

Photonics in Sericulture

Sarun Sumriddetchkajorn

Intelligent Devices and Systems Research Unit
National Electronics and Computer Technology Center
National Science and Technology Development Agency
Ministry of Science and Technology

Acknowledgements

- Wacharapong Kaewhom

Director, Queen Sirikit Sericulture Center Saraburi

- Photonics Technology Lab/NECTEC

- Mr. Chakkrit Kamtongdee for experimental setup/results

Photonics ?

Optics and Photonics

Essential Technologies for Our Nation

Committee on Harnessing Light: Capitalizing on Optical Science Trends and Challenges for Future Research

National Materials and Manufacturing Board

Division on Engineering and Physical Sciences

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

THE NATIONAL ACADEMIES PRESS
Washington, D.C.
www.nap.edu

PREPUBLICATION COPY—SUBJECT TO FURTHER EDITORIAL CORRECTION: DO NOT QUOTE OR CITE

Copyright © National Academy of Sciences. All rights reserved.

Science and Engineering Applications of Light

Committee on harnessing light, *Optics and Photonics Essential Technologies for Our Nation*, National Academy Press, Washington, D.C., 2012.

Why Light ?

No destruction

Parallel processing

Large bandwidth

No contact

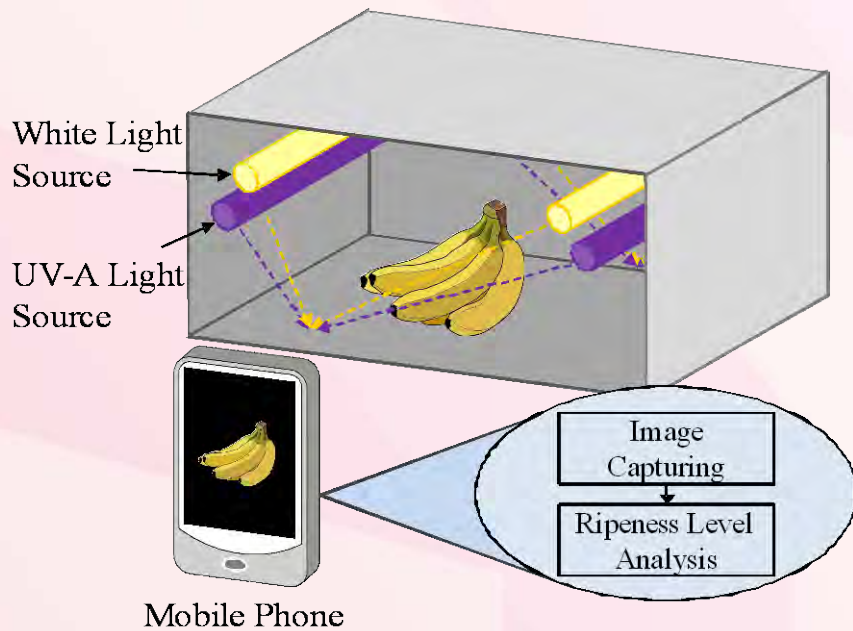
High resolution

Neural charge

High accuracy

Low EMC & EMI

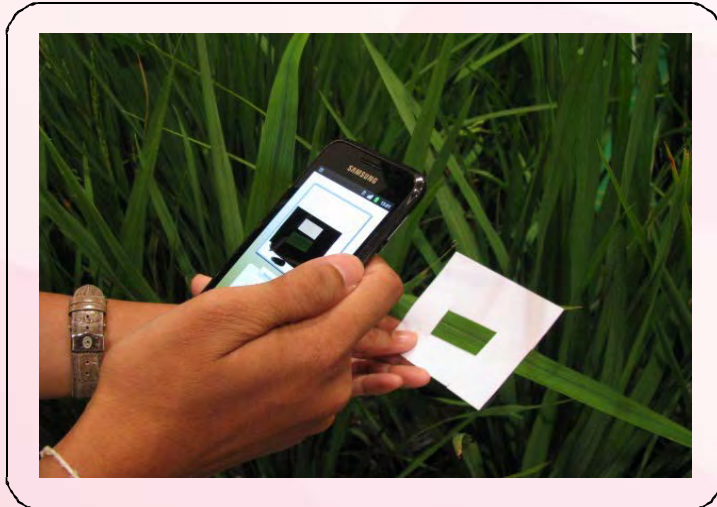
Spectral-Imaging based Ripeness Estimation System



VIS



Bai-KhaoApp: Nitrogen Estimator for Rice Field



Features

- High accuracy with 6 levels of color
- Low energy consumption:
 - 5VDC 20 mA (operating mode)
 - 5VDC 10 mA (standby mode)
- Compact and lightweight:
 - (WxLxH) 40×120 ×25 mm³
 - 120 grams

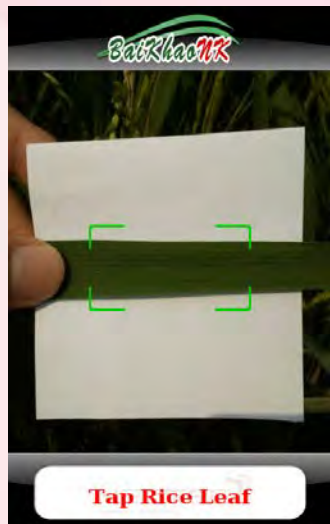
Examples of fertilization rates: (from Rice Dept)

• Tillering Stage

- Color level < 3: Urea fertilizer 12 kg./rai
- Color level = 3: Urea fertilizer 8.5 kg./rai
- Color level > 3: Urea fertilizer 5 kg./rai

• Panicle Initiation Stage

- Color level < 3: Urea fertilizer 16 kg./rai
- Color level = 3: Urea fertilizer 12.5 kg./rai
- Color level > 3: Urea fertilizer 9 kg./rai



Silk

Chinese knew about silk between 4000 and 3000 BCE



Sogdian silk, 8th century

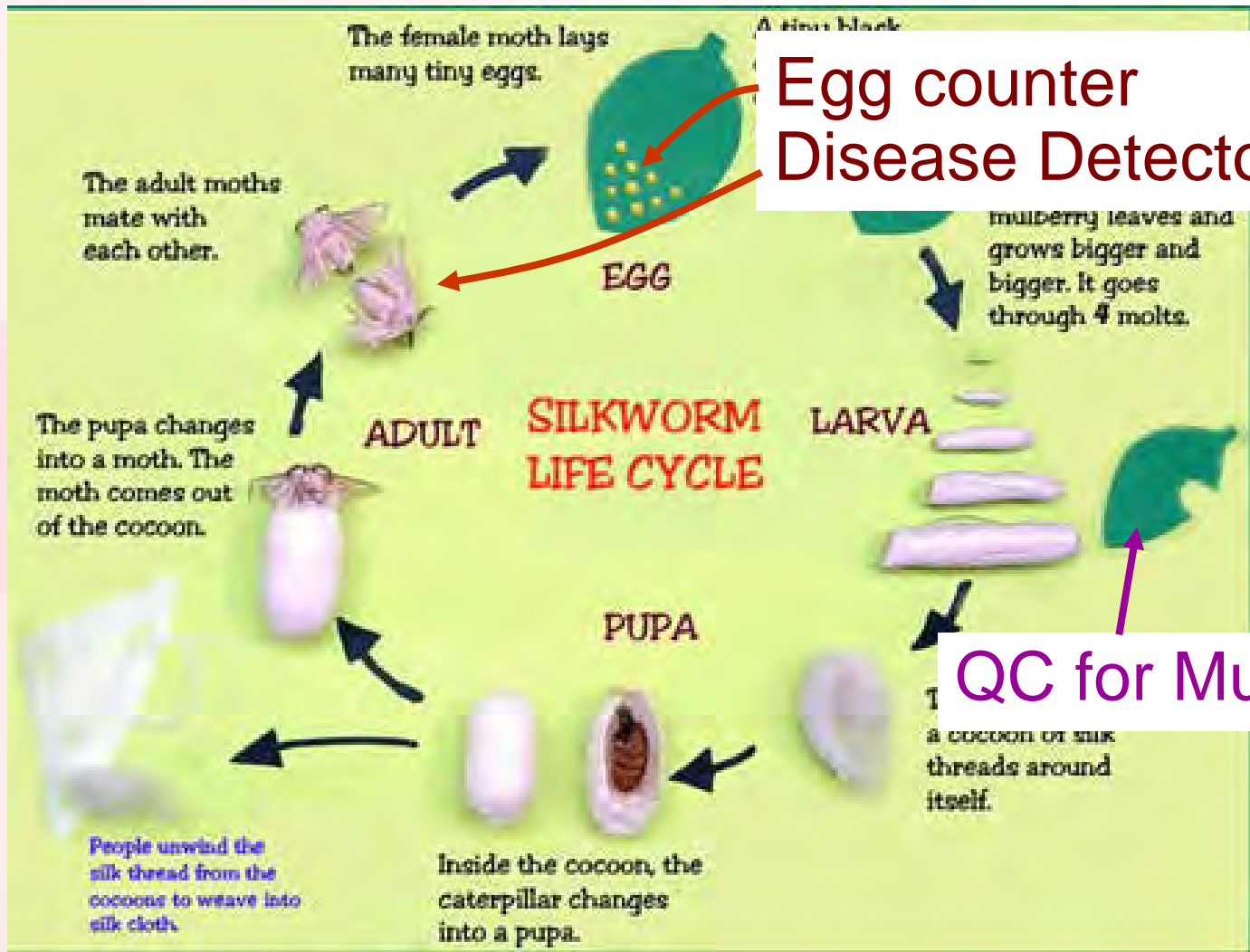
- Silk has been utilized around the world for several purposes (*e.g., clothing, optical materials*).
- Today sericulture industry has played a significant role in economic growth for several countries.

For example, silk related products in Thailand showed an export value of USD22.6 millions

Colorimeter
Glossy meter
Thickness analyzer



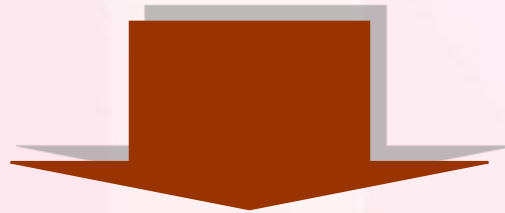
Silkworm (*Bombyx mori*)



<http://www.silkwormshop.com/images/lifecycle.jpg>

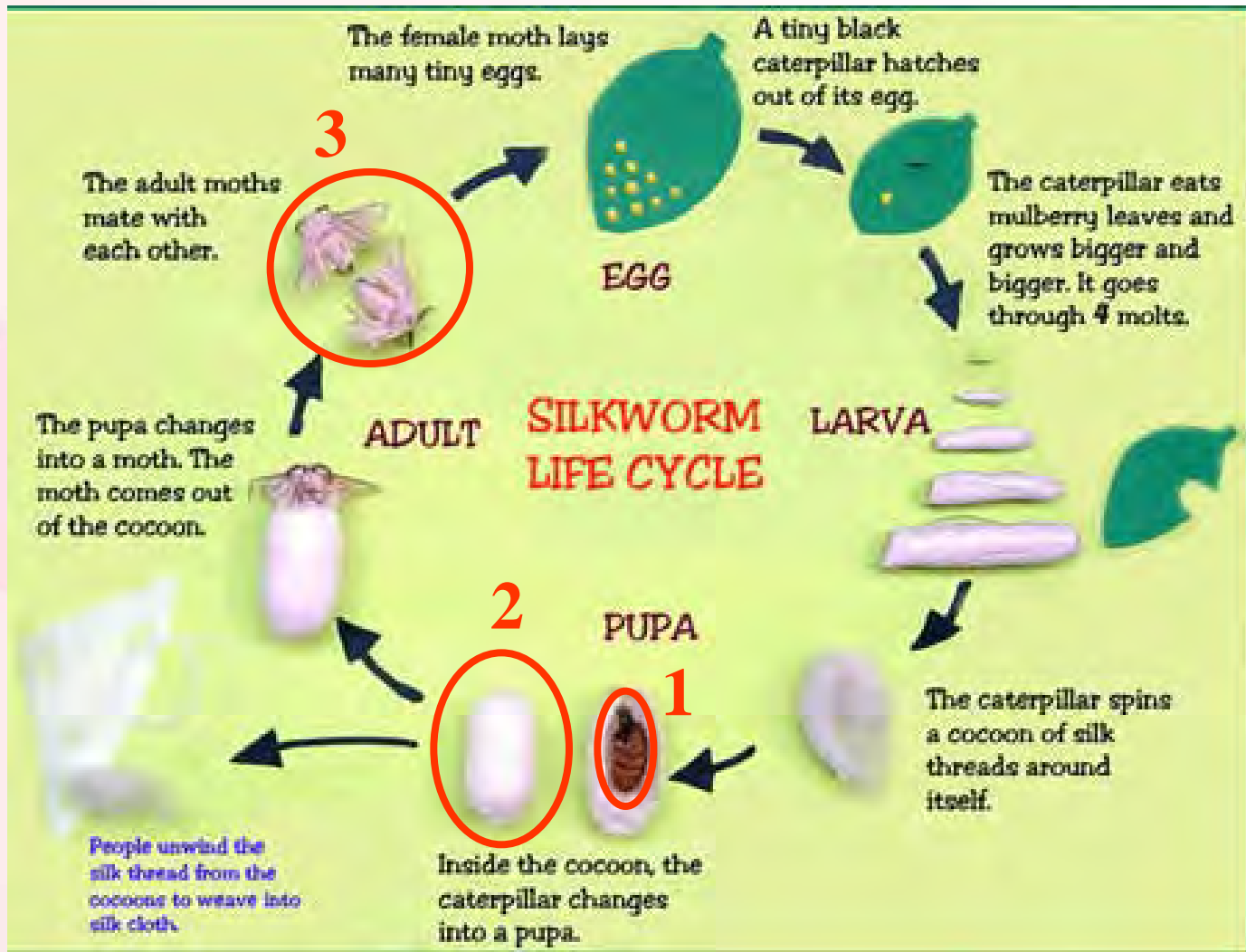
Needs

- To achieve high quality raw silk thread
- To obtain high quality breeders
- To conserve high quality breeders



It is highly desirable to be able to separate male and female silkworms

Silkworm (*Bombyx mori*)



<http://www.silkwormshop.com/images/lifecycle.jpg>

Silkworm Gender Separation Methods



- Visual inspection at the ventral surface of the 8th abdomen segment



Low cost
Slow
Requires highly skilled people

- Mass analysis
- Shape analysis



Need reference weight/shape
High error rates

- Magnetic Resonance Imaging
- Near Infrared Spectroscopy



High accuracy
Very expensive

- Fluorescent imaging under UVA



Suitable for limited varieties of silkworms



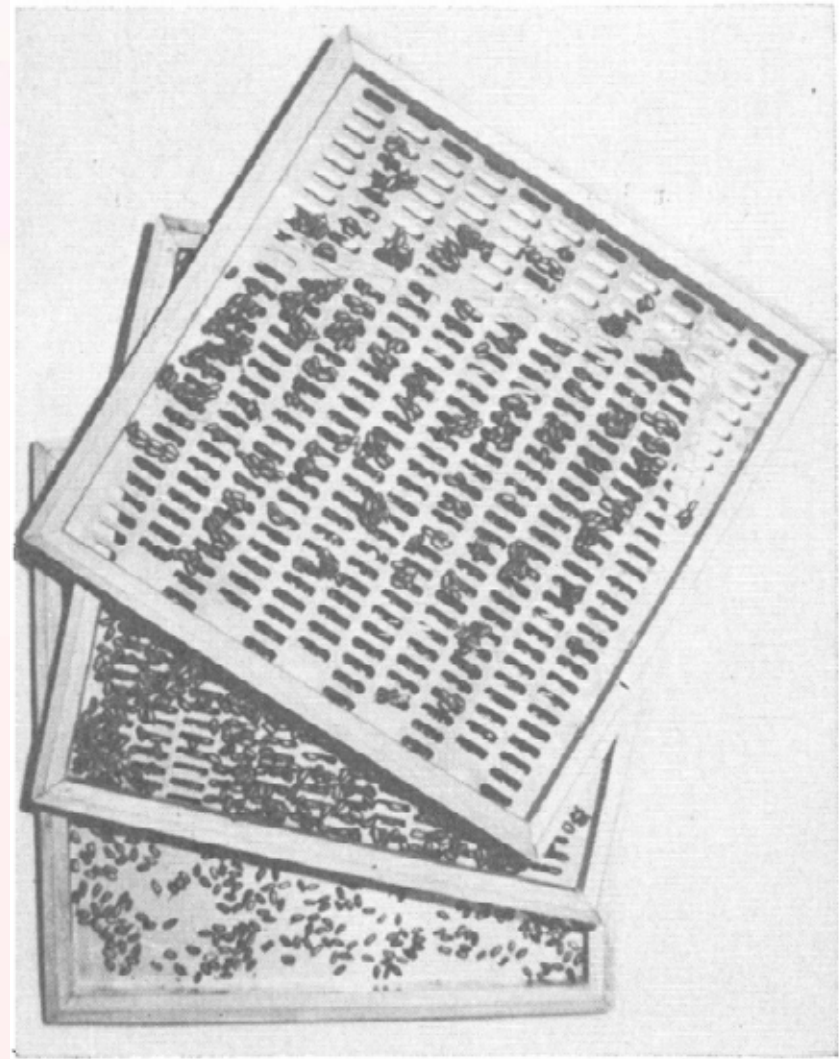
Silkworm Gender Separation via Mass Analysis



Silkworm Gender Separation via Size/Shape

ANNALS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA

[Vol. 65, no. 6
Nov 1972



Silkworm Gender Separation via Spectroscopy

(19) 日本国特許庁(JP)

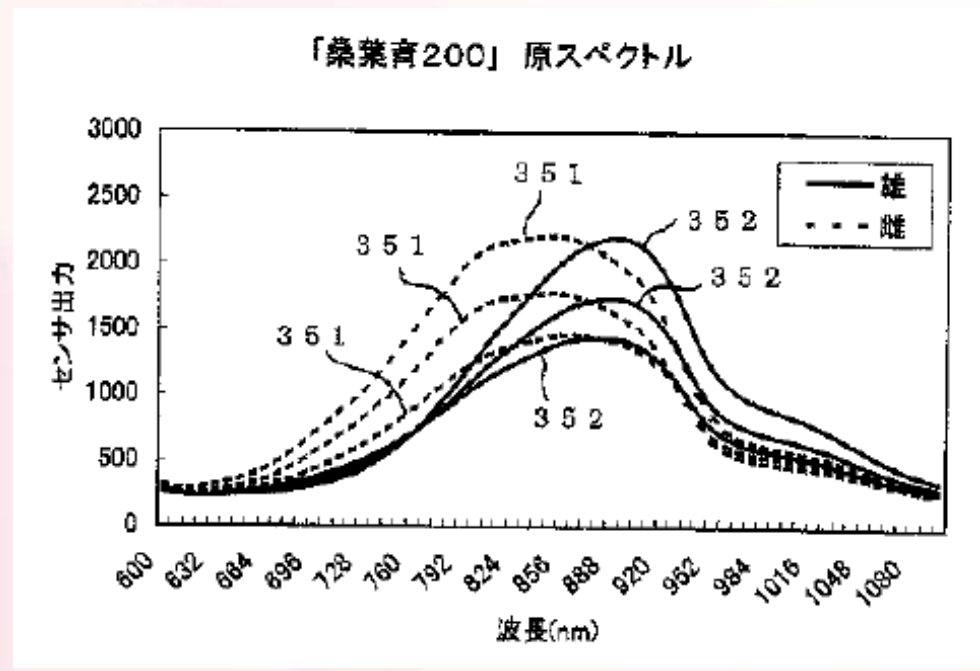
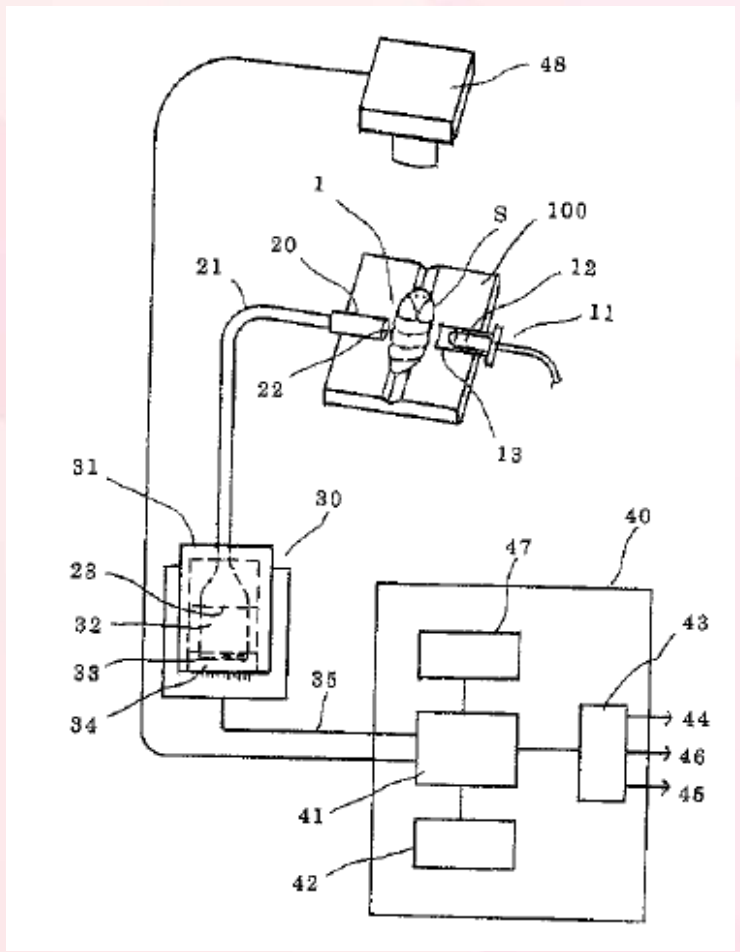
(12) 公開特許公報(A)

(11) 特許出願公開番号

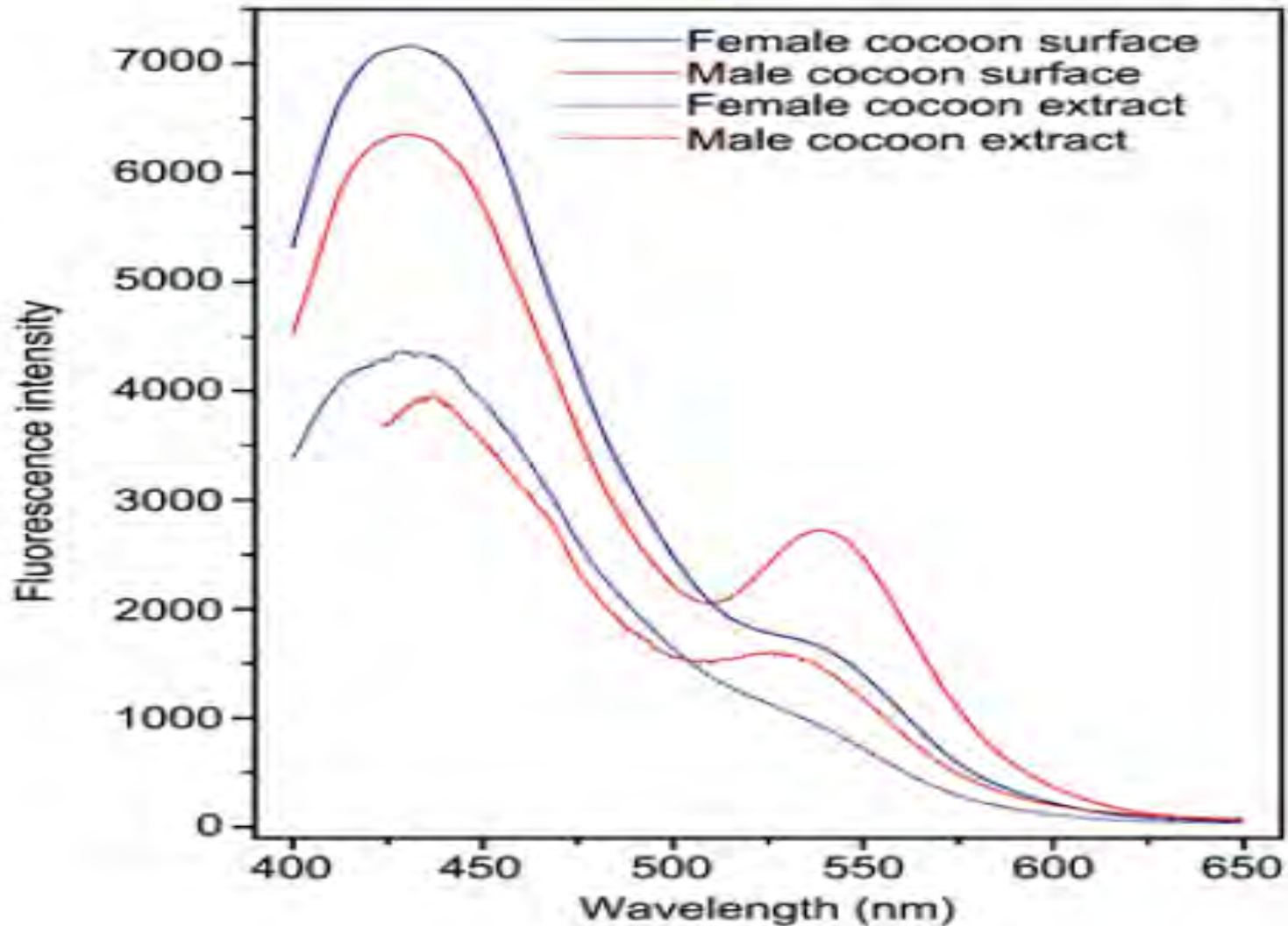
特開2007-71620

(P2007-71620A)

(43) 公開日 平成19年3月22日 (2007. 3. 22)



Silkworm Gender Separation via Fluorescence



Our Need

Silkworm Gender Identification System

- Lower Cost
- Faster Response
- High Accuracy

How ?

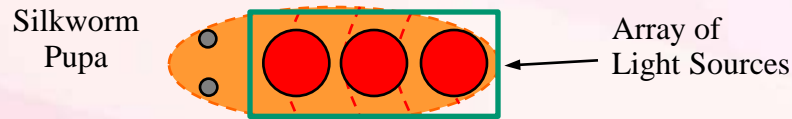
**Optical
Penetration**

+

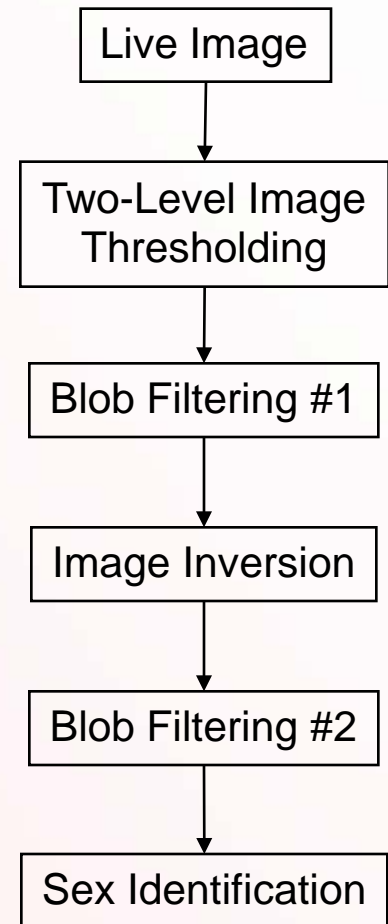
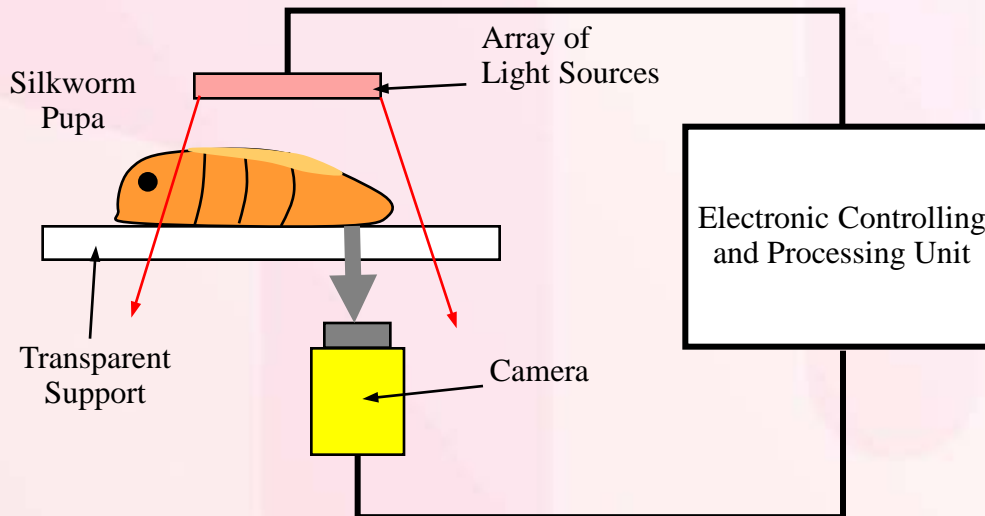
**Image
Processing**

NECTEC Light Penetration-based Silkworm Pupa Sex Identification Structure

TOP VIEW



SIDE VIEW



Female



Male



In average, female silkworm pupae are just **0.08 mm wider** and **0.19 mm longer** than male

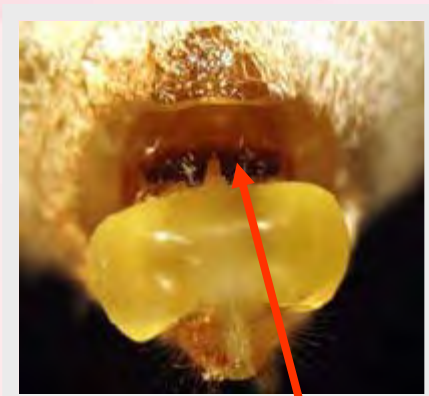
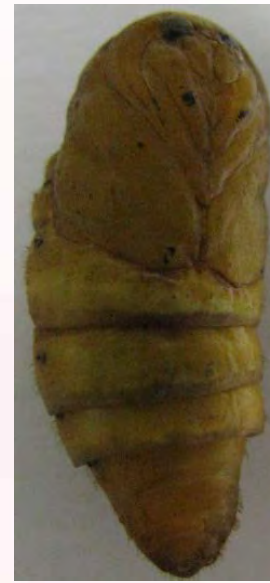


High accuracy in silkworm sex separation via weight and size is hard to accomplish.

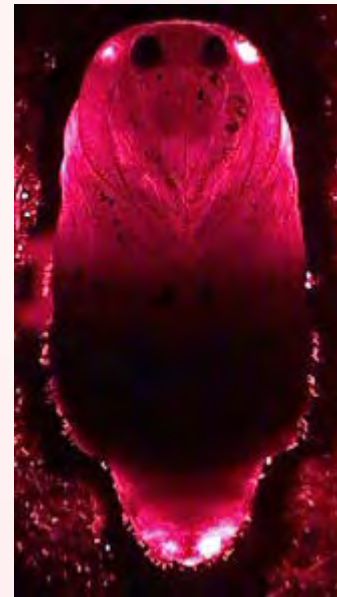
Female



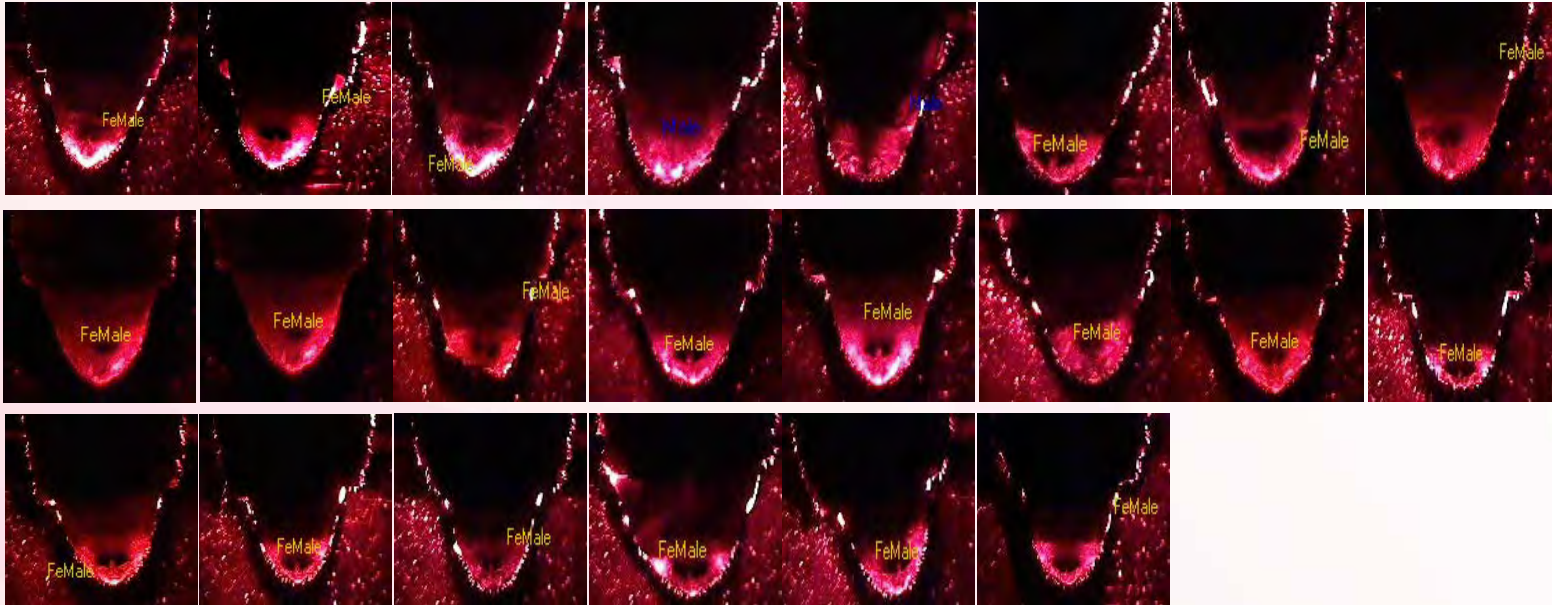
Male



**Chitin
Gland**



Female

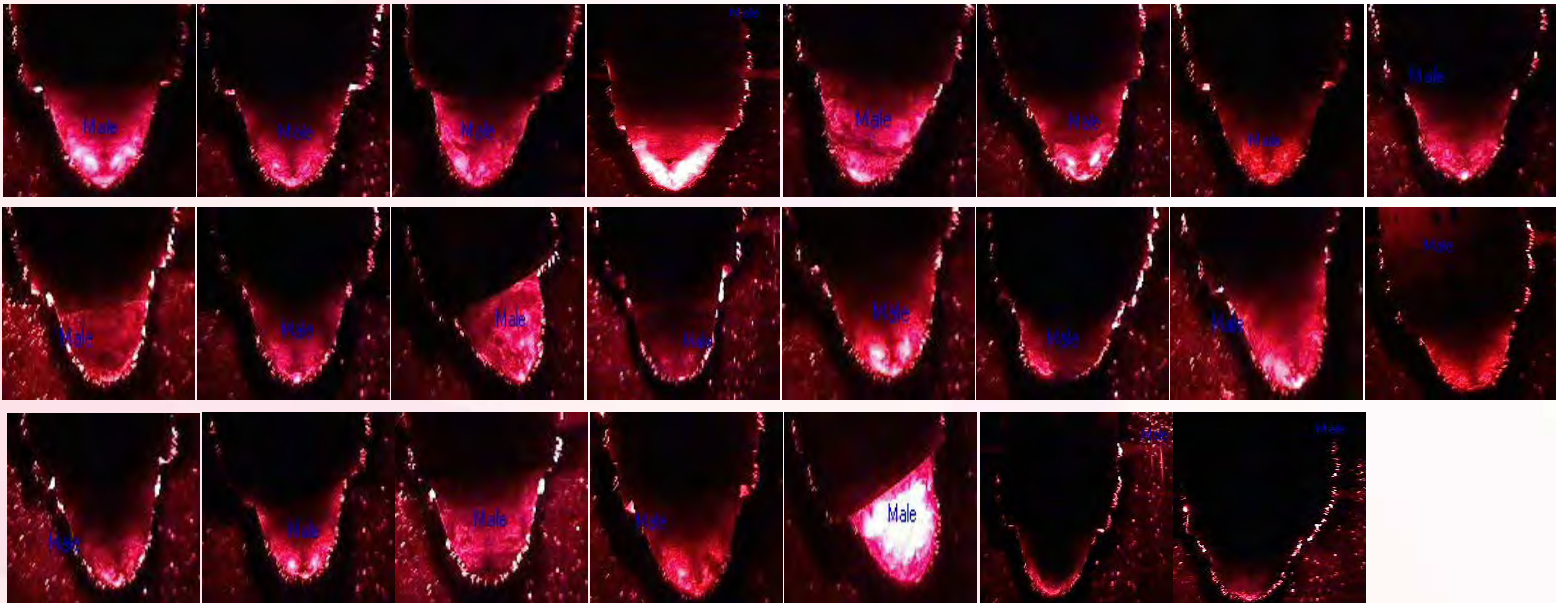


High Accuracy: 20/22 = 90.9%

Problem:

Shrinkage in the posterior area

Male



High Accuracy: 23/23 = 100%

Conclusion

- We propose a low-cost, fast and highly-accurate technique for the identification of silkworm gender

Optical Penetration

+

Simple Image Processing

- We can effectively identify 22 female and 23 male silkworms with 90.9% and 100% accuracies (i.e., total high accuracy of 95.6%), respectively, in a measured average 96.6 ms.
- **Future work relates to** the improvement of the identification accuracy and the field implementation

Thank You