

# Effects of temperature transfers on development, survival and reproduction of *Hermetia illucens* (Linnaeus) (Diptera: Stratiomyidae)



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# Organic waste is a huge problem in many countries

1.3 billion Tonnes of food are wasted per year (FAO 2011).

34 million Tonnes of municipal solid waste per year was produced in Canada (2008) (Statistics Canada, 2012)

3,262



# Food Waste



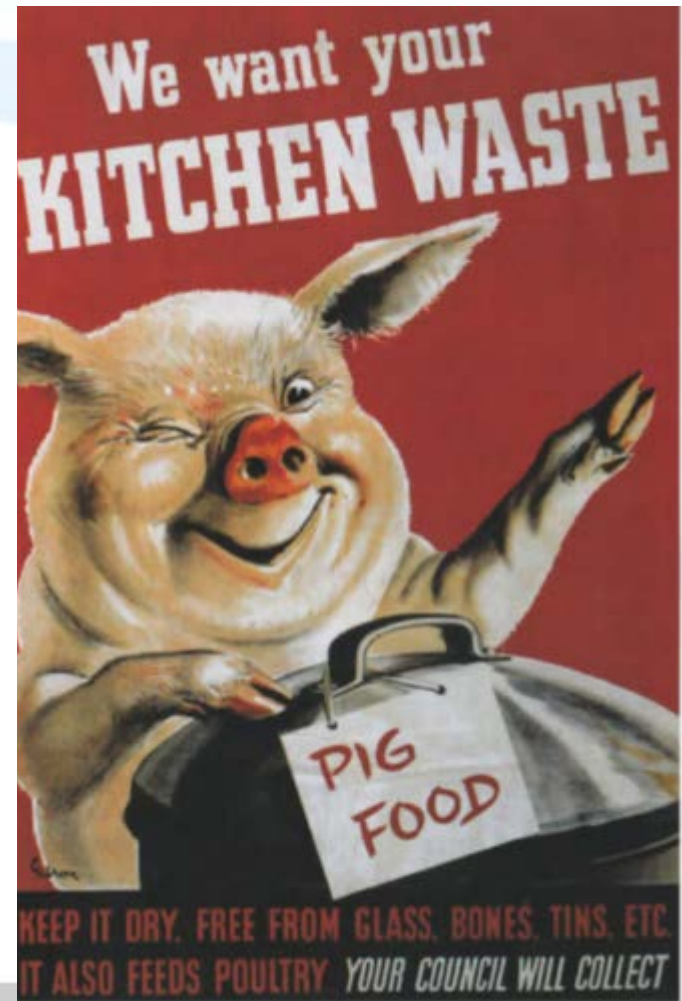
<http://www.ricesolutionslimited.com/food-waste.html>

# Gas emissions, and pollution like Methane



# Food Waste Treatment

High temperature steaming of food waste for pig feed



# Composting sites located around Taiwan

## Bulky compost facility



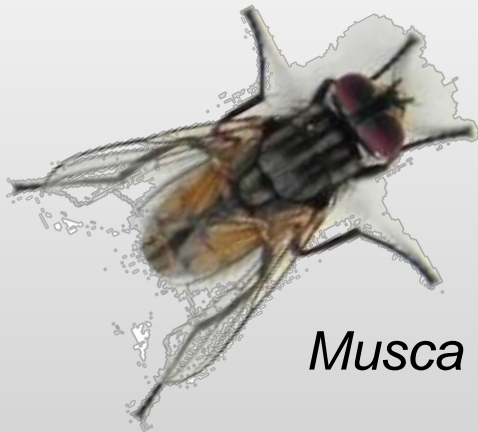
# Conversion of organic material by insects



*Ornidia obesa*



*Hermetia illucens*



*Musca domestica*

# Why *Hermetia illucens*

- Is capable of degrading large amounts of organic matter
- Has been used in the reduction of considerable quantities of solid waste
- Because its utilization in the production of biodiesel, animal feed, and fertilizer



Larva



Prepupa



Pupa



Adult



# *Hermetia illucens* biology

- It was believed *H. illucens* will lay only one egg mass
- Diapause haven't been properly addressed and was unknown till 2016.



# Our purpose

- Demonstrate the use of a novel technique for estimating population temperature response parameters that can be used to model the growth potential of poikilotherms
- We use *Hermetia illucens* as a case study to estimate its potential as an organic waste treatment



# Why use *Hermetia illucens* and temperature transfers

- *H. illucens* requires specific light intensity and adequate space for mating and oviposition
- Using constants temperatures is not an appropriate method to study *H. illucens*



# Materials and methods

3:1 combination of wheat bran, chicken feed and water

1.5 g of Sobic Acid

1.75 of Methyl-p-hydroxbenzoate

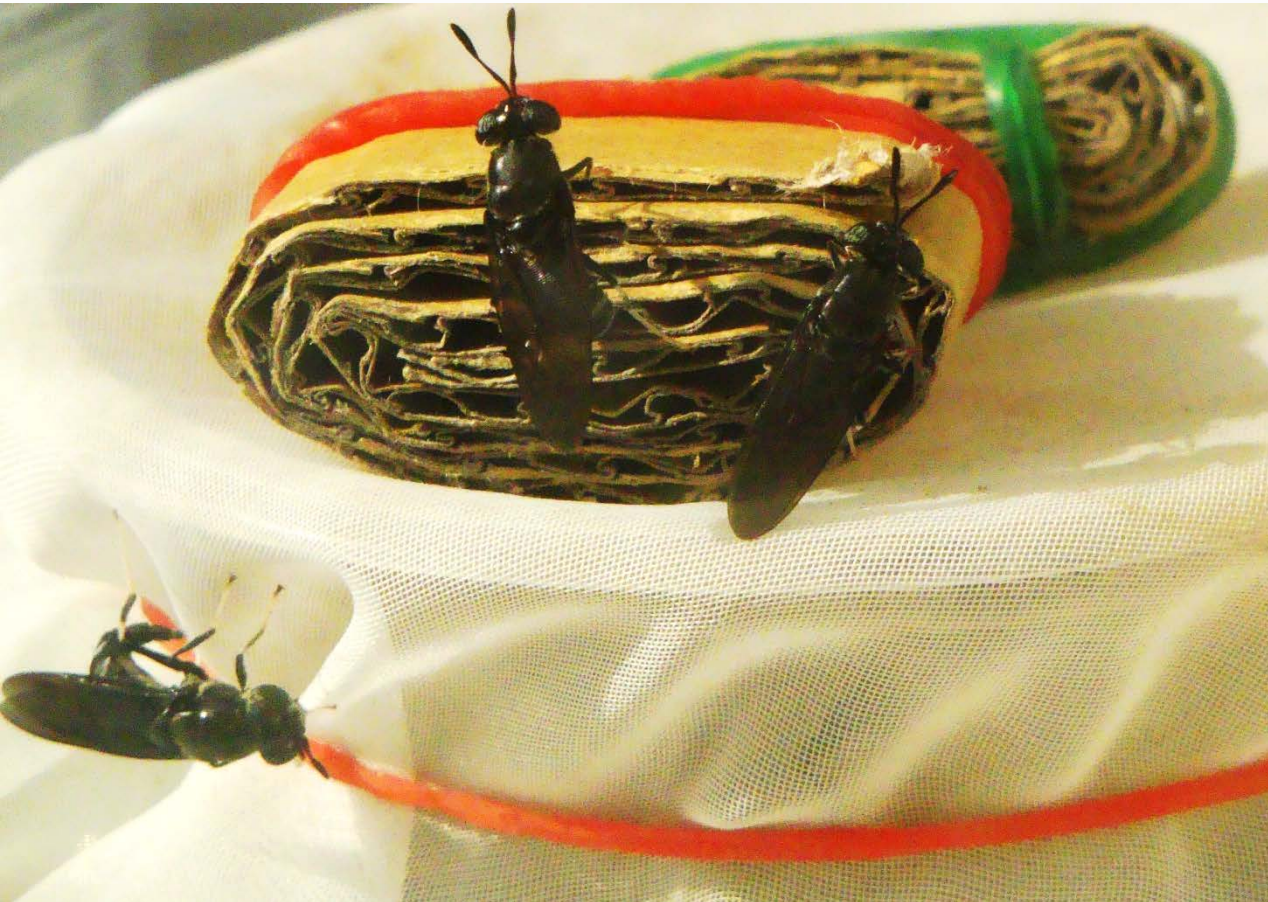
Diluted in 40 ml of 70% of alcohol

5ml of the solution was added to  
100g of artificial diet + 250 ml of  
water



Newly-laid egg masses of *H. illucens* was exposed at 28 ° C

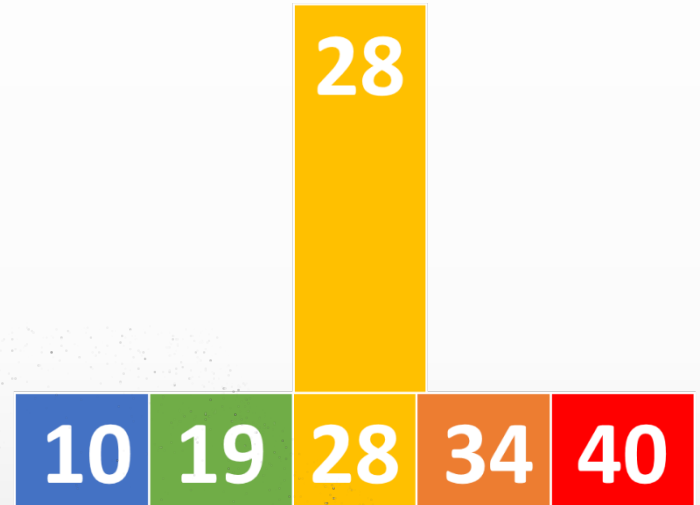
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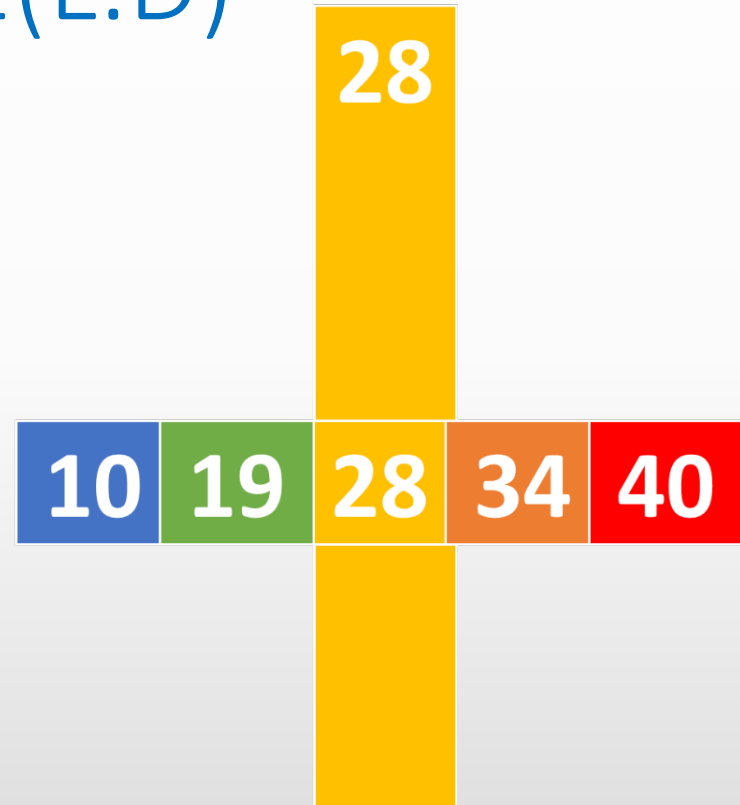
were then transferred into treatment temperatures (10, 19, 28, 34, and 40 °C) for five days



100 Eight day old larvae (from eggs)

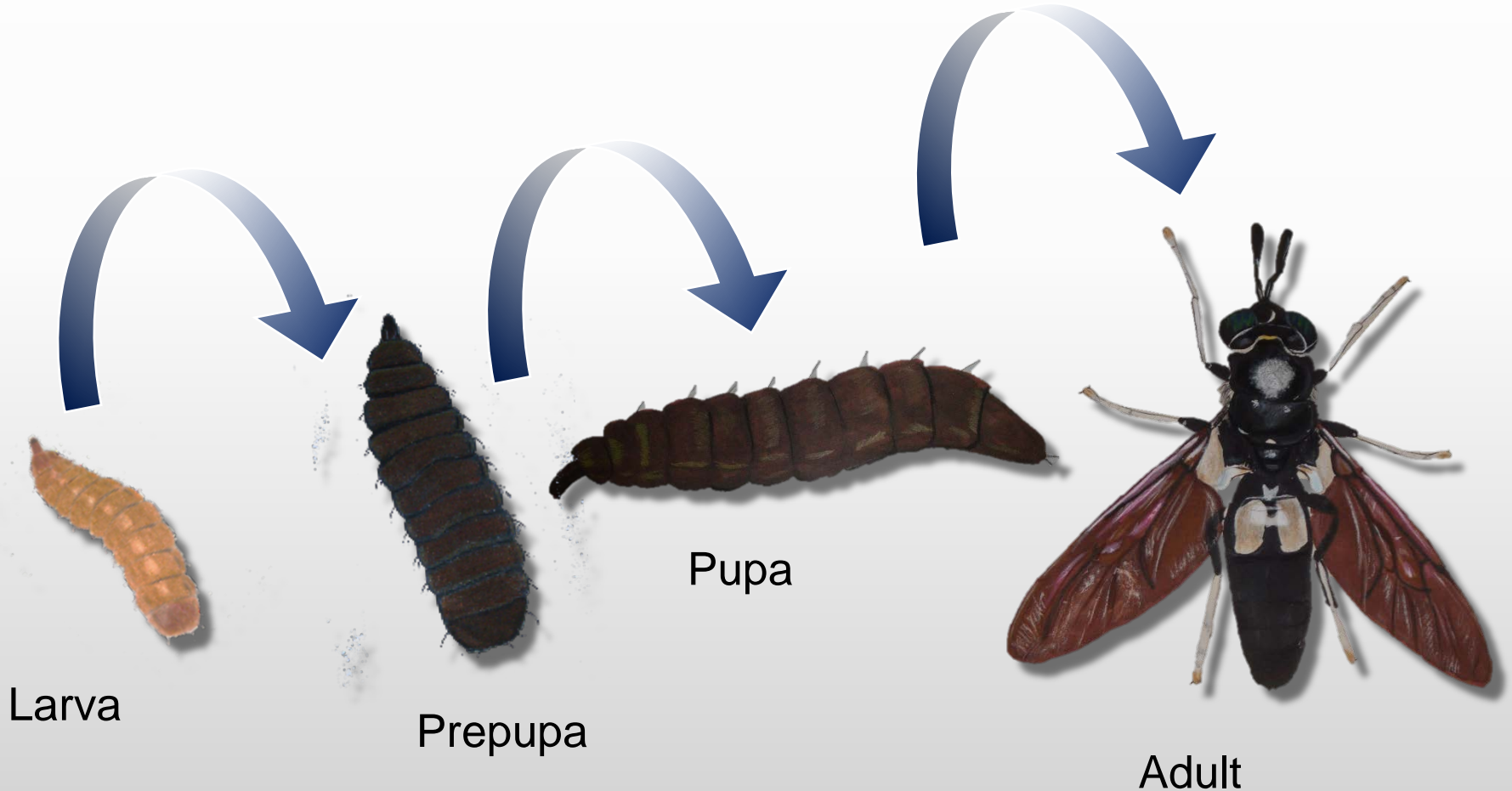


After exposure, larva, prepupa, and pupa were maintained at 28 °C with a photoperiod of 12:12(L:D)



Back to 28 °C (totally 13 days old)

Survival and fecundity were recorded daily for each individual until the death of the entire cohort (at 28 ° C )



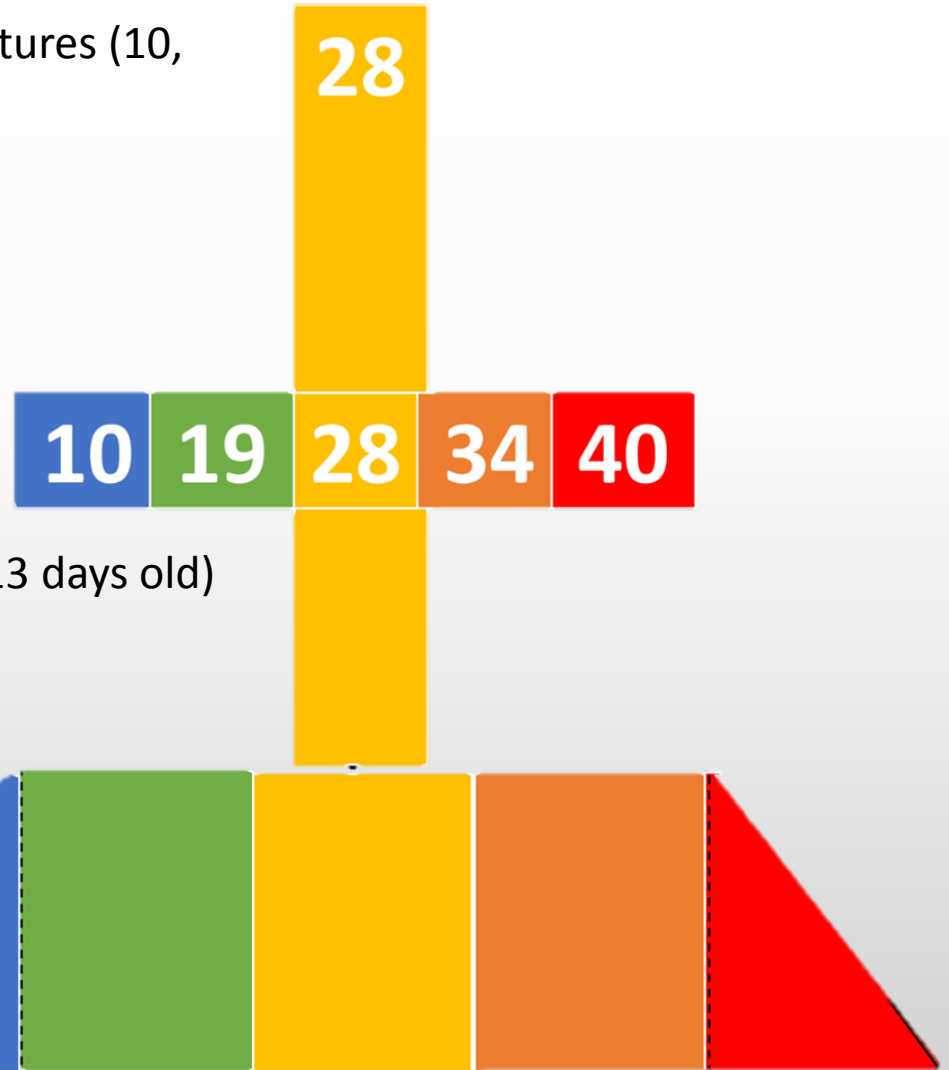


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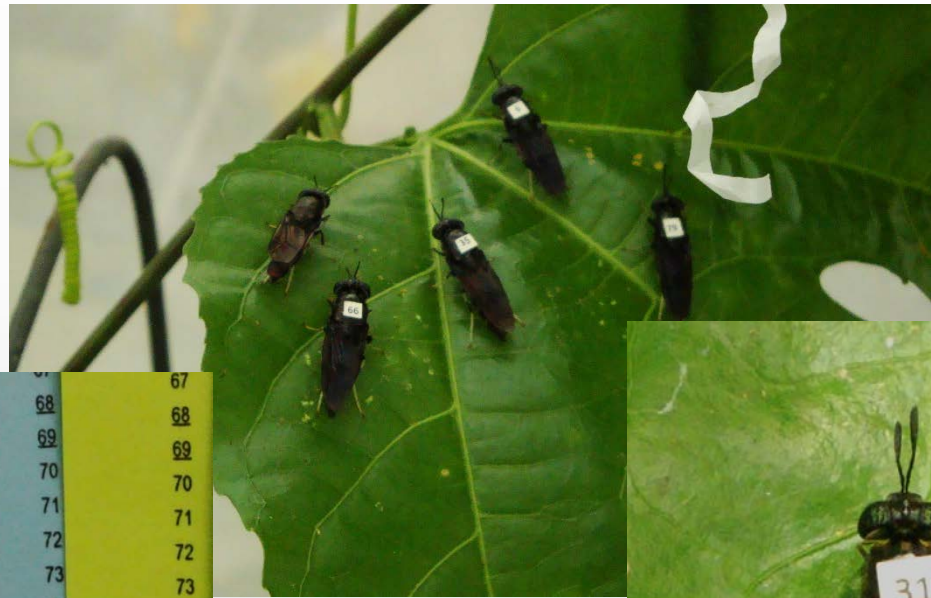
100 Eight day old larvae (from eggs)

Back to 28 °C (totally 13 days old)



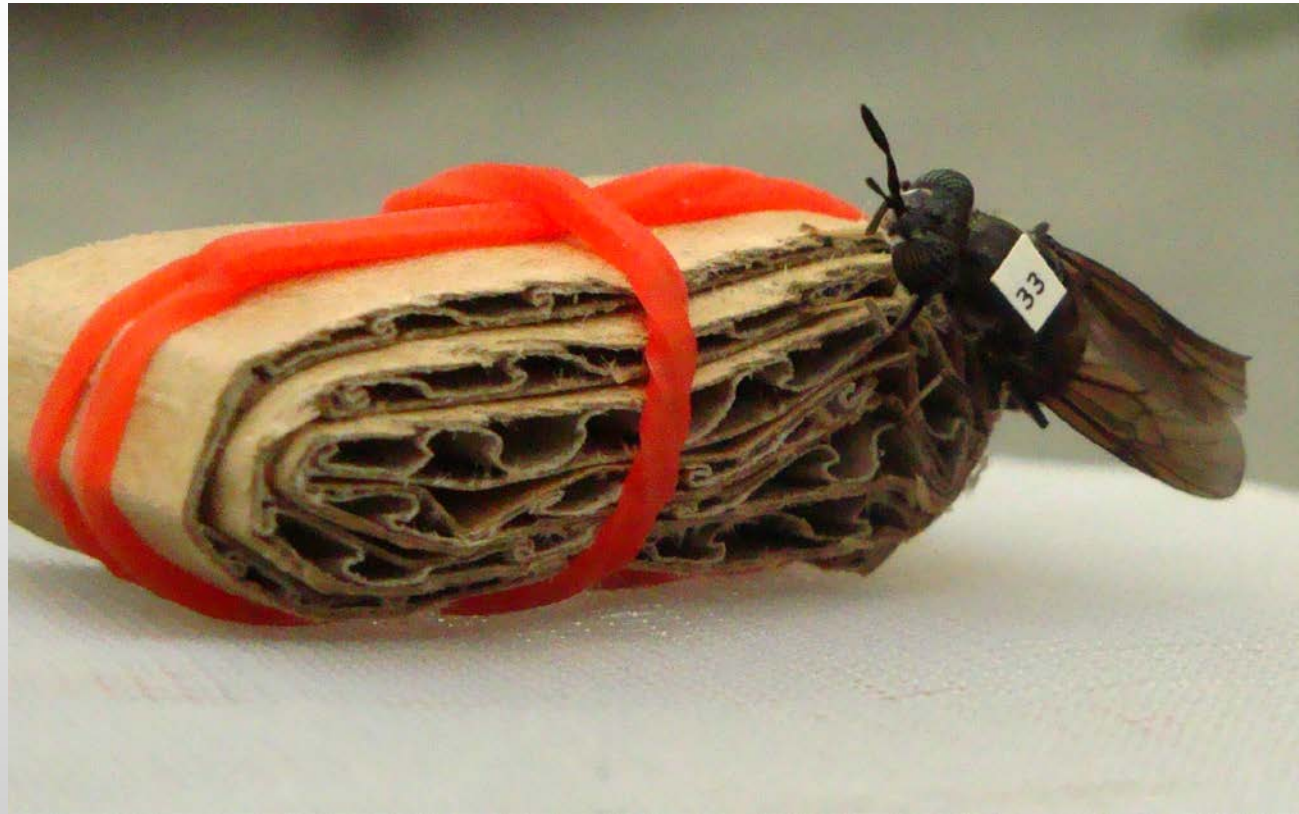
# *H. illucens* fecundity

Each surviving adult was marked with its respective number, glued to the thorax with nail polish, and then released into a 1- by 1- by 1-m cage in a 28 °C greenhouse.



# *H. illucens* fecundity

Cups filled with decomposing kitchen scraps were used as an attractant for oviposition



# Data were collected and analyzed based on an age-stage, two-sex life table

Life table is the key to population ecology, pest management, and biological control

## Age-Stage, Two-Sex Life Table Analysis

? ×

F M
Copyright 1997-2017 Hsin Chi
P C

Version: 2017.08.09

**Main procedures**

A1. Read data	C. Paired test	General boot
A2. Basic Run	D. Pick 1 by 1	Harvest
A3. Bootstrap	E. Match tables	Boot m(x)
B. Read N, F	F. 3D life table	Boot l(x)

**Select a figure to display**

s(x,j)	g(x,j)	d(x,j)	f(x,j)	e(x,j)	p(x,j)
l(x)	m(x)	l(x)m(x)	e(x)	CumuRx	v(x,j)
v(x)	SASD	SAD	Results	L	A2a
Survival to x stage		Survives stage x		SSD	
Stage mortality		Stage survival		Cal. ratio	
Tailed Ro	Tailed r	q(x,j)			F(r)

**Basic results**

Net repr. rate (Ro) =

Intrinsic rate (r) =

Finite rate =

Mean gen. time (T) =

**Graph**

You have following options to run TWOSEX.

Option A: Life table analysis (individual-reared data):

1. Prepare your data (pure text file) and save it to a SPECIFIC folder.
2. Click button "A1. Read data" to select your life table data file.
3. Click button "A2. Basic Run" to analyze your life table raw data.
4. Click button "A3. Bootstrap" to calculate SEs of all estimates.

Option B: Group-reared life table. Click "B. Read N, F."

Option C: Paired bootstrap test (If the combined data file is ready.).

Option D: Paired bootstrap test (You can select data file 1 by 1).

Option E: Match preadult and adult life table data.

Option F: Life table with offspring sex ratio dependent on female age.

Option G: Estimate SE of any sample data using bootstrap.

If you need to learn the data format, please download "How to use TWOSEX" from <http://140.120.197.173/ecology/>.

If you need help, please send e-mail to [hsinchi@dragon.nchu.edu.tw](mailto:hsinchi@dragon.nchu.edu.tw) or [chi0604@gmail.com](mailto:chi0604@gmail.com).

It is not because things are difficult that we do not dare, it is because we do not dare that they are difficult. — Seneca

**Lewontin**

Adult m(x)    Adult l(x)

m(x)+preA    l(x)+preA

Stage means    Outputs

All results    Note well!

Quit this program

**Author**

8/12/2017 10:20:10 AM

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 Turkey

# Population parameters of *H. illucens* reared on artificial diet at 10, 19, 28, 34, and 40 °C estimated by the paired bootstrap test method

Population parameter	10	19	28	34	40
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
Intrinsic rate of increase (r) (day <sup>-1</sup> )	0.040± 0.008	0.097± 0.004	0.085± 0.005	0.096± 0.006	0.079± 0.004
Finite rate of increase λ (day <sup>-1</sup> )	1.041± 0.009	1.102± 0.005	1.088± 0.006	1.101± 0.007	1.082± 0.004
Net reproduction rate (R <sub>0</sub> ) (offspring)	<b>18.06± 11.31</b> <b>c</b>	<b>244.89 ± 40.279</b> <b>a</b>	<b>213.88± 39.804</b> <b>b</b>	<b>382.07 ± 51.434</b> <b>a</b>	<b>342.9± 51.563</b> <b>a</b>
Mean generation time (T) (day)	71.846± 6.886	56.541± 1.951	63.039± 3.498	61.434 ± 3.998	73.632± 3.545

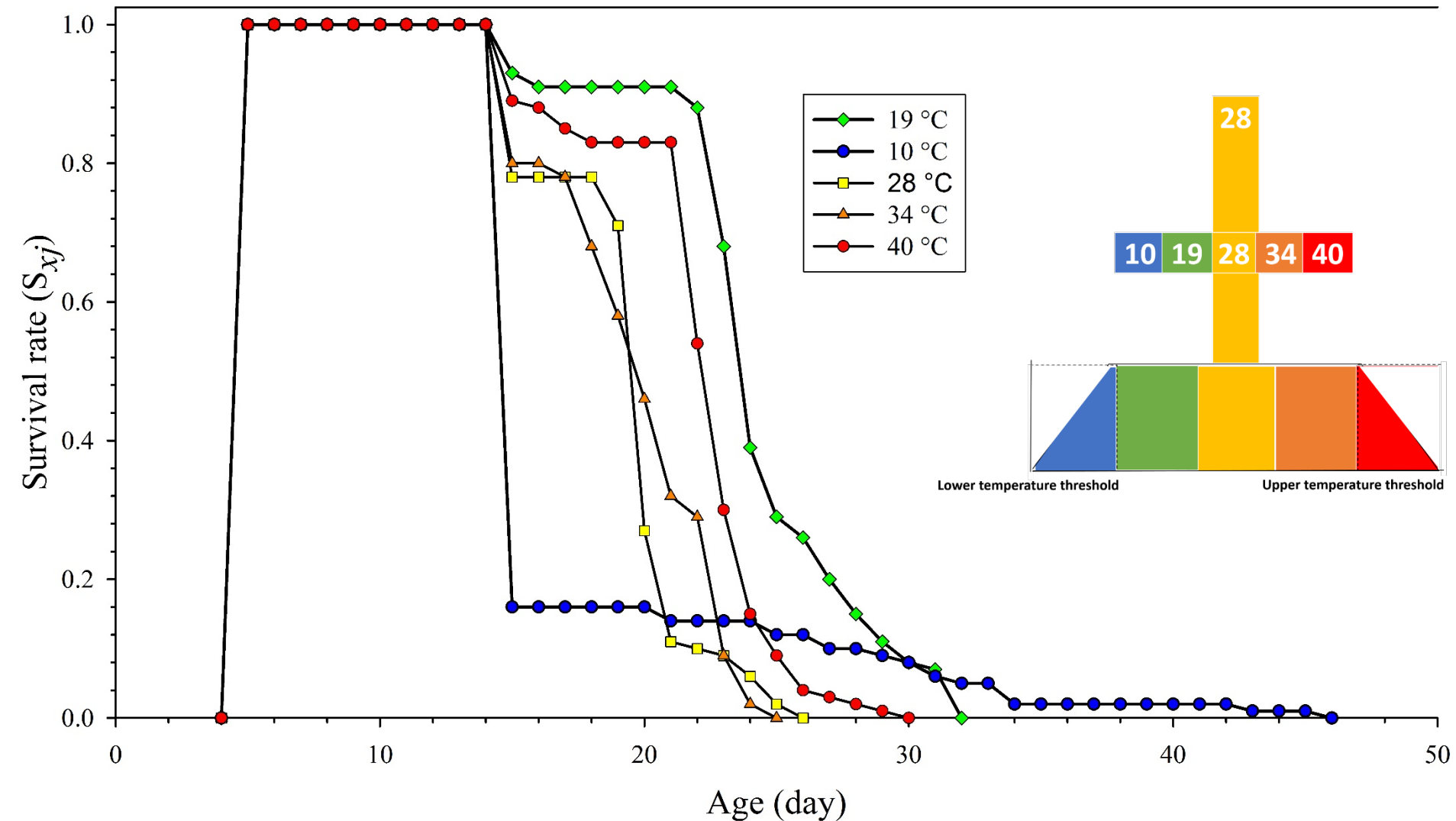


# Stage-specific duration (days) of *H. illucens* reared in artificial diet at 10, 19, 28, 34, and 40 °C

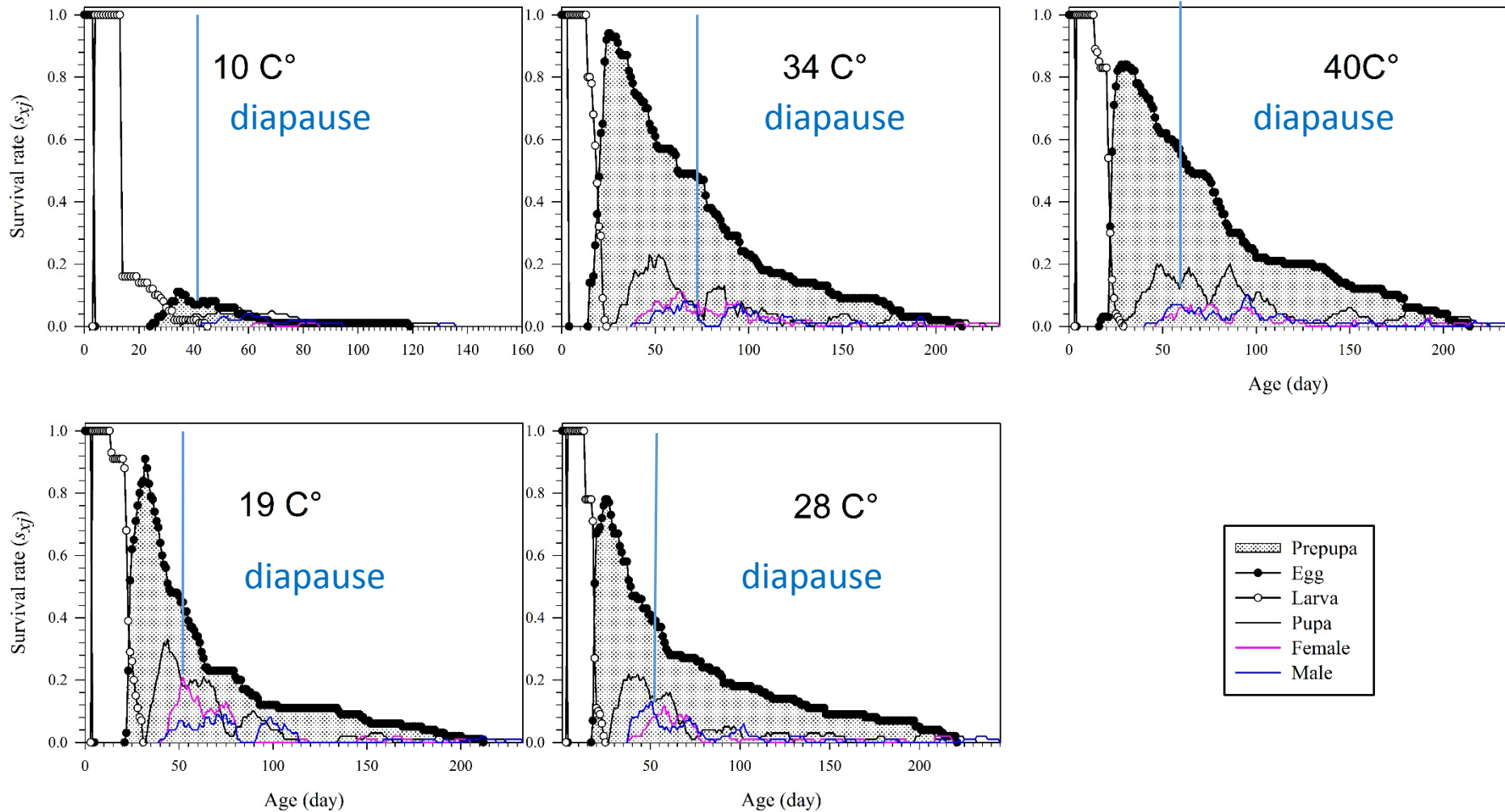
Stage	10 Mean ± SE	19 Mean ± SE	28 Mean ± SE	34 Mean ± SE	40 Mean ± SE
Larvae	<b>27.54 ± 1.67</b> <b>a</b>	<b>20.42±0.294</b> <b>b</b>	<b>15.74± 0.188</b> <b>e</b>	<b>15.13±0.3</b> <b>e</b>	<b>18.21±0.213</b> <b>c</b>
Prepupae	22.62 ± 4.56	40.96±4.201	53.64±5.909	60.6 ±4.487	66±5.255
Pupae	14.17 ± 1.12	12.32±0.299	12.32±0.252	11.37±0.293	14.97 ±0.327
Fecundity (eggs/female)	-	499.78± 65.019	578.05±77.653	707.54±69.866	762 ±78.762



# Age-stage-specific survival rate ( $S_{xj}$ ) of *H. illucens* larva after temperature transfers

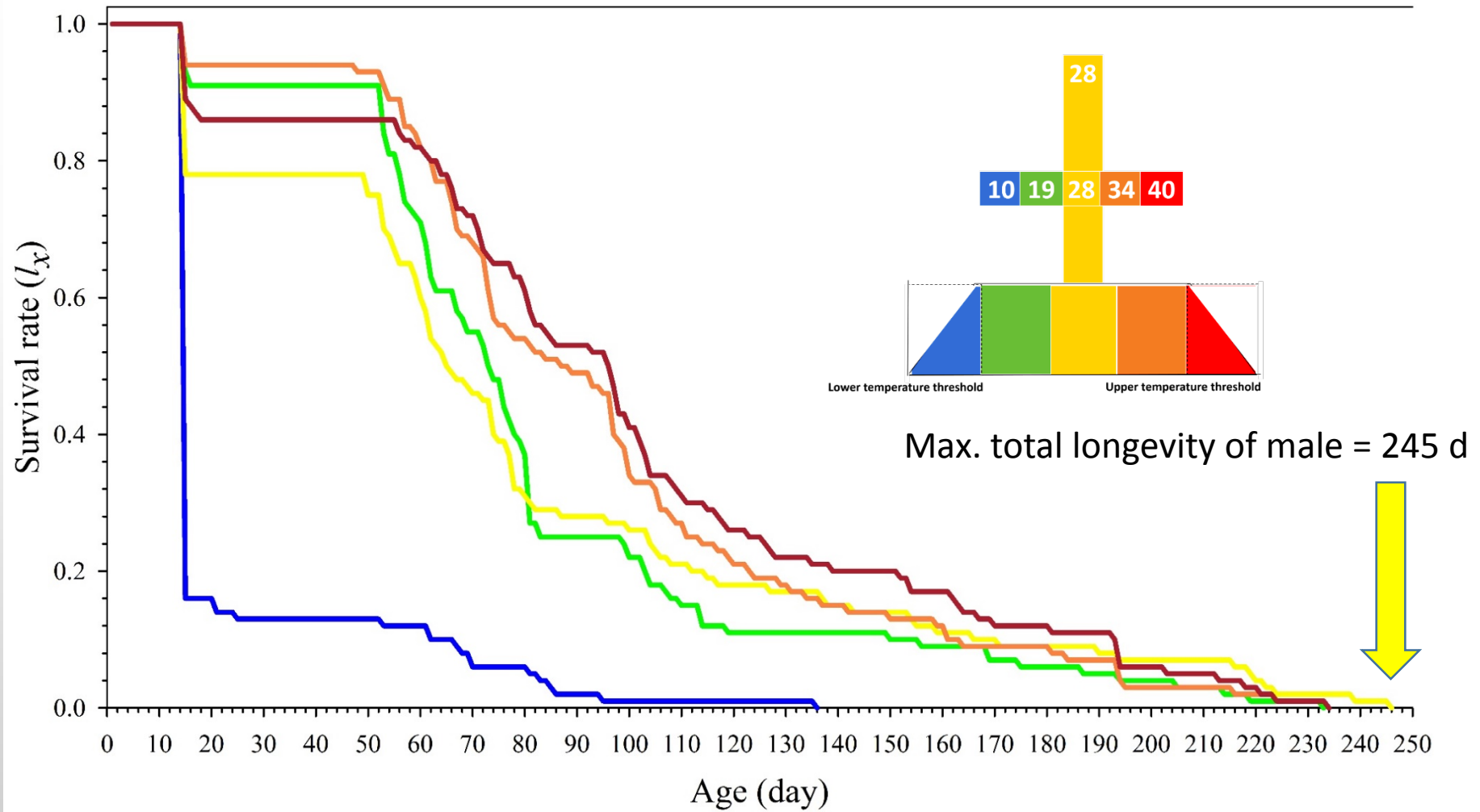


# Age-stage survival rate ( $S_{xj}$ ) of *H. illucens*, diapaused and non diapaused individuals included



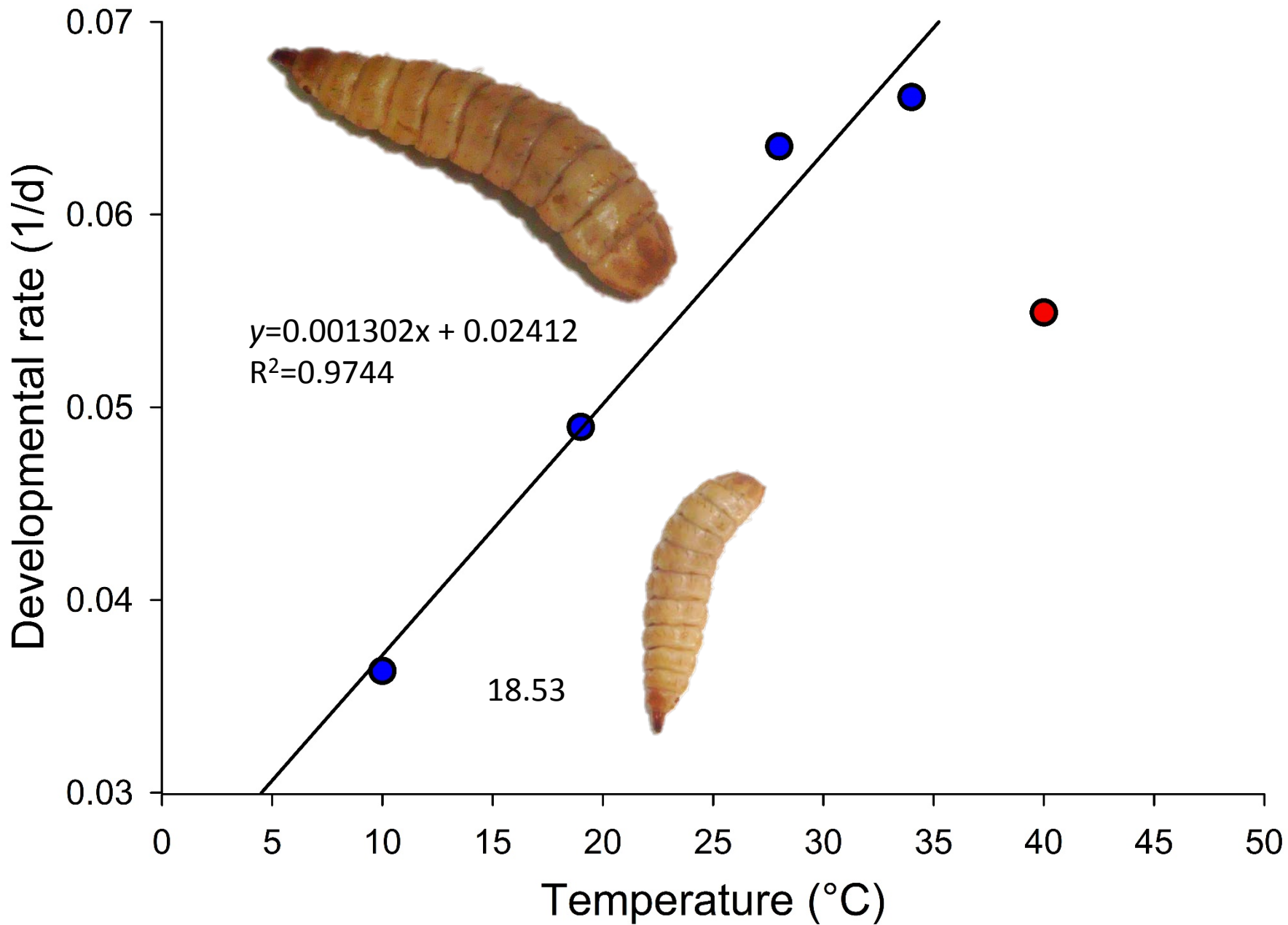


# Age-specific survival rate ( $l_x$ ) individually reared, diapaused and non diapaused individuals included

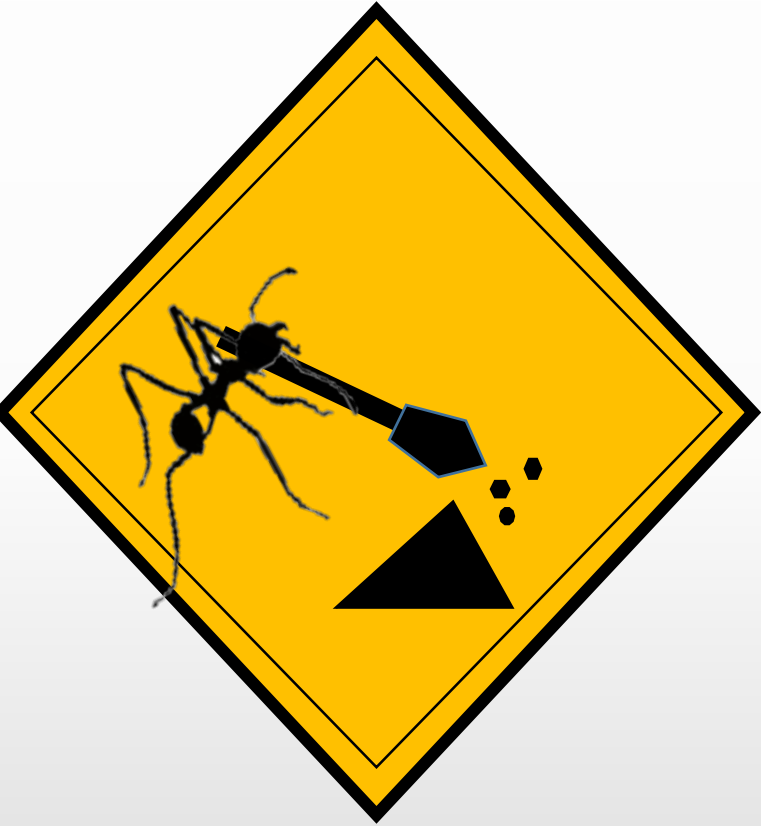


At 10 °C only 2 individuals were females (n=12) and at 34°C 54 were females (n=94), some females were able to lay eggs two times during its adult life span

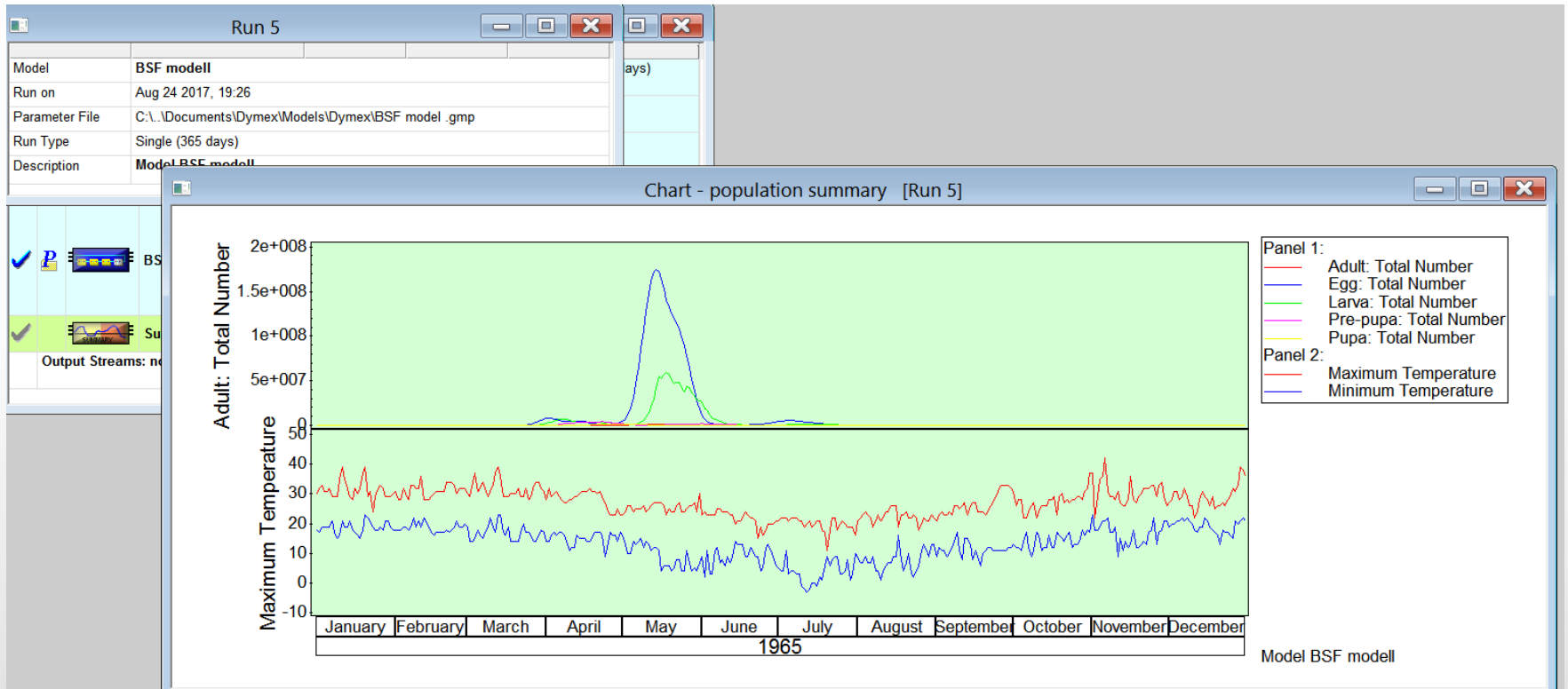
Temperature (°C)	Male	Female	Total
10	10	2	12
19	42	49	91
28	40	37	77
34	40	54 40 produce offspring 7 lay eggs two times	94
40	41	45 34 produce offspring 7 lay eggs two times	86



# Under construction



# Up next...DYMEX model



# Main findings

- We demonstrated that only a five days exposure to different temperature will influence *H. illucens* life history
- Females are capable to lay eggs two times during its adult life span under favorable conditions.



# Conclusions

- The experimental method offers the rapid development of DYMEX models, and avoids many of the pitfalls of using constant temperature development rate studies.
- Additional research is needed to address the causes of diapause initiation and termination
- This study provides new information on oviposition of *H. illucens* exposed to different temperatures and demonstrates the effective use of temperature transfers in this insect.
- The results will be useful in improving current methods of *H. illucens* rearing under controlled conditions.

# Special thanks!!

Dirty job





# Thank you!



**LOVE AND FOOD AREN'T  
MEANT TO BE WASTED**

