

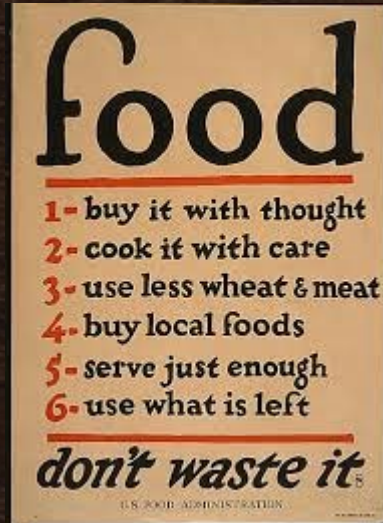
Population dynamics model to explore waste management areas in Taiwan, using black soldier fly *Hermetia illucens* (Diptera: Stratiomyidae)

BLACK SOLDIER FLY IS THE FUTURE GLOBAL SOLUTION OF ORGANIC WASTE RECYCLING

Ana Clariza Samayoa, Darren J. Kriticos & Shaw-Yhi Hwang

October 18, 2018

Organic waste



Surplus tomatoes dumped on farmland in Tenerife.



Surplus oranges in California, USA.



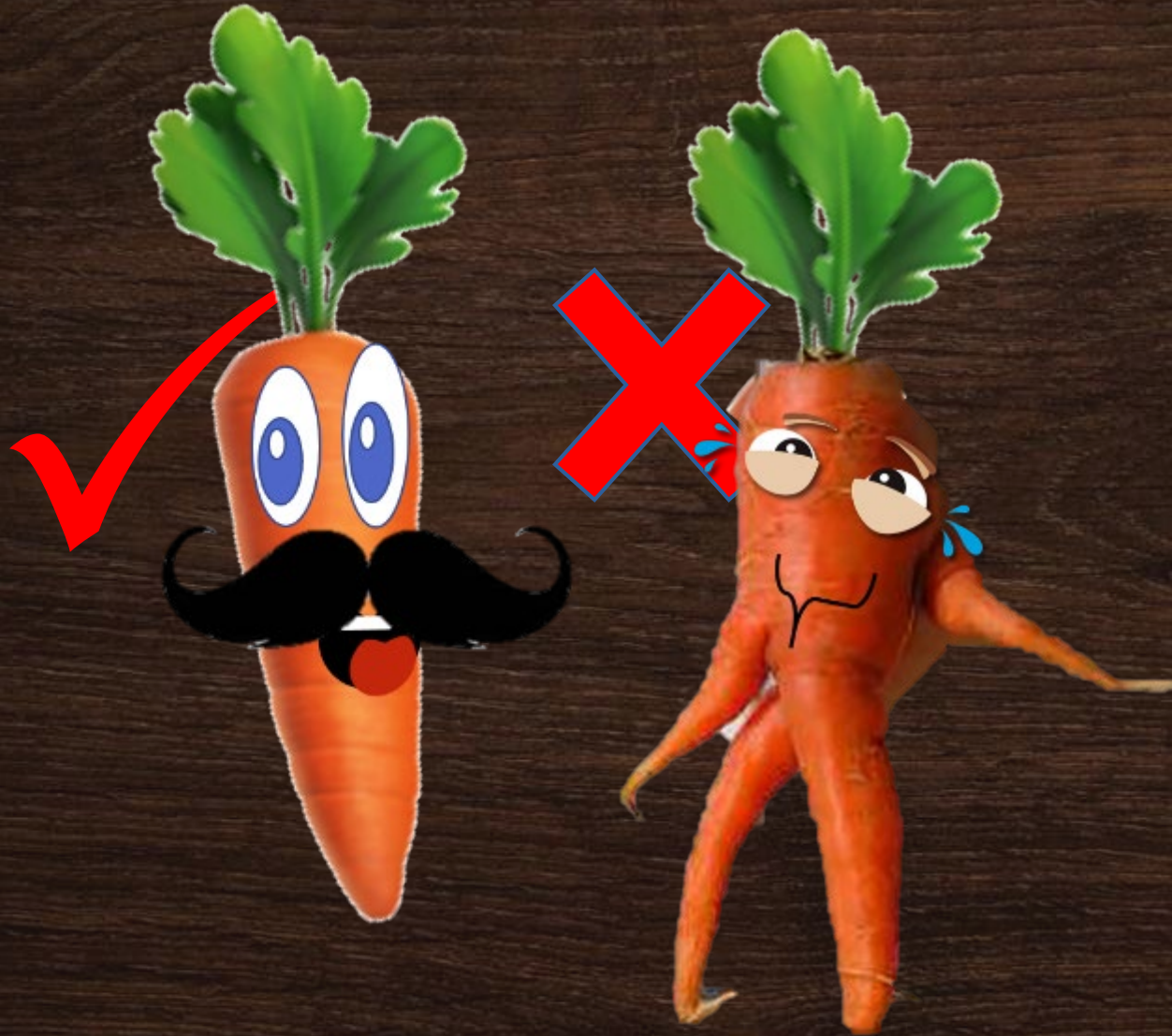
Agricultural wastes

Manure

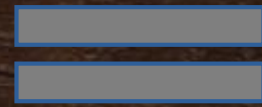
Waste disposal trough history



food waste

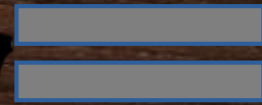


food waste



Waste

food waste



Waste

Waste does not just disappear
Its transformed or is incinerated



Imagine all your wastes transform in money



How can we reduce organic waste?

Conversion of organic material
by insects

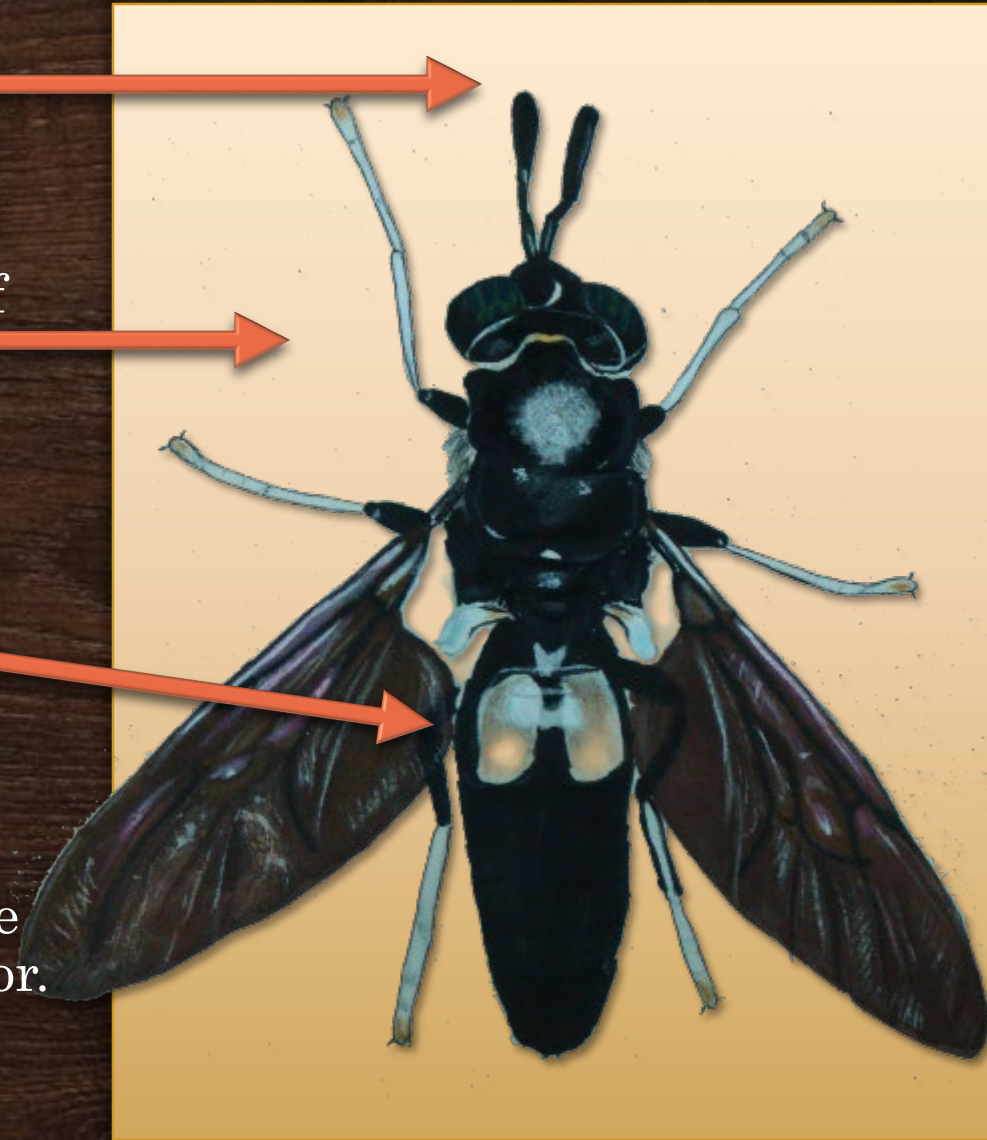


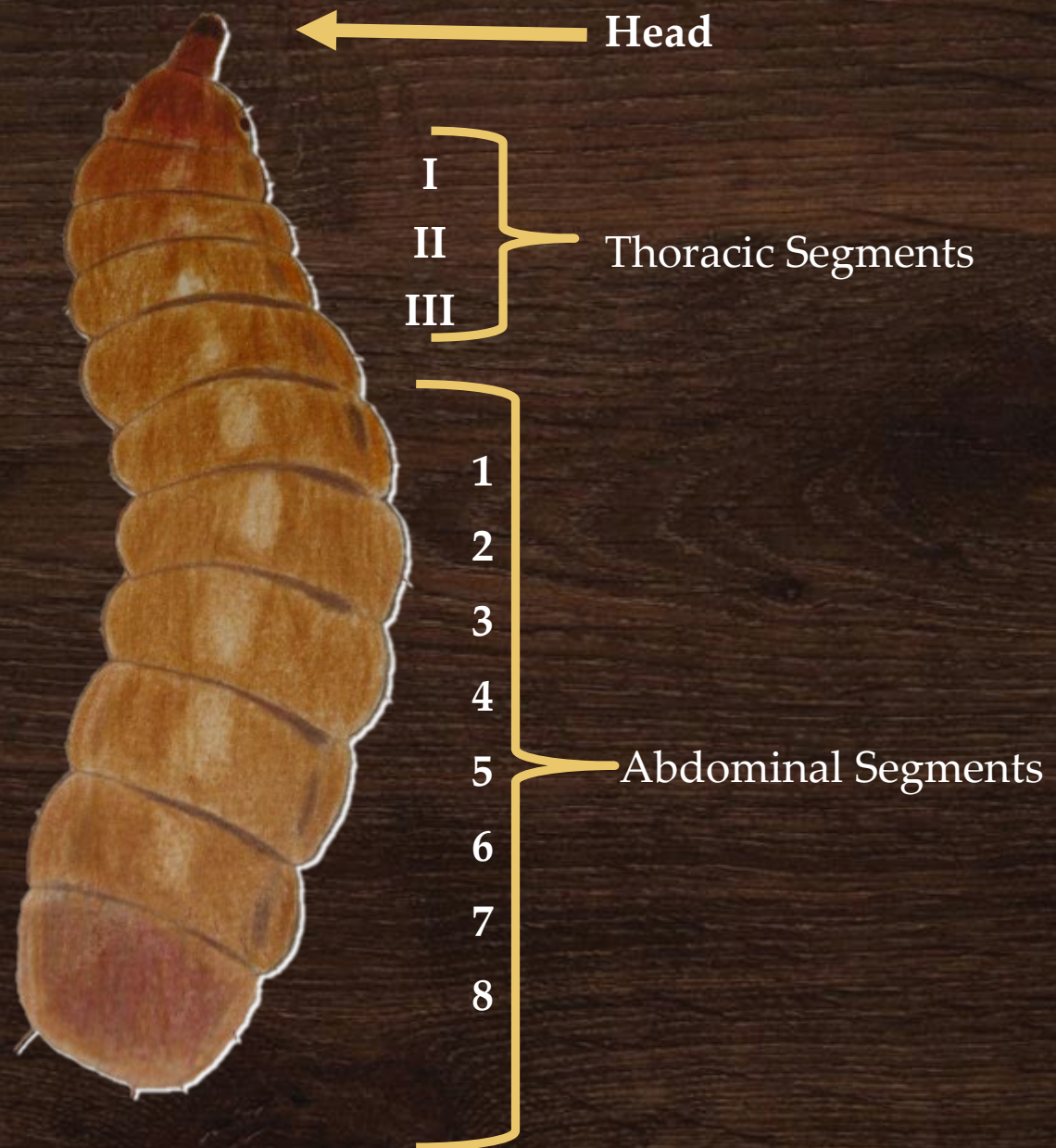
Ornithia obesa



Hermetia illucens

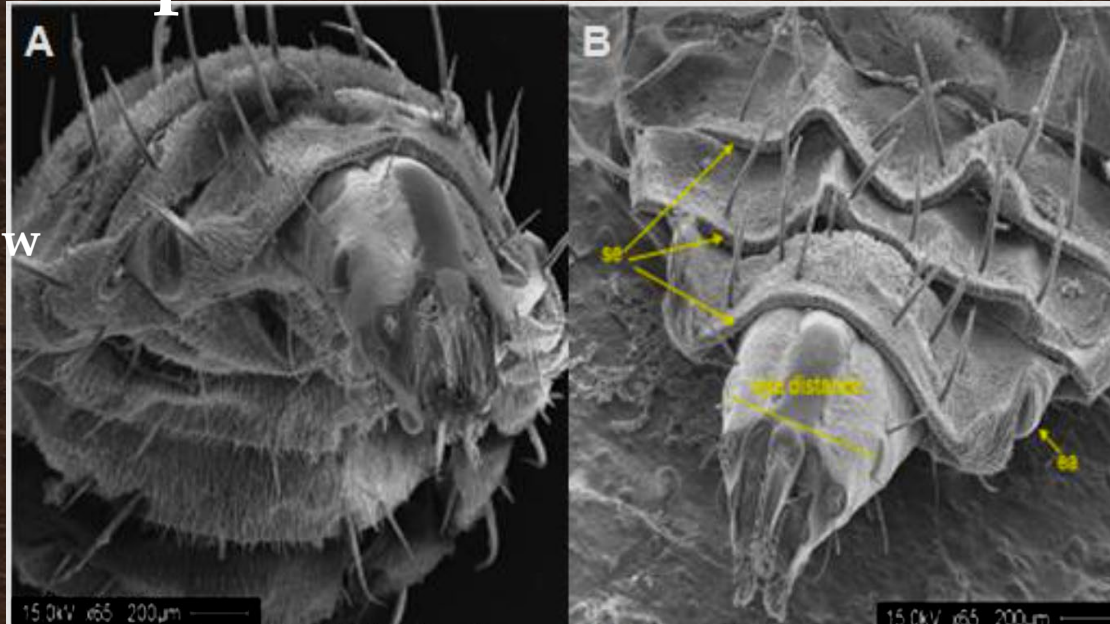
- Antennae are elongated with three segments.
- White coloration near the end of each leg.
- Two translucent "windows" located on the first abdominal segment.
- 15 to 20 mm in length, wasp-like appearance, black or blue in color.





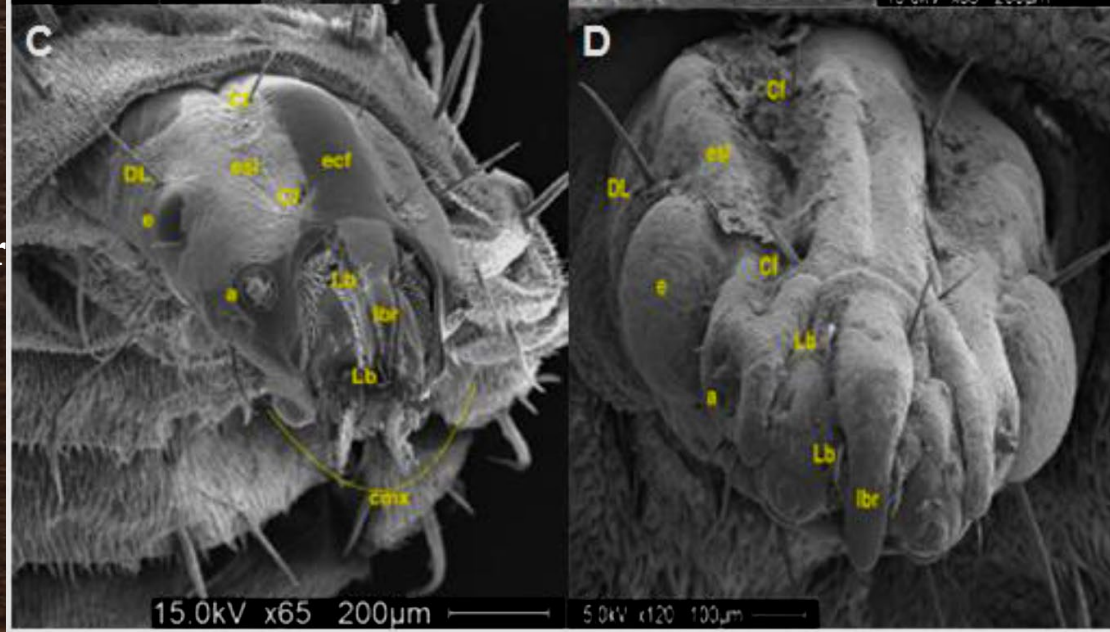
Head capsule and first thoracic segment

General view

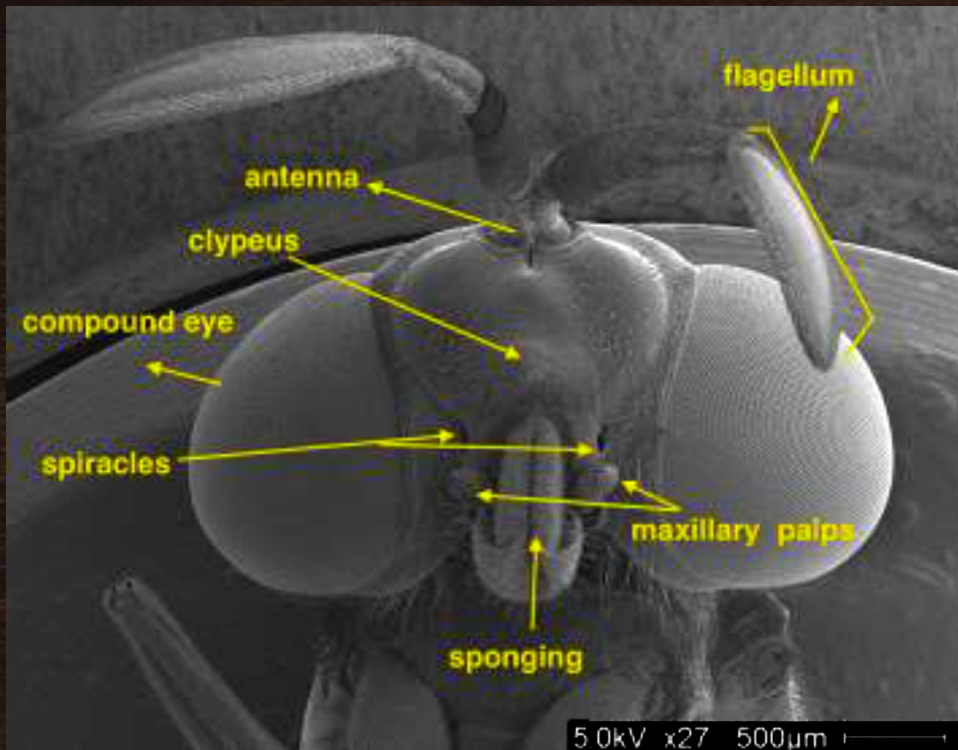


Detail of head
in the third
instar.

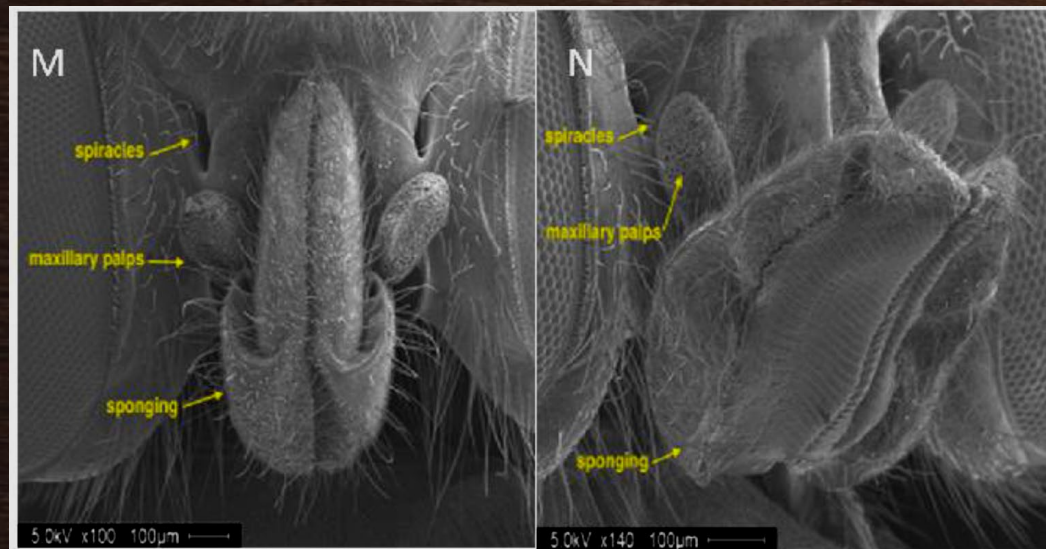
First instar



Oliveira et al, 2016

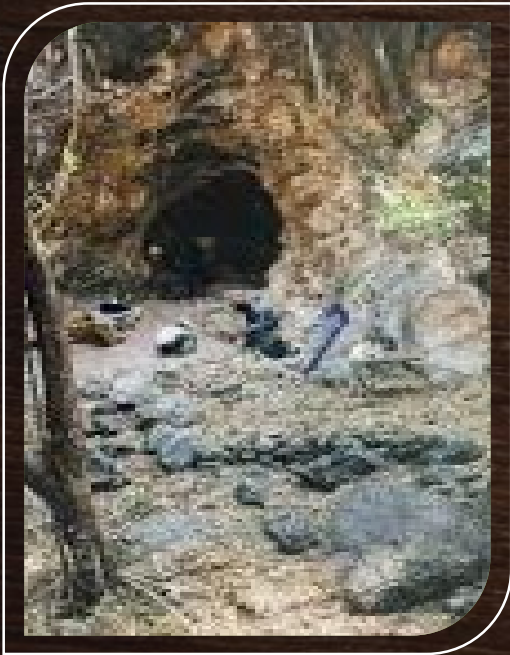


Frontal view of the head of a female



Frontal view of the sponging, spiracles and maxillary palps

This is the first time the relationship between insects and funeral deposits with an age of 200 B.C.- 200 A.D. inside a cave, are registered for Mexico.



Why *Hermetia illucens*

Because its utilization in the production of biodiesel, animal feed, and fertilizer

Wide distribution

Is capable of degrading large amounts of organic matter

Not considered as pest



What we didn't know?

- No life table available
 - Developmental times
 - Survival and fecundity
- If diapause occurs in *H. illucens*
- What is the effect of long-term diapause



My research

How to construct a life table



First Life table of BSF



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

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)

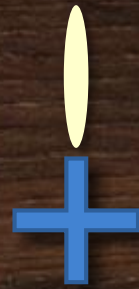
Select a figure to display

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)

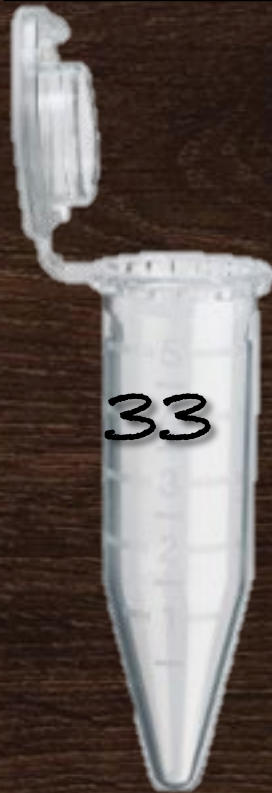
Chi and Liu 1985, Chi 1988



Eggs



Filter paper



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



Survival and development were recorded daily for each individual until the death of the entire cohort



Each surviving adult was marked with its respective number



Glued to the thorax with nail polish

28 °C greenhouse

1- by 1- by 1-
m Cage

H. illucens fecundity

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



Eggs were individually counted from the cardboard

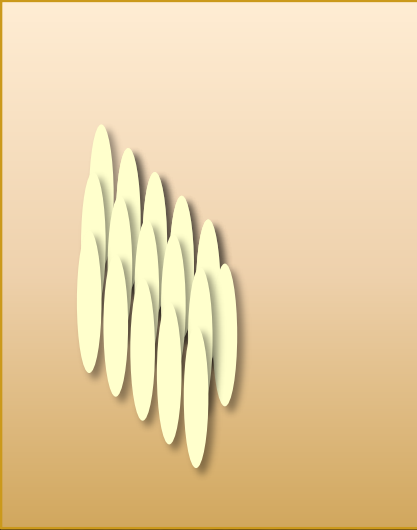


Results

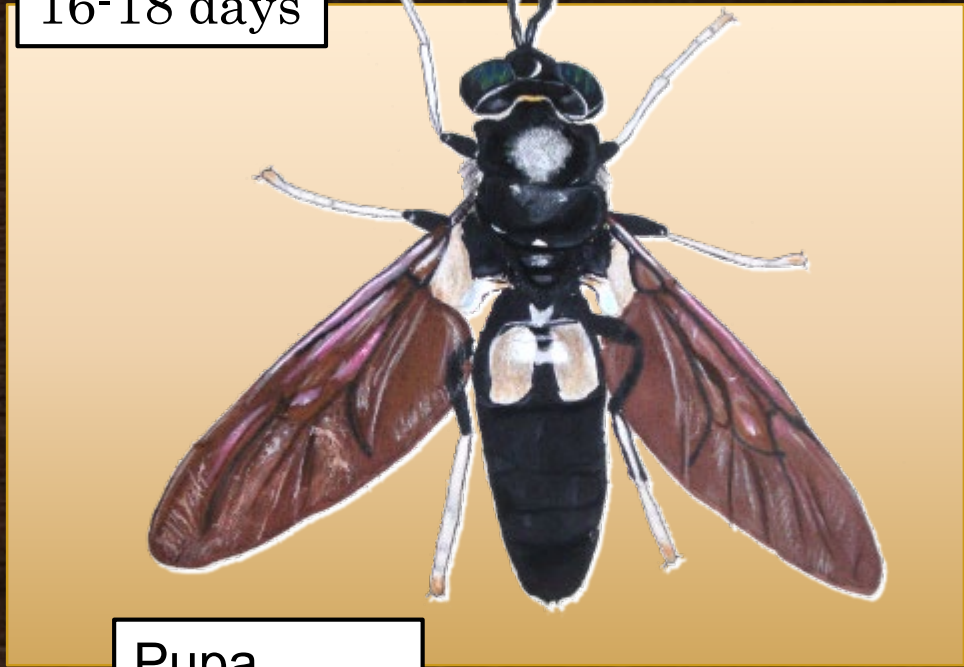
I will die
alone!!!



Eggs
3 days



Adult
16-18 days



Larva
23 days

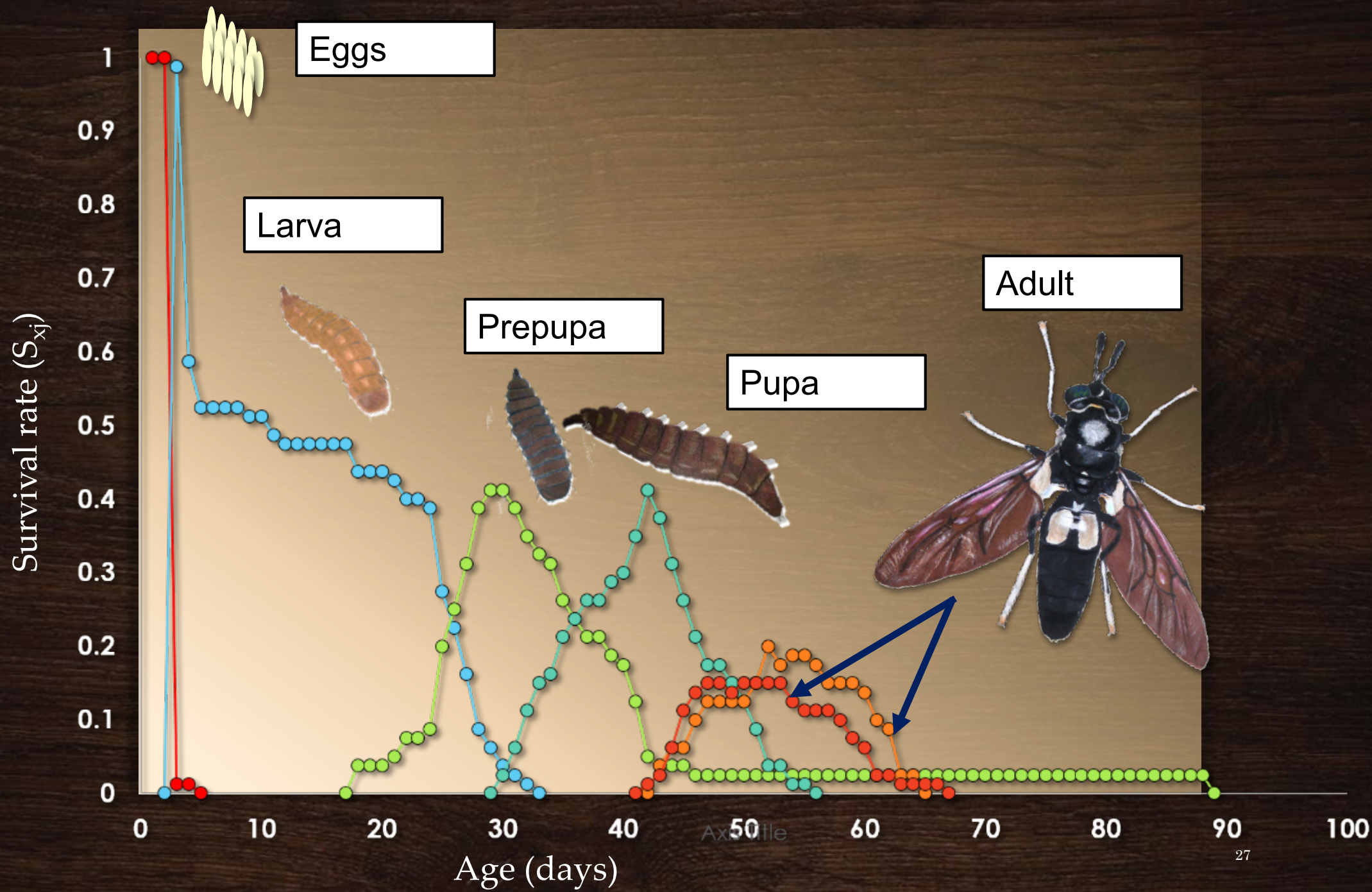


Prepupa
11 days



Pupa
11 days





Population parameters of *H. illucens* individually reared

Population parameter	Bootstrap method Mean \pm SE
Intrinsic rate of increase (r) (day^{-1})	0.0747 \pm 0.007
Finite rate of increase λ (day^{-1})	1.0776 \pm 0.007
Net reproduction rate (R_0) (offspring)	68.2321 \pm 23.173
Mean generation time (T) (day)	55.652 \pm 0.668



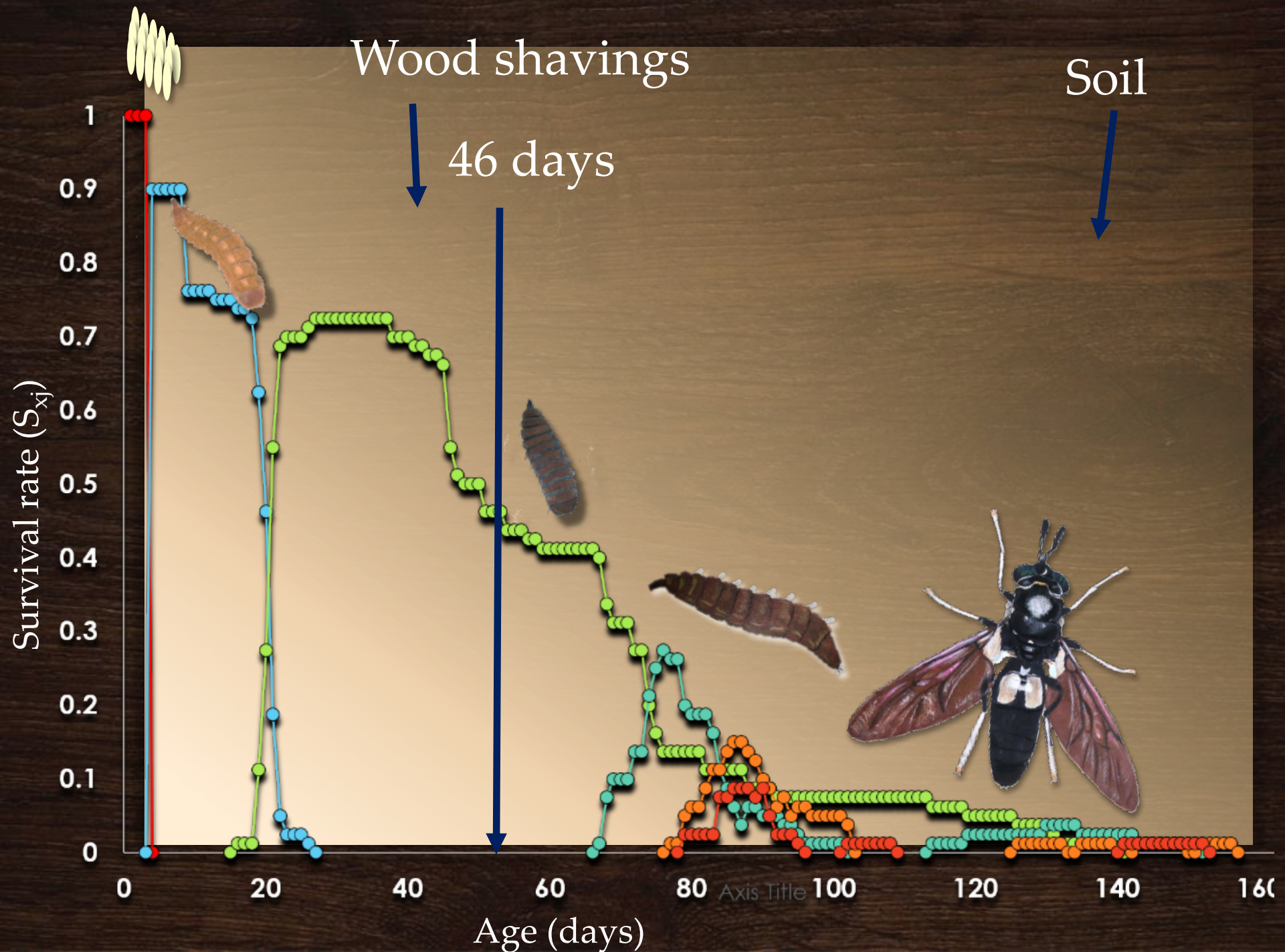
Only six females Oviposit

236 to 1,088 eggs.

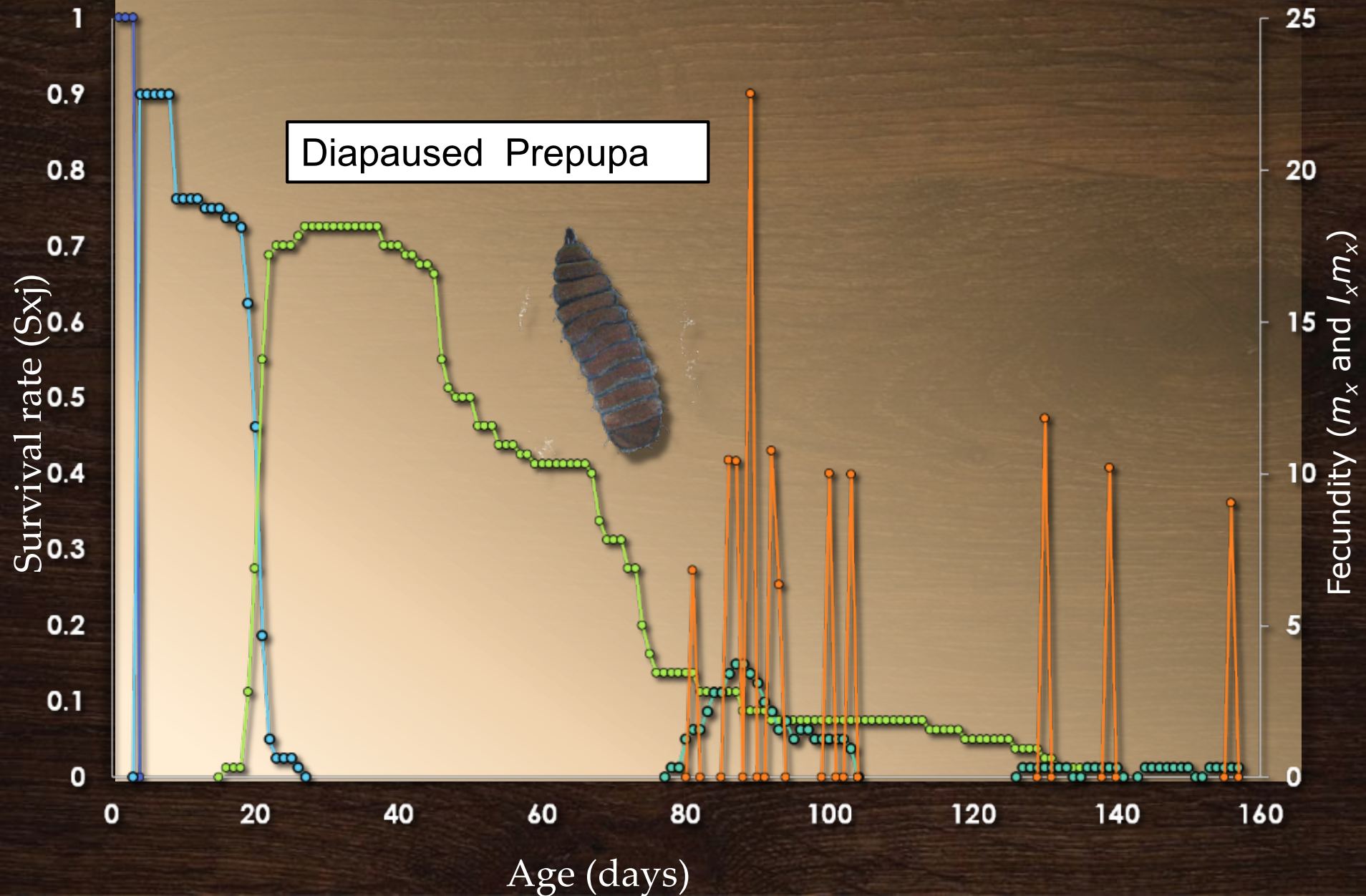
15 males

21 females

5,458 eggs



16 to day 140 (approximately 124 days)



Population parameters of *H. illucens*

Population parameter	Bootstrap method Mean \pm SE
Intrinsic rate of increase (r) (day^{-1})	0.0498 \pm 0. 0031
Finite rate of increase λ (day^{-1})	1.0511 \pm 0. 0033
Net reproduction rate (R_0) (offspring)	118.2875\pm 27. 3443
Mean generation time (T) (day)	95.823 \pm 3.518



12 females Oviposit

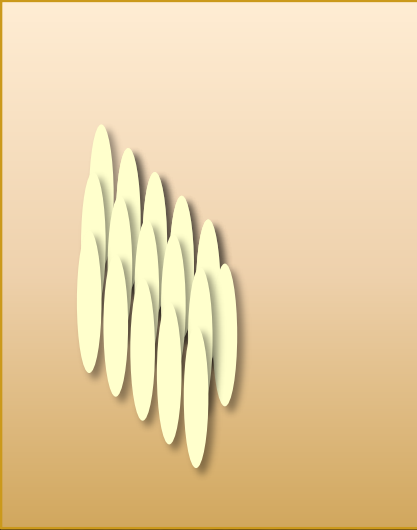
508 to 1,047 eggs

10 males

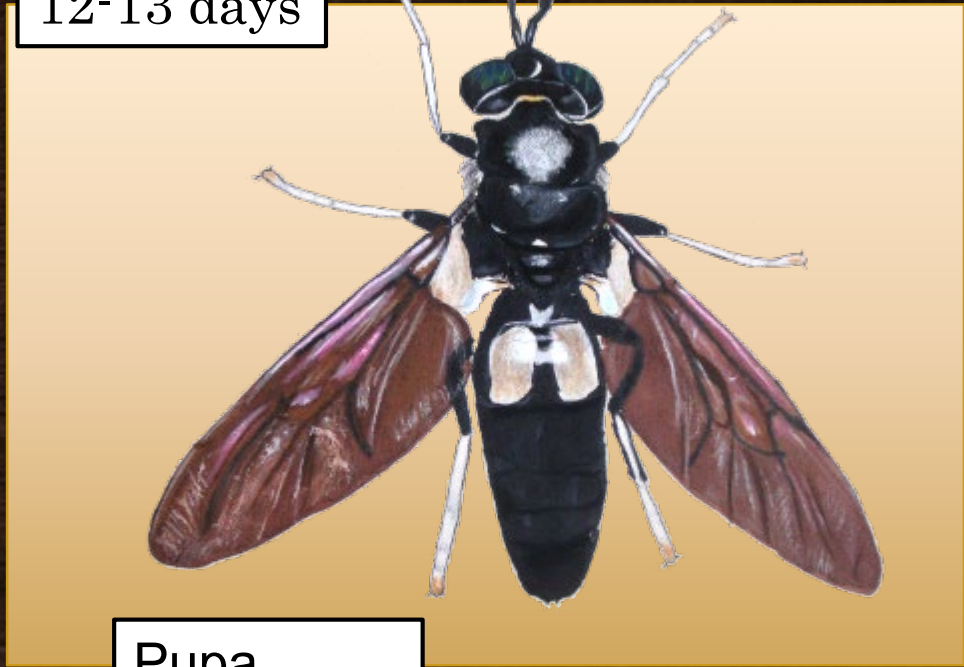
22 females

9,463 eggs

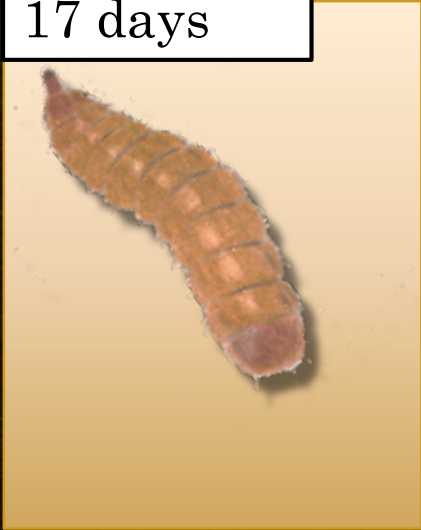
Eggs
4 days



Adult
12-13 days



Larva
17 days



Prepupa
61 days

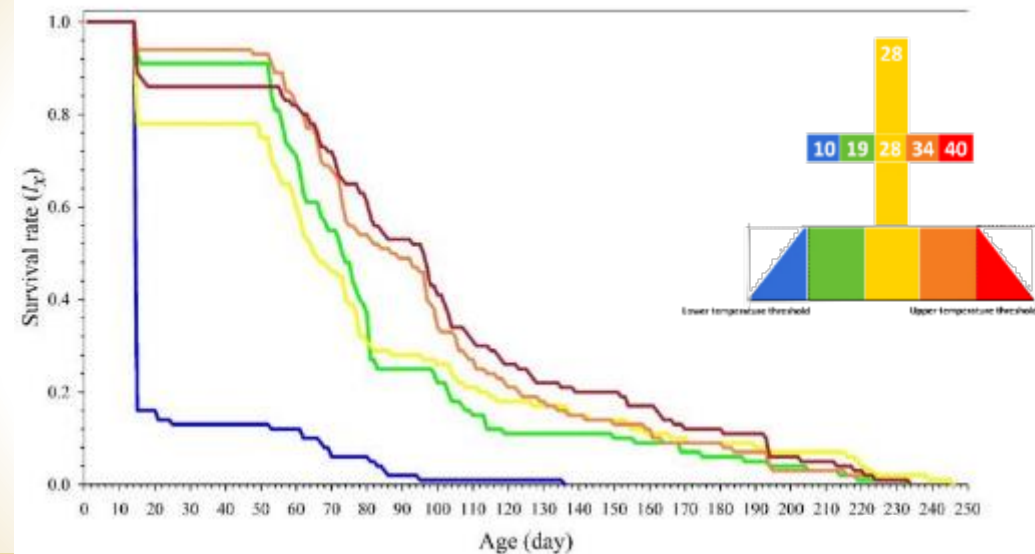


Pupa
11 days



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

Temperature transfers experiments



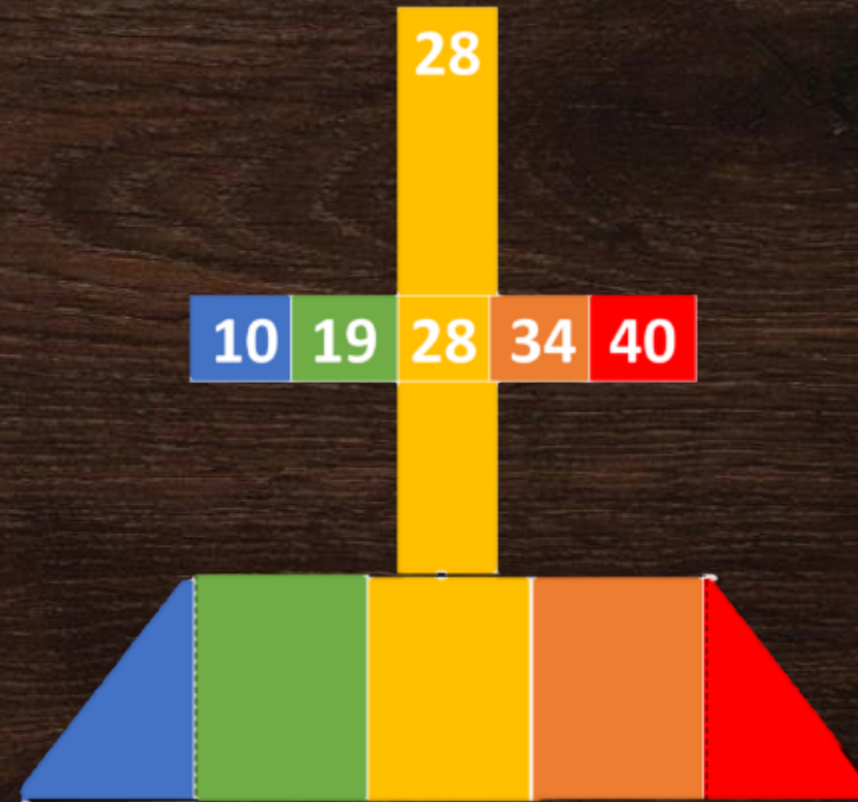
Our purpose

- Demonstrate the use of a novel technique for estimating population temperature response parameters that can be used to model the growth potential of poikilotherms



“Temperature transfers (near-threshold development)
To obtain reliable estimates of development time near such extremes, insects can be exposed first to a near-threshold temperature (T1) for a fixed amount of time (t1); short enough to avoid excessive mortality but long enough for significant development to occur, and then transferred to another temperature (T2) to record the time $t_{2,i}$ required by individual i to complete the stage under more optimal conditions.”

Régnière, Jacques, et al. 2012



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-hydroxybenzoate

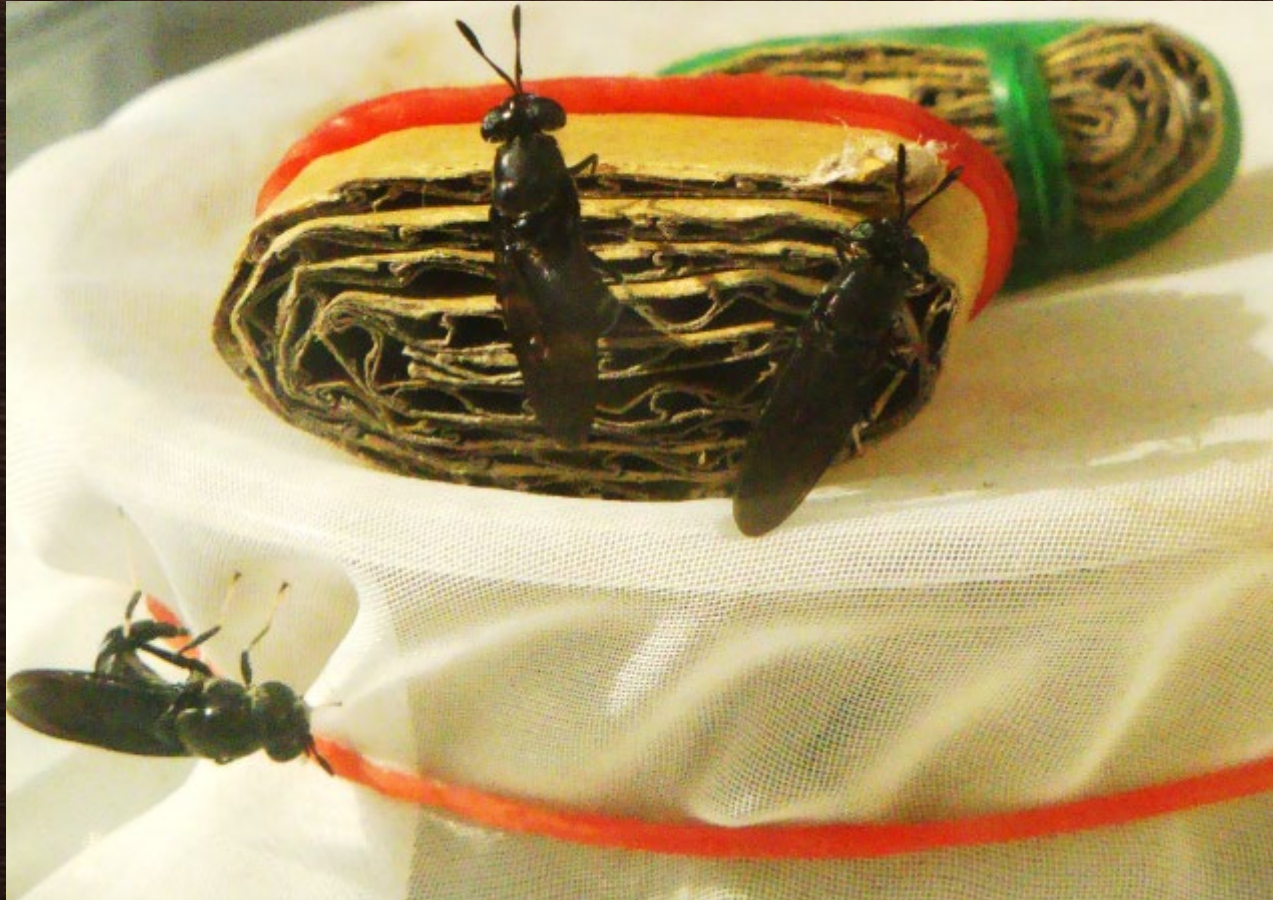
Diluted in 40 ml of 70% of alcohol

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

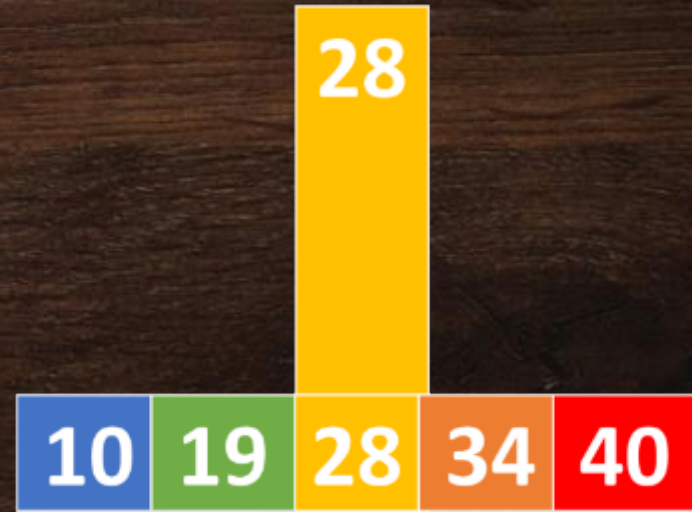


Newly-laid egg masses of *H. illucens* was exposed at 28 ° C

28



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



100 individuals, 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)

H. illucens fecundity

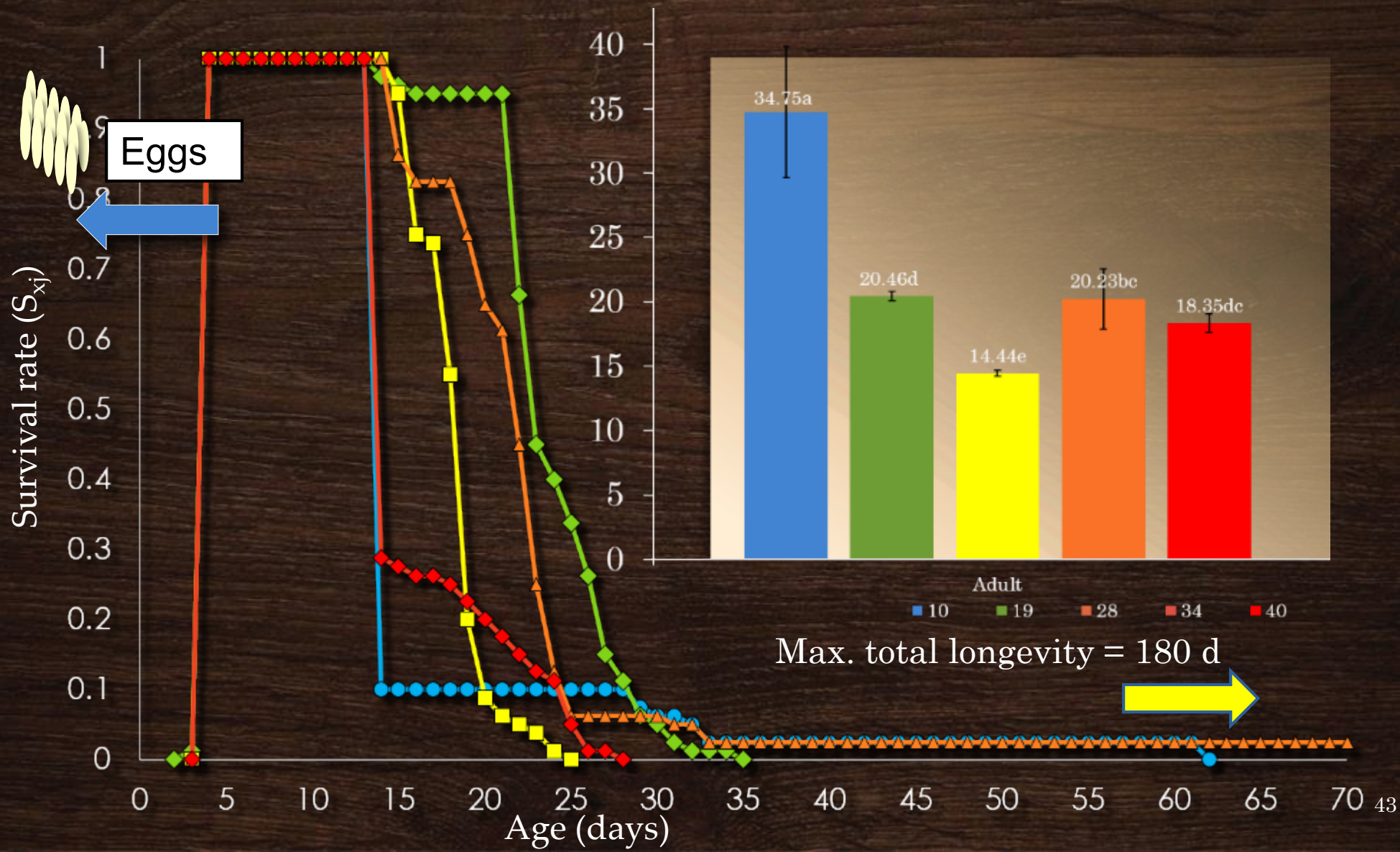


76	76	76	76	76	76
77	77	77	77	77	77
78	78	78	78	78	78
79	79	79	79	79	79
80	80	80	80	80	80
81	81	81	81	81	81
82	82	82	82	82	82
83	83	83	83	83	83
84	84	84	84	84	84
85	85	85	85	85	85
86	86	86	86	86	86
87	87	87	87	87	87
88	88	88	88	88	88
89	89	89	89	89	89
90	90	90	90	90	90
91	91	91	91	91	91
92	92	92	92	92	92
93	93	93	93	93	93
94	94	94	94	94	94
95	95	95	95	95	95
96	96	96	96	96	96
97	97	97	97	97	97
98	98	98	98	98	98
99	99	99	99	99	99

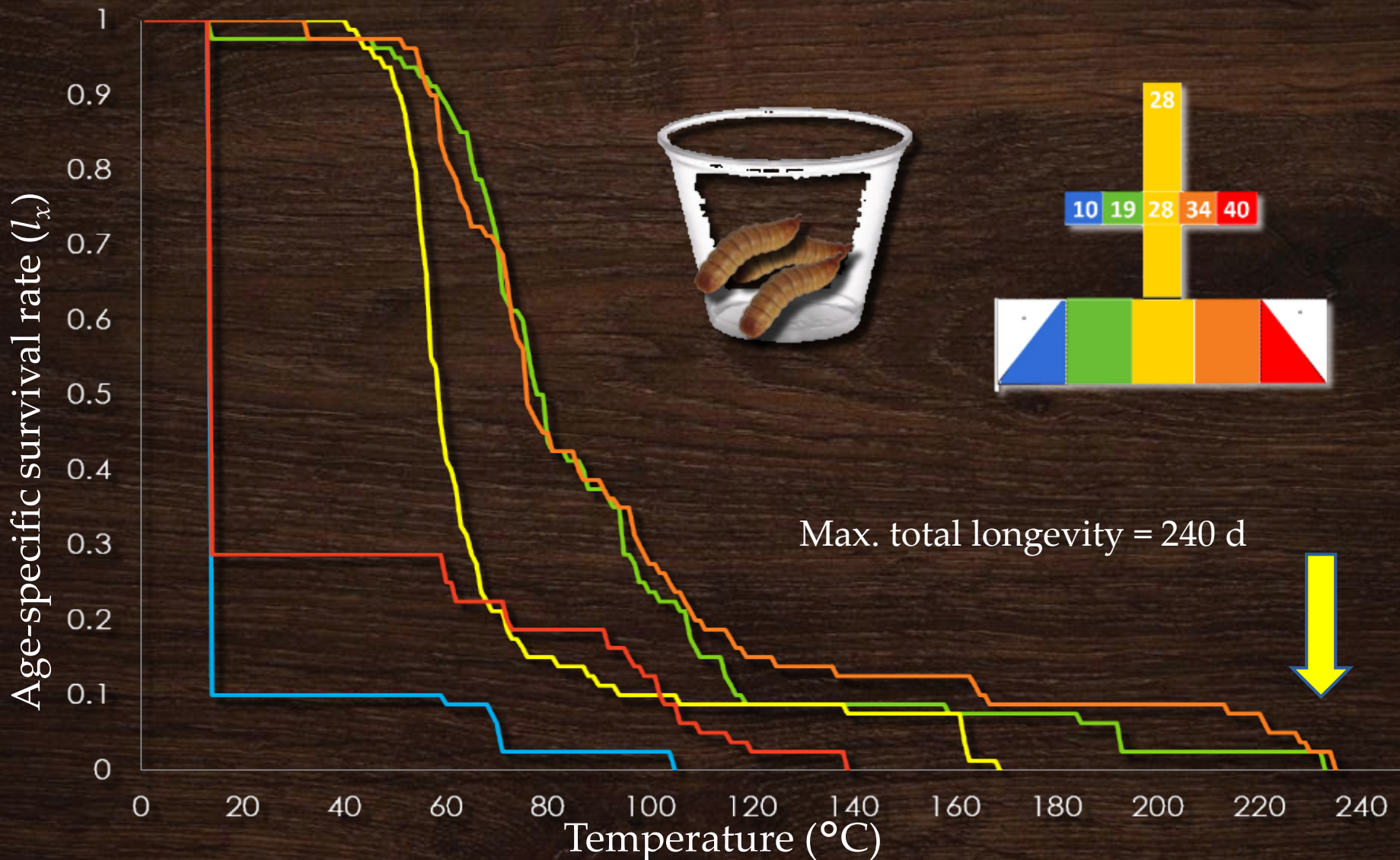
Results



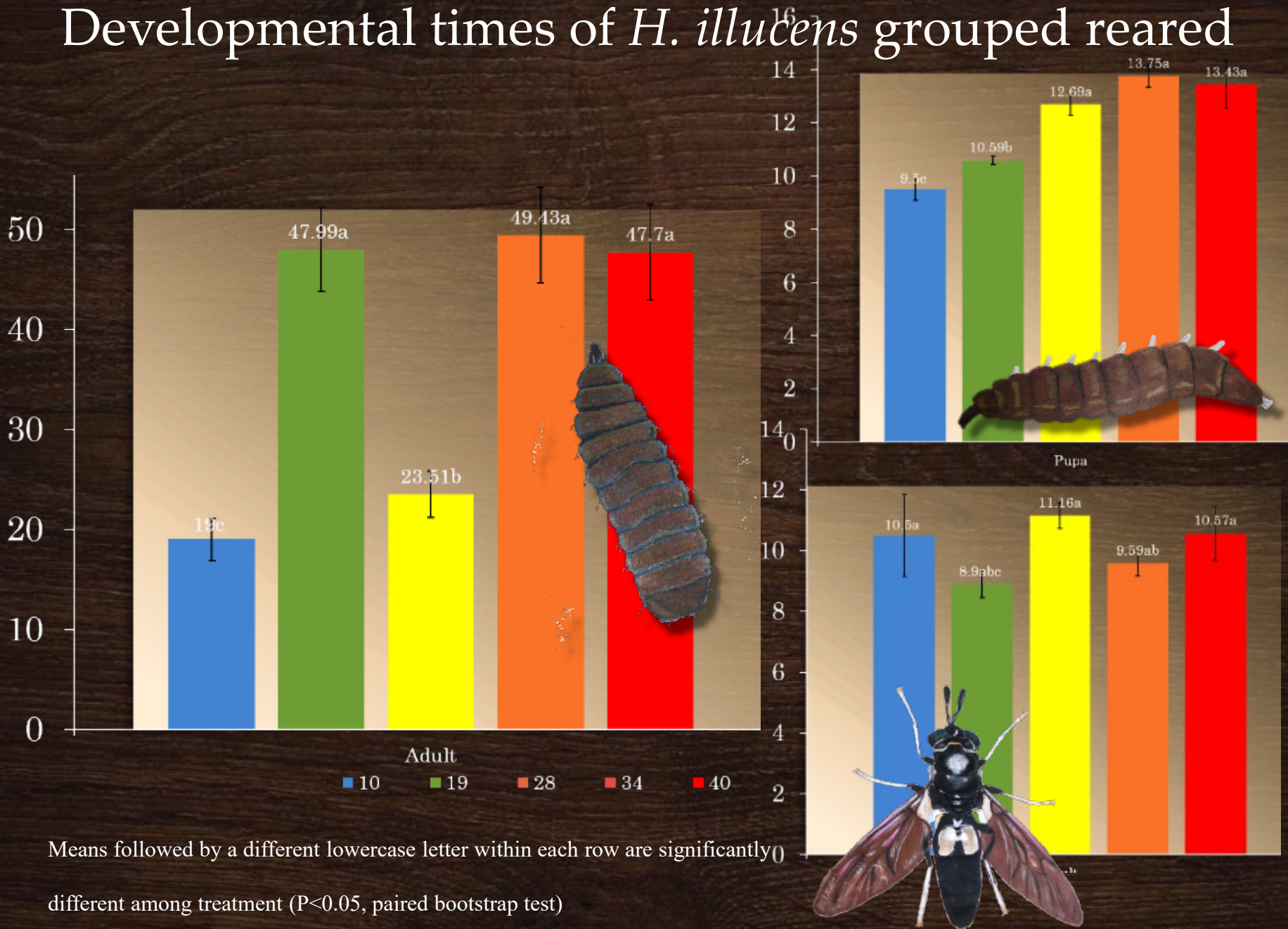
Age-stage-specific survival rate (S_{xj}) of *H. illucens* larva group-reared



Age-specific survival rate (l_x) grouped reared, diapaused and non diapaused individuals included



Developmental times of *H. illucens* grouped reared



Means followed by a different lowercase letter within each row are significantly different among treatment ($P < 0.05$, paired bootstrap test)

We demonstrated that only a five days exposure to different temperature will influence *H. Illucens* life history.



Until other uses are economically feasible the uses of *H. illucens* are reduced to waste management and animal feed.



We are the first laboratory doing research regarding BSF in Taiwan



DYMEX



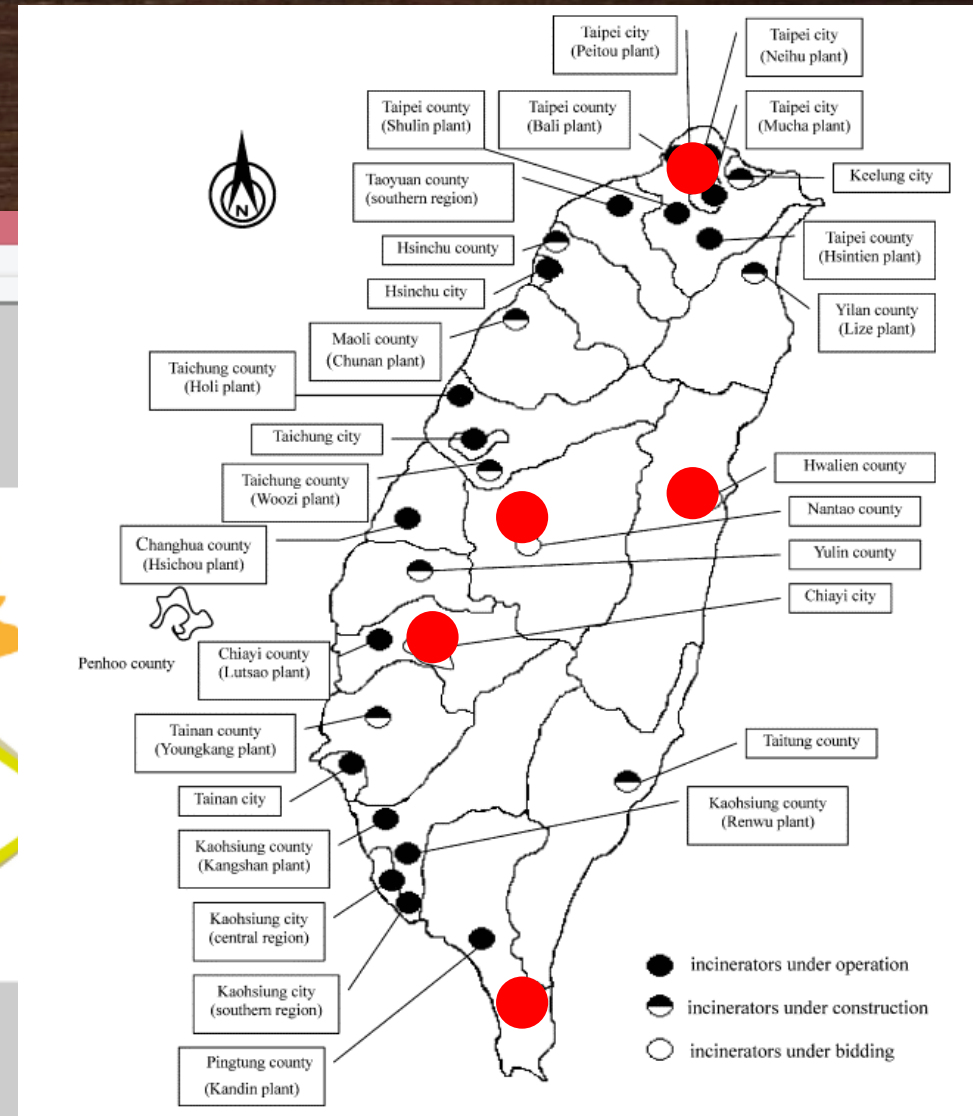
From five locations in Taiwan

The screenshot shows the 'BSF modell' software interface. The main window displays a list of model components:

Component	Description
Timer	From 1 Oct 2007 to 30 Oct 2008 (395 days)
MetBase1	the good one chiayi.csv (2 Jan 07)
Average daily temp	
Daily temp cycle	
BSF lifecycle	Stages being initialized: Egg Larva Pre-pupa Pupa Adult
SummaryManager	

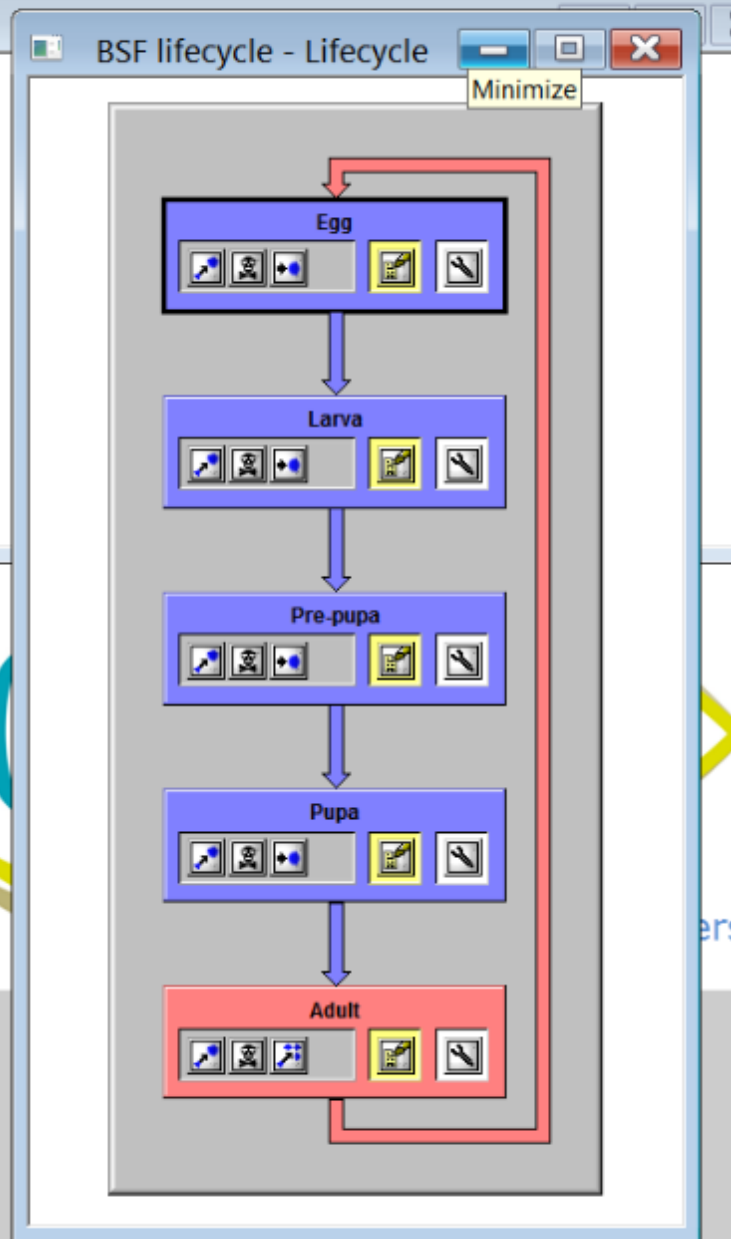
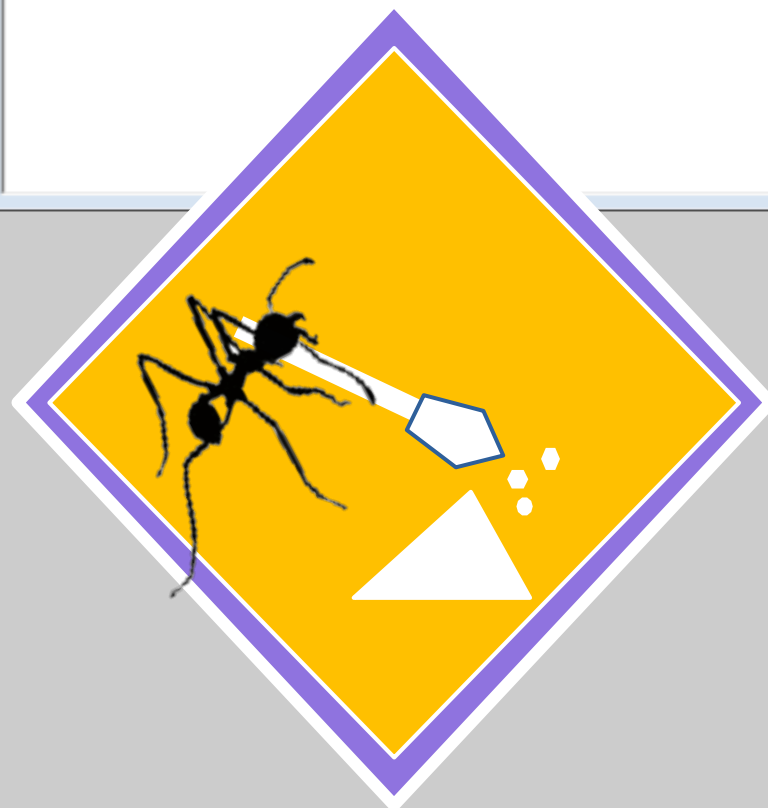
Output Streams: not used.

The interface also features a logo for 'ayme SIMULATOR' with a grasshopper illustration.



BSF modell

- Timer
- MetBase1 (10)
- Average daily temp (20) [Expression]
- Daily temp cycle (30) [Circadian]
- BSF lifecycle (40) [Lifecycle]**



Still...Under construction



- outdoors population of *H. illucens* is prompt to decline and overwinter during the coolest months
- Populations during the warmer months will increase.



The model predicted biomass production values at each site. The current model can be used as a tool in waste management, larva production and compost production.



Taichun, Republic of Taiwan

為避免浪費 請酌量取用。
如剩餘過量，需酌收
清潔費!

To avoid wasting food, please take finish
your plate. There is a charge for ice
cream left over. 😊

Jeju, Republic of Korea

“Are your eyes bigger than your stomach?”

Reduce food waste, help the earth and farmers

섬채는 건강합니다.

신선한 식재료와 최소한의 양념으로 제주 밥상의 기본을 지켜줍니다.

제주 전통음식의 기원 온 특질이라면 신선함을 말할 수 없을 것입니다. 풍도가 높은 땅에 지렁이가 밟을까봐 걱정될까봐 무수히온 채로 먹는 것이 서민들의 기본이 되었고, 신선할 정도 밖에 별다른 양념도 필요치 않았습니니다. 이러한 식단은 현대인이 추구하는 ‘건강한 식사’ 모델과 일치하고, 섬채의 지향에도 맞닿아 있습니다. 신선한 채물과 최소한의 양념, 제주 밥상의 우수성을 계승함과 동시에 건강하고 균형 잡힌 식사를 제공하기 위한 섬채의 두 가지 원칙은 흔들리지 않을 것입니다.

섬채는 믿을 수 있습니다.

전체 비용 중 식재료 비율 60% 이상, 로컬푸드로 차린 판매향 밥상

섬채를 운영하기 위해 필요한 총 지출 비용 중 식재료가 차지하는 비율은 60% 가 넘습니다. 보통 식당에서 30~40%의 비율을 유지하는 것과 비교하면 압도적인 수치입니다. 섬채는 거의 모든 식자재를 가능한 국내산, 제주산을 고집하기 때문입니다. 안전한 먹거리, 환경 보호, 그리고 지역 농수축산물 국공급 활성화를 위한 이유있는 고집, 계속해서 지켜가겠습니다.

• 각 메뉴에 대해 상세 요거는 섬채 홈페이지 및 QR코드에
▶▶▶ 제주산 식재료 60% 이상 사용 ▶▶▶ 100% 신선 식재료 사용 ▶▶▶ 100% 로컬푸드로 차린 밥상

섬채는 도민과 함께 합니다.

전 직원 정규직 고용, 운영 수익의 2/3 지역사회 환원

섬채는 행복나눔과트림동조합에서 2016년 4월 론칭한 한식뷔페입니다. 제주도 내 서비스 노동자의 일주근간 개성과 다양한 경제공동체 활성화를 목표로 만들어진 최초의 마트 직영협동조합이자 사회적기업으로, 양질의 일자리를 창출하기 위해 노력하여, 노동자의 입장에서 최고의 근무환경을 만들고자 합니다. 또한 운영 수익의 2/3를 지역 사회에 환원함으로써 건강한 공동체 회복에 힘을 보태고 있습니다.

이제, 제주에선 섬채입니다.

이런 음식이 없다면, 이 가격에 10,000원을 받고 있습니다. 처음에는 종류별로 조금씩 맛을 본 후, 입에 맞는 음식 위주로 담아 오신다면 더욱 좋겠지!

[나눔과 비용] 섬채 번그로 캠페인

동성탕 차린 음식, 맛있게 드시고 남기지 않아주세요. 깨끗한 접시는 우리 농가의 지구 환경에 큰 힘이 됩니다.
“Are your eyes bigger than your stomach?”
Reduce food waste, help the earth and farmers.

사회적기업 행복나눔아르헨폴조합
www.narumna.com/jeju.kr

이웃을 살리는 행복나눔조합 대표: 김민서 010-985-0111 / 02-1234-5678 주소: 서울특별시 강남구 테헤란로 123-456	로컬푸드 한식뷔페 섬채 대표: 김민서 010-985-0111 / 02-1234-5678 www.narumna.com/jeju.kr	행복나눔 사회적기업 대표: 김민서 010-985-0111 / 02-1234-5678 www.narumna.com	로컬푸드 마트 직영 사업부 대표: 김민서 010-985-0111 / 02-1234-5678 www.narumna.com	특수협동조합 대표: 김민서 010-985-0111 / 02-1234-5678 www.narumna.com
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Thank you!

