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CAMPUS DOIS VIZINHOS

UNIVERSITY OF GEORGIA

Selection criteria for improving honey production in Africanized honey bees

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Why honey bees?

Table 1. Ranking of the fifteen countries, which shipped over three-quarters (76.5%) off all world's natural honey exported during 2017, in million dollars (US$) and percentage (%)

Country	Ranking	US$	%
China	1°	270.7	11.44
New Zealand	2°	269.2	11.38
Argentina	3°	183.2	7.7
Germany	4°	145.6	6.2
Ukraine	5°	133.9	5.7
Brazil	6°	121.3	5.1
Spain	7°	110.3	4.7
Mexico	8°	104.7	4.4
Hungary	9°	89.7	3.8
Belgium	10°	77.3	3.3
India	11°	73.3	3.1
Vietnan	12°	70.6	3
Canada	13°	60.2	2.5
Romania	14°	52.1	2.2
Bulgaria	15°	48.1	2
Total	-	1811.0	76.5

Fasted-growing

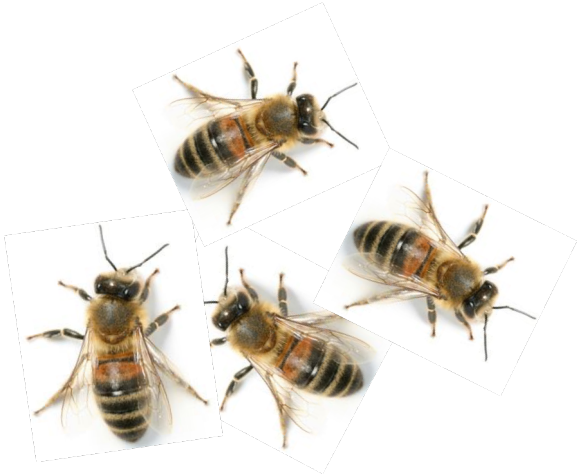
Up 124.1%

http://www.worldstopexports.com
https://www.trademap.org/Index.aspx

Honey production = complex interplay

Queen

+



Workers

+

RugliG, Getty Images/iStockphoto

Environment

Genes

Eggs

Nectar

C.I. K

Pollen

Pheromones

Mechanisms behind honey production are not fully understood

Introduction

Background – queen's & colony traits

Eckert (1934); Eckert (1937); Hoopingarner & Farrar (1959); Boch & Jamielson (1960)

Nelson & Gary(1983); Szabo & Lefkovitch (1988)

Queen's size & honey production

Delaney et al., 2011; Jackson et al., 2011; Cobey et al. (2011); Rangel et al. (2012); Amiri et al (2017)

Tarpy & Fletcher (1998); Hatch et al. (1999); Tarpy et al. (2000); Tarpy & Page (2000); (2001)

Tarpy et al. (2004); Kocher et al. (2008); Kocher et al (2009); Tarpy & Fletcher (2003); Gilley et al. (2003); Tarpy &Gilley (2004)

Queen's size & reproduction potential

1934 1960 1962 1987 1990 1998 1999 2000 2007 2017

Heritability
Genetic Correlation

Oldroyd and Moran (1983); Collins et al. (1984); Milne & Friars (1984); Milne (1985), (1985a), (1985b), (1985c); Collins et al. (1987)

Collins (1979); Chevalet & Cournet (1982); Rinderer et al. (1983); Gonçalves e Stort (1978); Bar-Cohen et al. (1978); Bar-Cohen (1967); El Banby (1967)

Pirchner et al. (1962); Soller e

Bienefeld & Pirchner (1990), (1991); Harbo & Harris (1999); Boecking et al. (2000); Engelsdorf & Otis (2000)

Behaviour

Faquinello et al. (2011), Costa-Maia et al. (2011), Wielewski et al. (2012), Padilha et al. (2013), Garcia et al. (2013); Zakour et al. (2012)

Bienefeld et al. (2007); Brascamp et al. (2014); Brascamp et al. (2016)

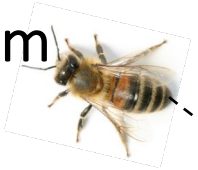
Behavior BLUP

Heritabilities
Genetic Correlations
Methodology

r_g  ,  = ⬆ +

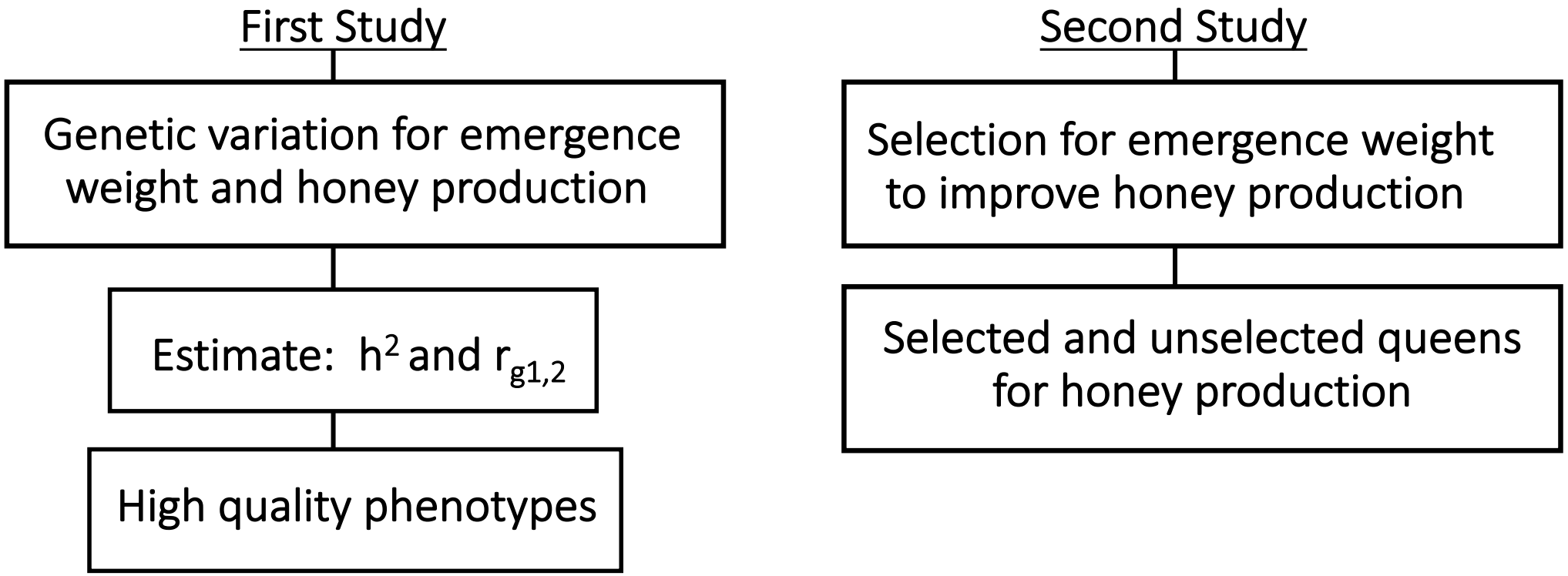
Criteria to improve honey production

Aim



To investigate the feasibility of using emergence weight measured in the queen as criteria for improving honey production

Material and Methods



Material and Methods

First study: Maringa State University

The base population

↓

Daughter queens rearing

↓

Emergence weight

↓

Queen identification

↓

Fecundation

↓

Honey production

Material and Methods

First study:

The base population

↓

Daughter queens rearing

↓

Emergence weight

↓

Queen identification

↓

Fecundation

↓

Honey production

Data set →

Variance components estimation

Gibbs1f90

Misztal et al. (2002)

Two-trait analysis

- **Pedigree – Great granddaughters**
- **45 queens reared/generation**
- **180 animals with records**
- **Missing information - Drone**

$$y_{1ij} = la_i + a_{1i} + e_{1ij}$$

$$y_{2ij} = cg_i + a_{2i} + e_{2ij}$$

Result

First study:

Table 2. Posterior means and standard errors, in parentheses, of heritability, genetic and phenotypic correlations for queen's emergence weight and honey production, in Africanized honey bees.

Trait	Heritability	Genetic correlation	Phenotypic correlation
Emergence weight	0.49 (0.27)	0.46 (0.35)	0.52 (0.15)
Honey production	0.32 (0.15)		

Emergence weight would speed up the process to improve honey production!

First study:

Annual Genetic Gain

Indirect selection

$$\Delta G_{Honey,Weight} = \frac{h_{Honey} * h_{Weight} * r_{g1,2} * i * \sigma_{y\ Honey}}{GI}$$

$$\Delta G_{Honey,Weight} = 5.30\ kg/year$$

Direct selection

$$\Delta G_{Honey} = \frac{h_{Honey} * i * \sigma_{a\ Honey}}{GI}$$

$$\Delta G_{Honey} = 1.86\ kg/year$$

$$>$$

2.8 times greater

Material and Methods

Second study:

The base population (60)

↓

Daughter queens rearing (200)

↓

Emergence weight

↓

Genetic Evaluation
Daughter queens – highest EBV (60)

↓

Queen identification

↓

Fecundation

↓

Daughter queens rearing (200)

(…)

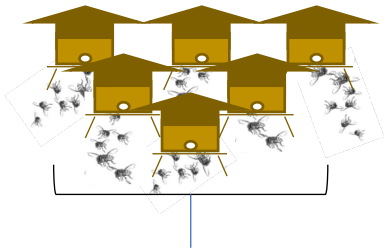
5 Generations

Material and Methods

Second study: Federal Technological University of Paraná

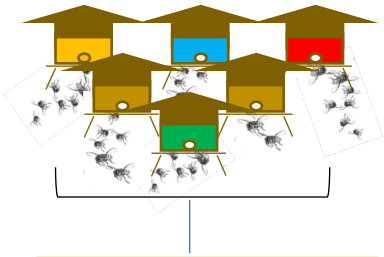
Field test

Selected (Generation 5)



60
Daughter queens

Unselected



60
Daughter queens

Regular mating flights

Same apiary

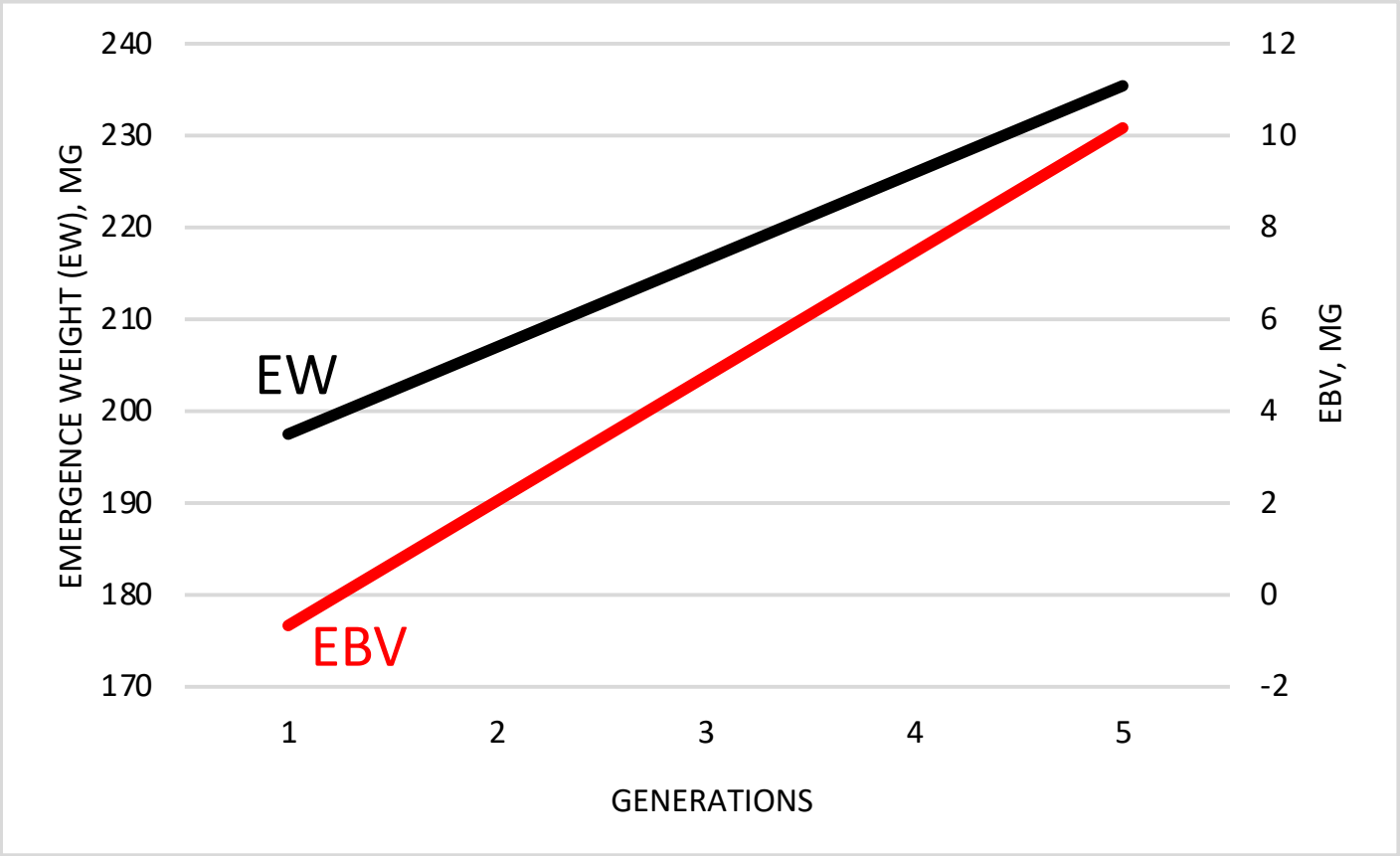
60 days after

Honey production

Results

Second study:

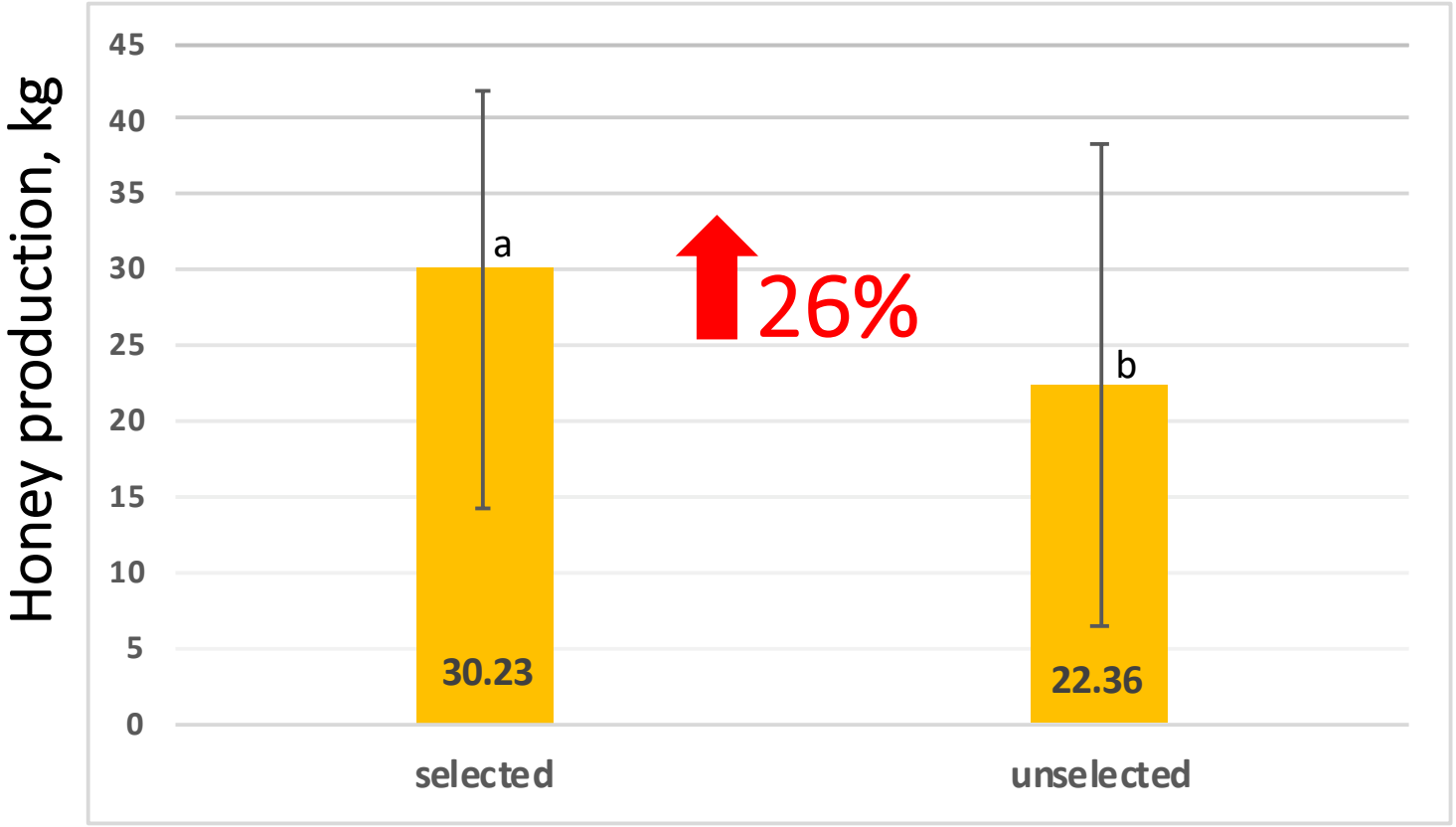
Phenotypic and Genetic trends for queen's emergence weight



Results

Second study:

Honey production (kg) – Selected and Unselected colonies



Potential of selecting queens based on emergence weight

Conclusion

Adopting the *in vitro* production of queens and selecting for emergence weight is feasible for breeding programs aiming to increase honey production

Future

Our objective, in a near future,
is to provide improved queens to beekeepers,
to help them improve honey production in Brazil

Questions

CNPq
Conselho Nacional de Desenvolvimento Científico e Tecnológico

CAPES

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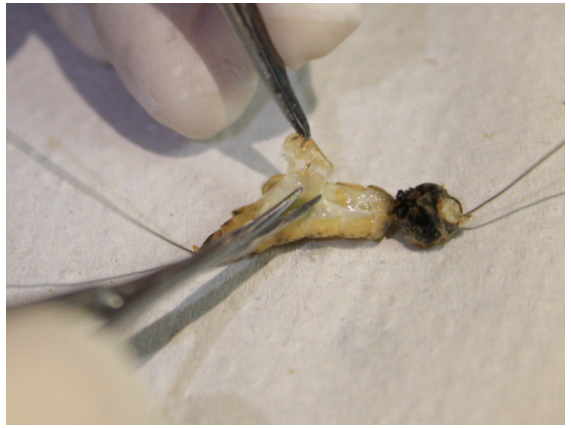
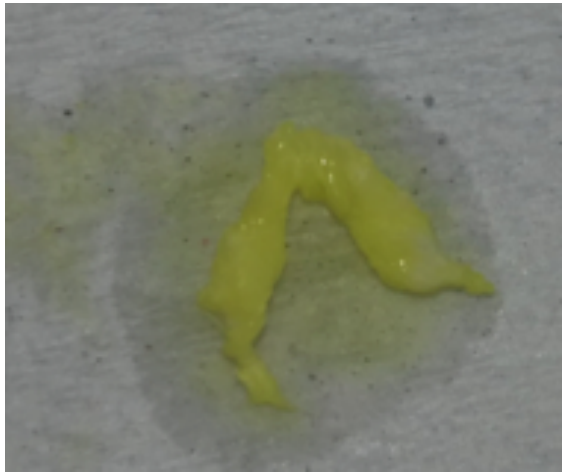
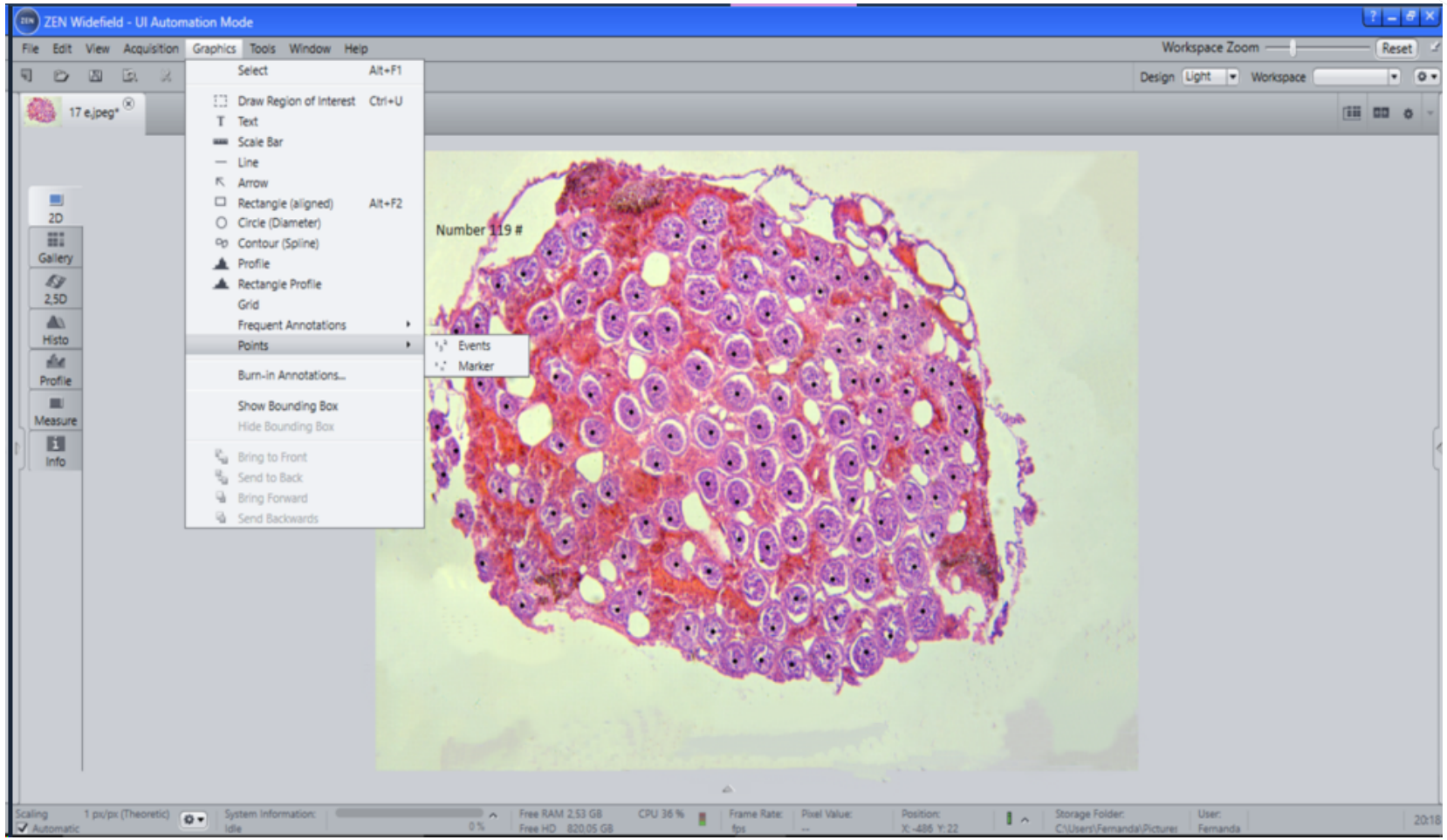
Extra Slides

Studies currently under investigation

Genetic correlation between emergence weight and queen reproductive system

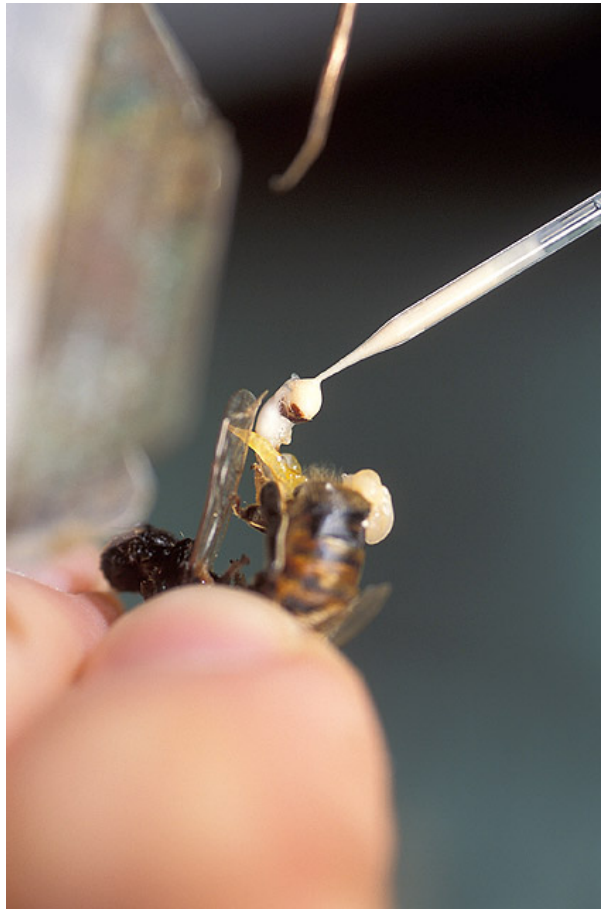






Studies currently under investigation

Instrumental Insemination for complete pedigree

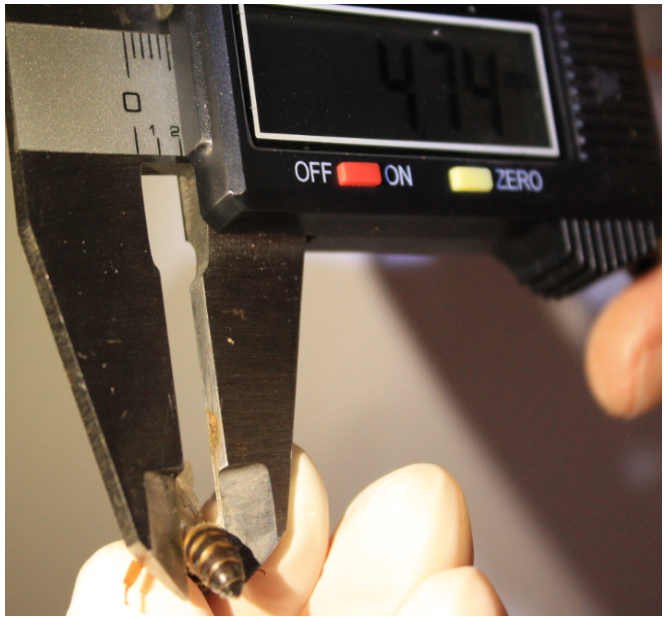


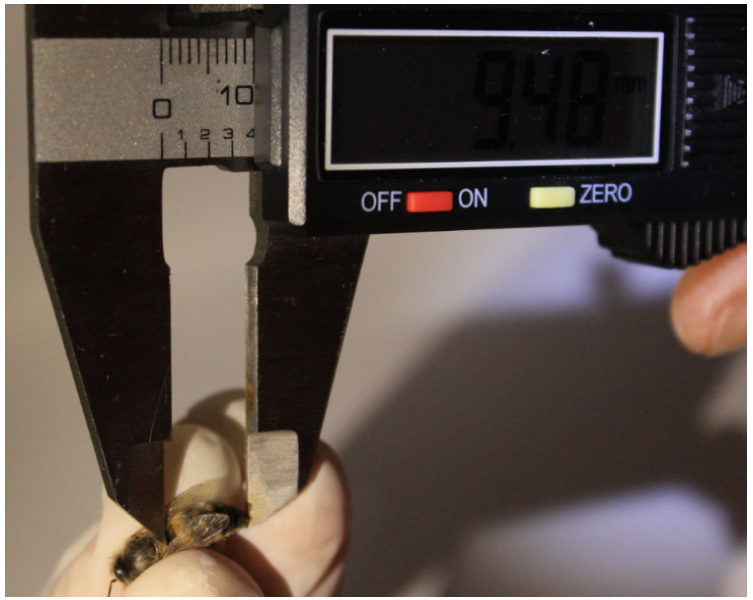
Studies currently under investigation

Drone rearing by virgin queen's CO_2 stimulation

Studies currently under investigation

Genetic correlation between emergence weight and MORPHOMETRICS TRAITS





Material and Methods

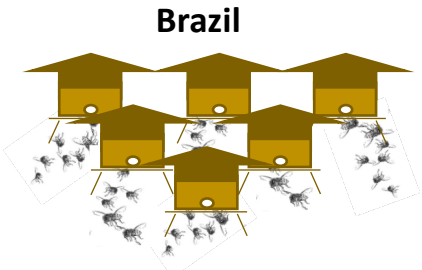
First study:

Honey production

Material and Methods

First study :

The base population



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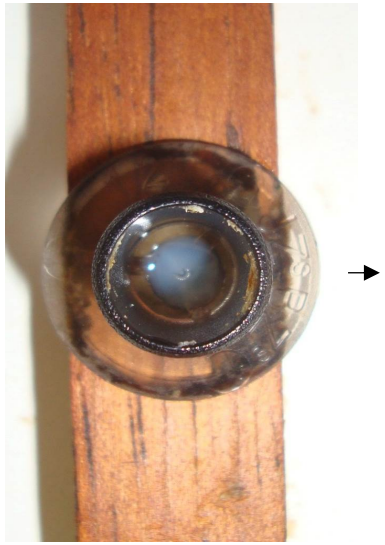
Maringá

Material and Methods

First study:

Queen rearing

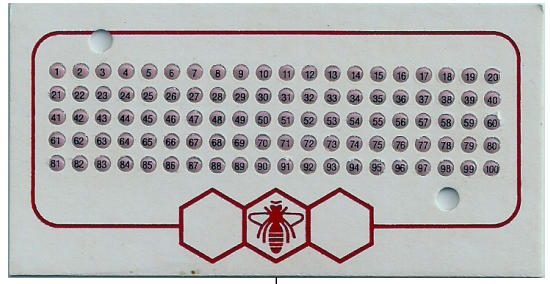
Queen rearing
Doolittle (1889)

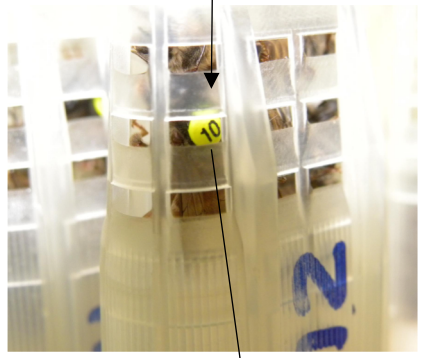


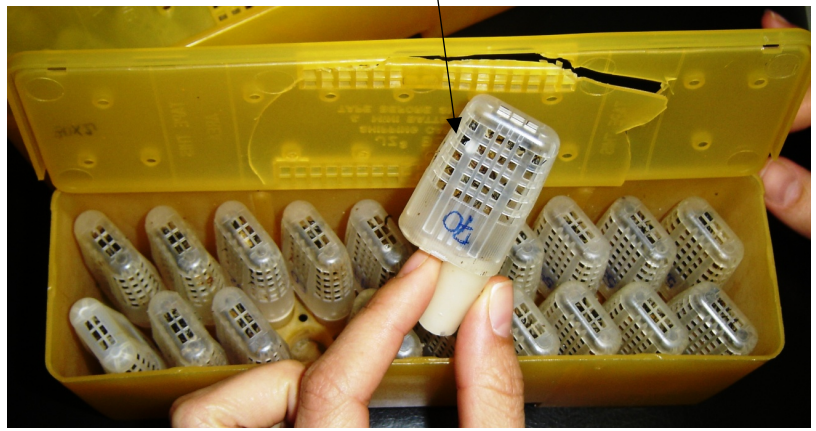
Material and Methods

First study:

Emergence weight measurements







Material and Methods

First study:

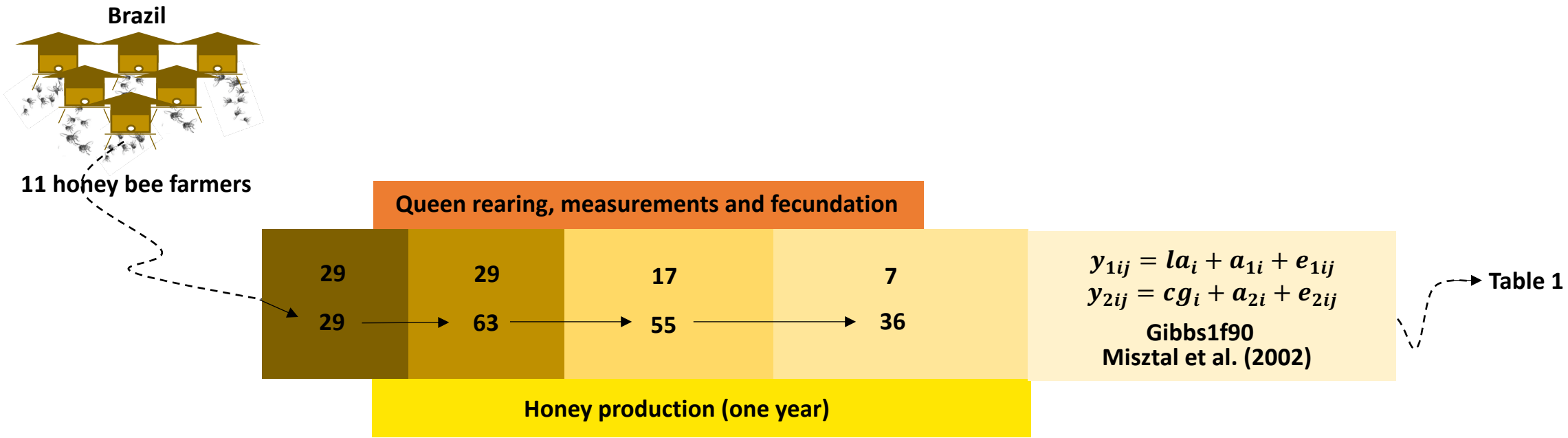
Honey production

Regular Mating Flight
17 to 20 drones

Winston (1987)

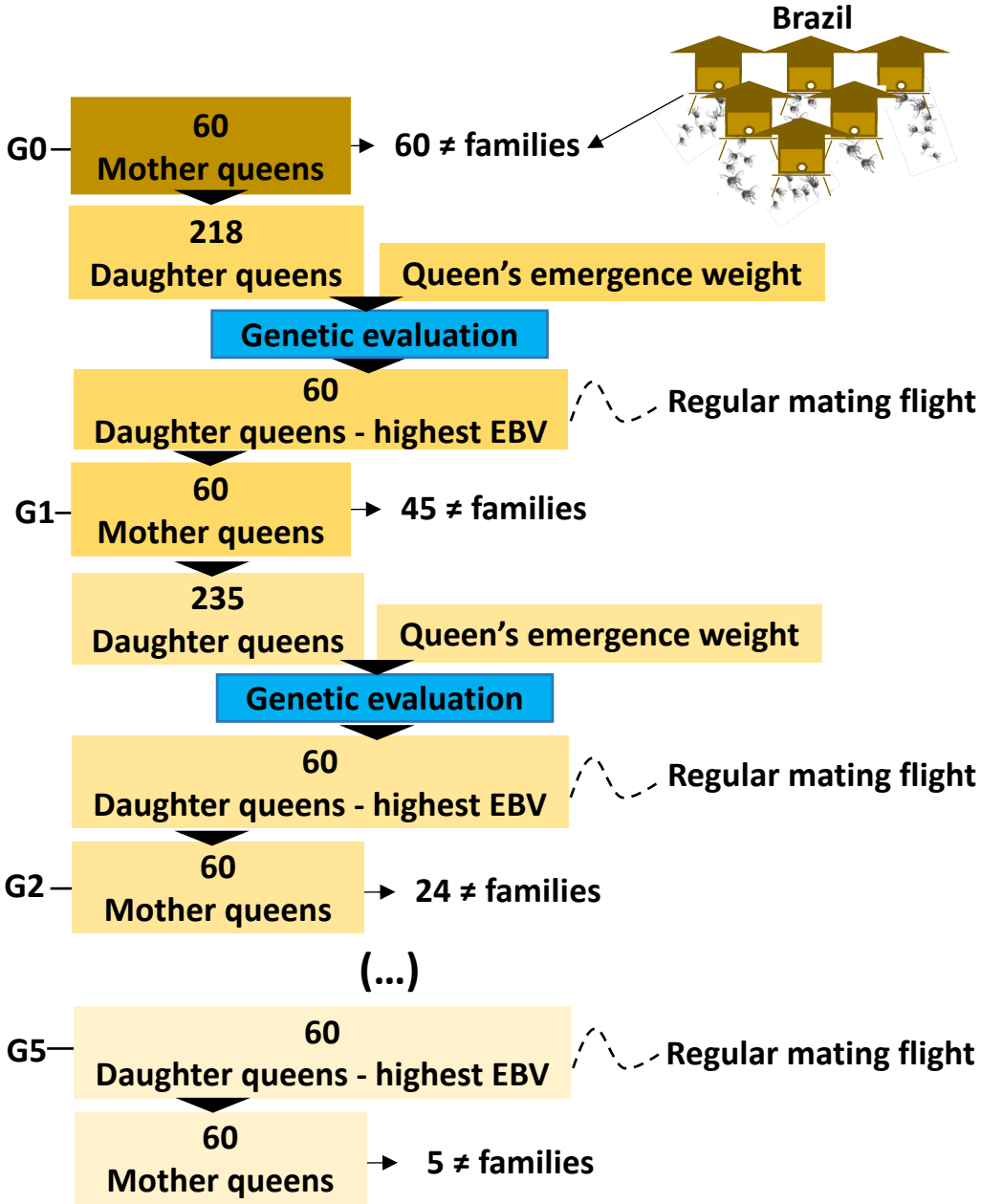
Material and Methods

2009: the first study



Material and Methods

Second study:



First study:

Annual Genetic Gain

Direct selection

$$\Delta G_{Honey} = \frac{h_{Honey} * i * \sigma_{a\ Honey}}{GI}$$

$$\Delta G_{Honey} = \frac{(0.57) * (1.14) * (5.73)}{1}$$

$$(\ \Delta G_{Honey} = 3.72\ kg/year\ )/2$$

$$\boldsymbol{\Delta G_{Honey} = 1.86\ kg/year}$$

Indirect selection

$$\Delta G_{Honey,Weight} = \frac{h_{Honey} * h_{Weight} * r_{g1,2} * i * \sigma_{y\ Honey}}{GI}$$

$$\Delta G_{Honey,Weight} = \frac{(0.57) * (0.70) * (0.46) * (1.14) * (10.13)}{0.20}$$

$$(\ \Delta G_{Honey,Weight} = 10.60\ kg/year\ )/2$$

$$\boldsymbol{\Delta G_{Honey,Weight} = 5.30\ kg/year}$$

Return an annual gain 2.8 times greater than honey production

Projection

Selection intensity (i) = 1.14 ➢ b= 30.85%

Generation interval (GI) ➢ Direct Selection by honey = 1 year

Generation interval (GI) ➢ Indirect Selection by emergence weight = 0.20 year

365 days/70 days (each generation) = 4,8 generations/year; 1 year/4.8 generations = 0.20 year

Honey

σ_a^2= 32.83 kg^2

$\sigma_a = \sqrt{\sigma_a^2}$ = $\sqrt{32.83}$ = 5.73 kg

h^2= 0.32

h= $\sqrt{h^2}$ = $\sqrt{0.32} = 0.57$

σ_y^2= 102.59 kg^2

$\sigma_y = \sqrt{\sigma_y^2}$ = $\sqrt{102.59}$ = 10.13 kg

Emergence weight

h^2= 0.49

h= $\sqrt{h^2}$ = $\sqrt{0.49} = 0.70$