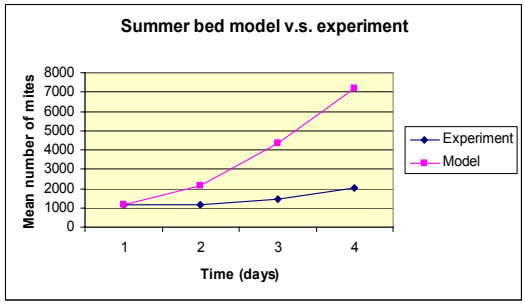
Simulating transient conditions: 1



Simulating transient conditions: 2



Simulating transient conditions: 2



Limitations of Lectus model to date

Missing mite physiology data
- Range of conditions for which data is available is very limited (eg. at extremes) and very little relates to transient conditions
- Not enough data on mite movement, carrying capacity and lab vs. wild mites

Limitations of Lectus model to date

1 *Missing mite physiology data*
- Range of conditions for which data is available is very limited (eg. at extremes) and very little relates to transient conditions
- Not enough data on mite movement, carrying capacity and lab vs. wild mites

2 *Scope needs to be widened*
- Apart from the mattress, other bedding components (eg. pillows and duvets) and other habitats such as carpets and upholstery need to be considered
- This would then entail modelling migration to and from habitats, including the effect of cleaning or vacuuming
- Better data required for the physical properties of all mite habitats
- An allergen production model is needed

Limitations of Lectus model to date

1 *Missing mite physiology data*
- Range of conditions for which data is available is very limited (eg. at extremes) and very little relates to transient conditions
- Not enough data on mite movement, carrying capacity and lab vs. wild mites

2 *Limited in scope*
- Apart from the mattress, other bedding components (eg. pillows and duvets) and other habitats such as carpets and upholstery need to be considered
- This would then entail modelling migration to and from habitats, including the effect of cleaning or vacuuming
- Better data required for the physical properties of all mite habitats
- An allergen production model is needed

3 *Data required for testing and validating the model*
- The opportunity provided by the current WarmFront study

We feel we've come a long way, but there's still a long way to go!