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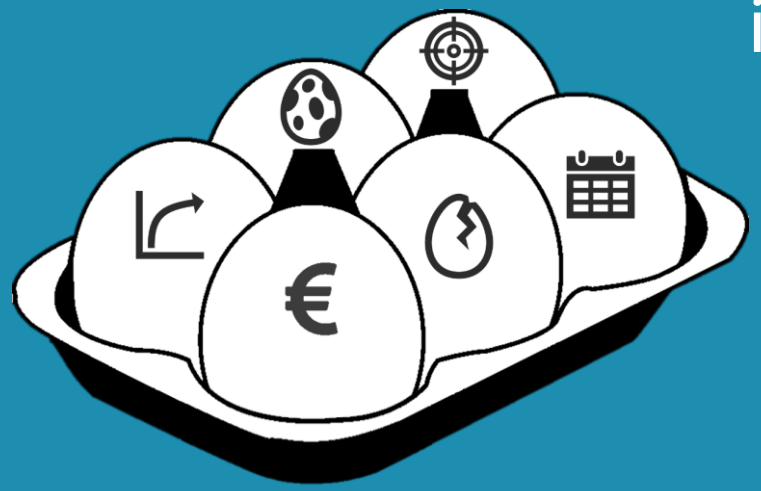


In ovo sexing technologies in hatching eggs: insights from papers and patents

Matthias Corion, **Simão Santos**, Bart De Ketelaere, Dragana Spasic, Maarten Hertog, Jeroen Lammertyn

September 6th, 2023

Day-old male chick culling

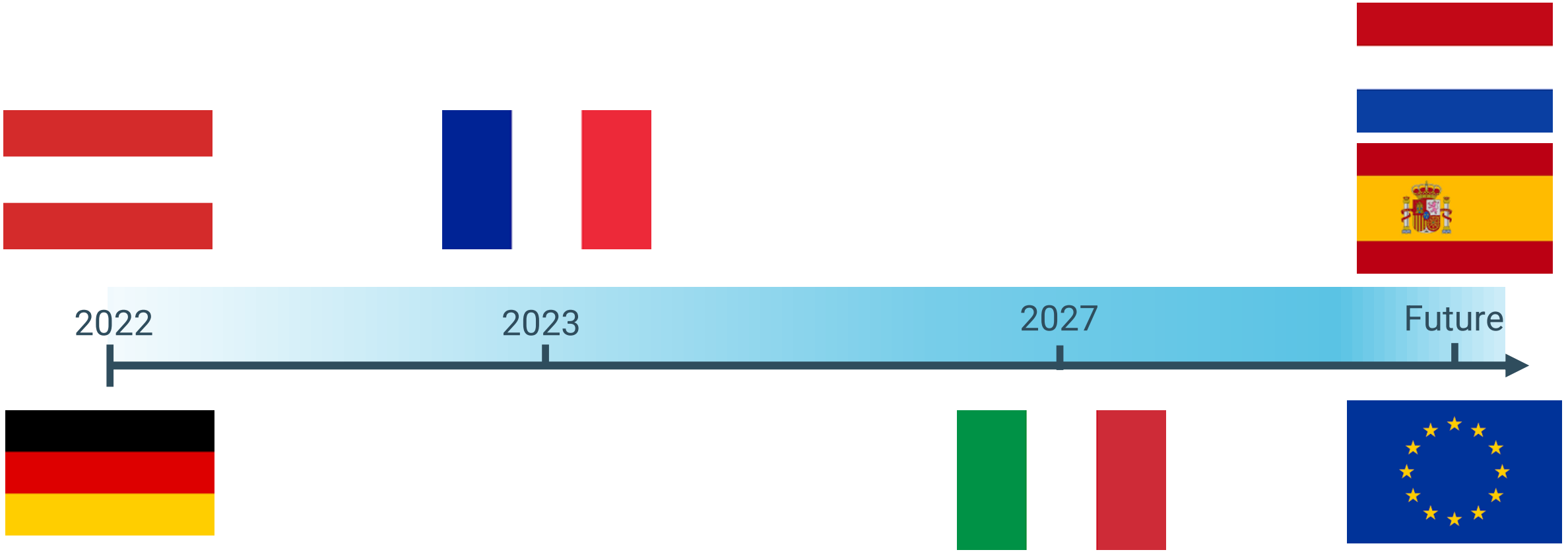
350 million killed in the EU per year

Economic

Ethical

Bruijnis, M. R. N., et al. "Moral “Lock-In” in responsible innovation: the ethical and social aspects of killing day-old chicks and its alternatives." Journal of Agricultural and Environmental Ethics 28 (2015): 939-960.

Chick culling prohibition - Europe



Di Concetto, A., Morice, O., Corion, M., Santos, S. (2023). Chick and Duckling Killing: Achieving an EU-Wide Prohibition. *Chick and Duckling Killing: Achieving an EU-Wide Prohibition*, European Institute for Animal Law & Policy.

Suggested alternatives

Raising male brothers or Dual-purpose chickens

- Lacks growth efficiency and meat quality
- Higher economic burden
- Increase in environmental burden

Male brothers

Dual-purpose

Broilers

Krautwald-Junghanns, Maria-Elisabeth, et al. "Current approaches to avoid the culling of day-old male chicks in the layer industry, with special reference to spectroscopic methods." Poultry science 97.3 (2018): 749-757.

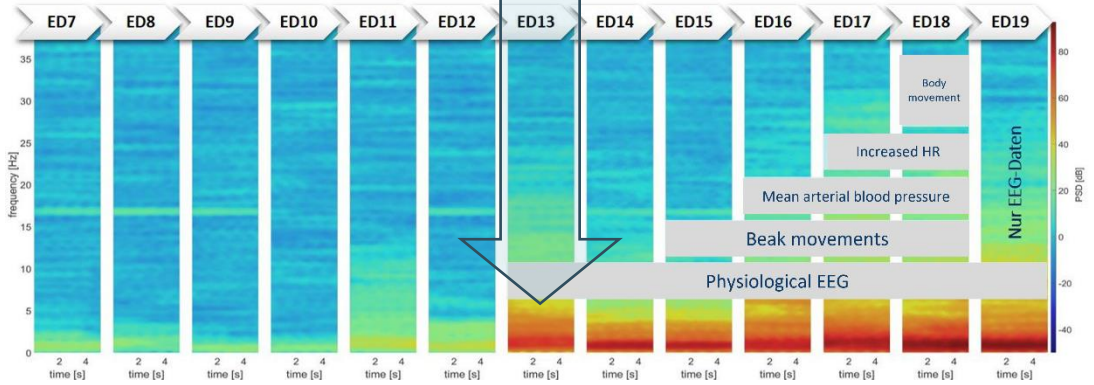
In ovo sexing

Sexual determination of fetus before hatching

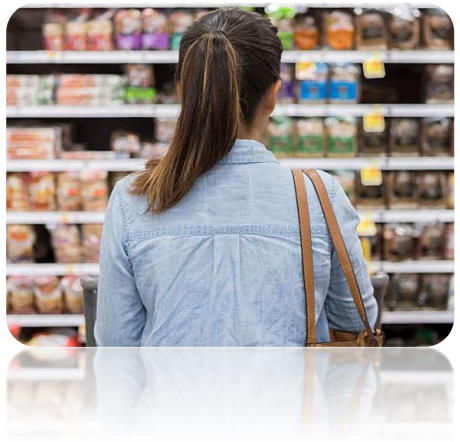
- Embryonic pain perception
- Technology investment costs

Consumers prefer early phase *in ovo* sexing

Pain perception

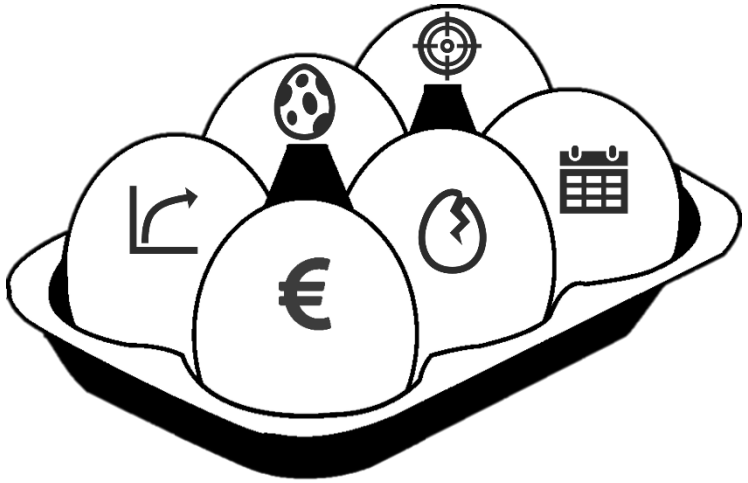


Technische Universtität München, 2023



Reithmayer, C., & Mußhoff, O. (2019). Consumer preferences for alternatives to chick culling in Germany. Poultry Science, 98(10), 4539–4548.

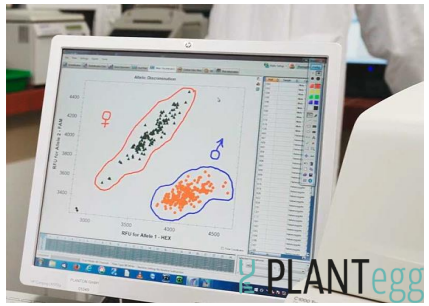
Technology requirements

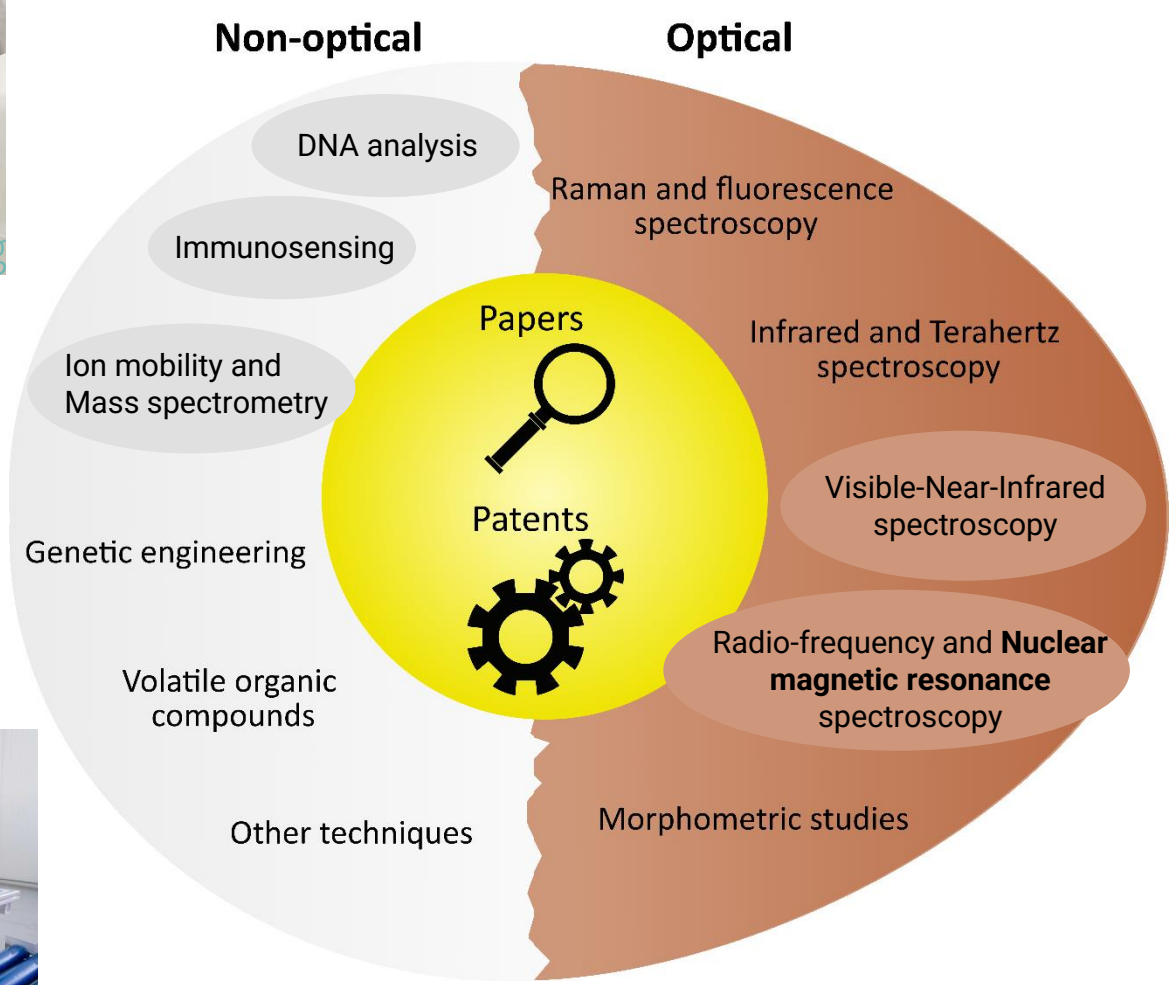


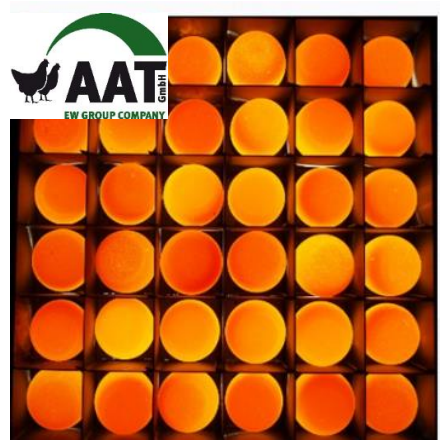
- High throughput
- All breeds
- > 98% accuracy
- Low cost
- Keep the hatchability rates high
- As early as possible (< day 13)

Corion, M. & Santos, S., et al. "Trends in in ovo sexing technologies: insights and interpretation from papers and patents." Journal of Animal Science and Biotechnology 14.1 (2023): 102.

In ovo sexing technologies







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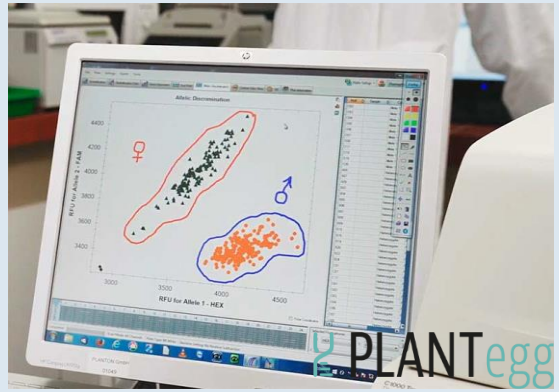
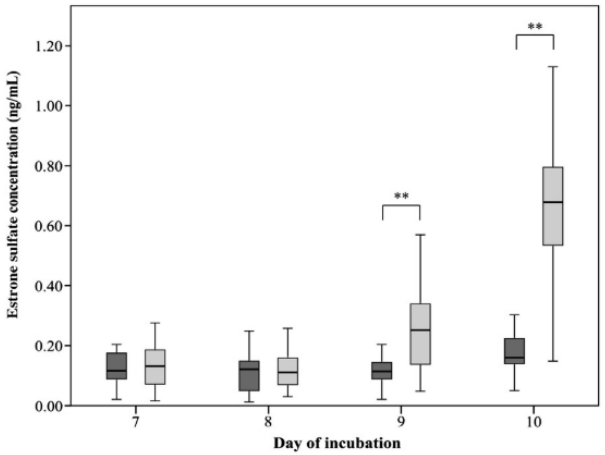
Non-Optical



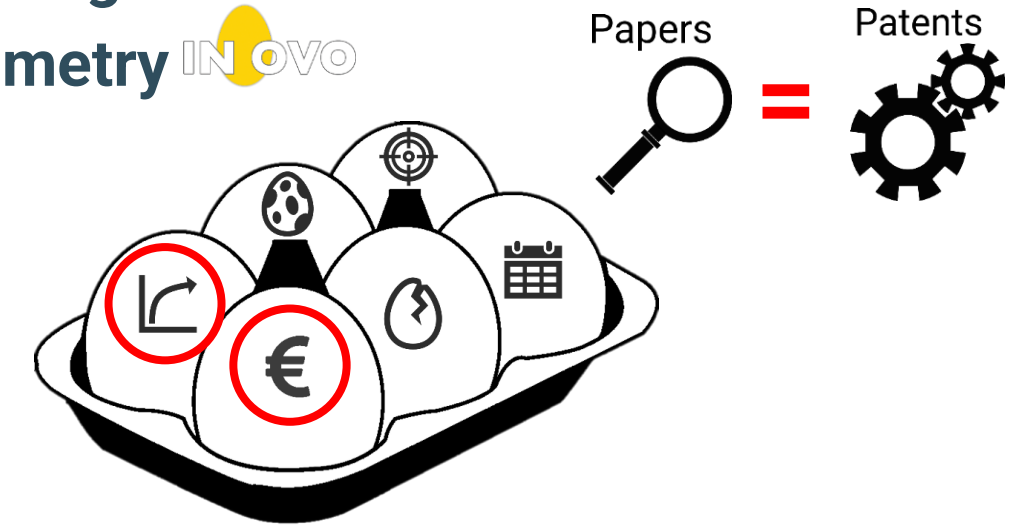
Non-optical *in ovo* sexing techniques

1. **DNA analysis** PLANTegg
2. **Immunosensing** SELEGGT responsible solutions
3. **Mass spectrometry** INOVO

Santos et al., 2023



Weissmann et al., 2013



Corion, M. & Santos, S., et al. "Trends in in ovo sexing technologies: insights and interpretation from papers and patents." Journal of Animal Science and Biotechnology 14.1 (2023): 102.

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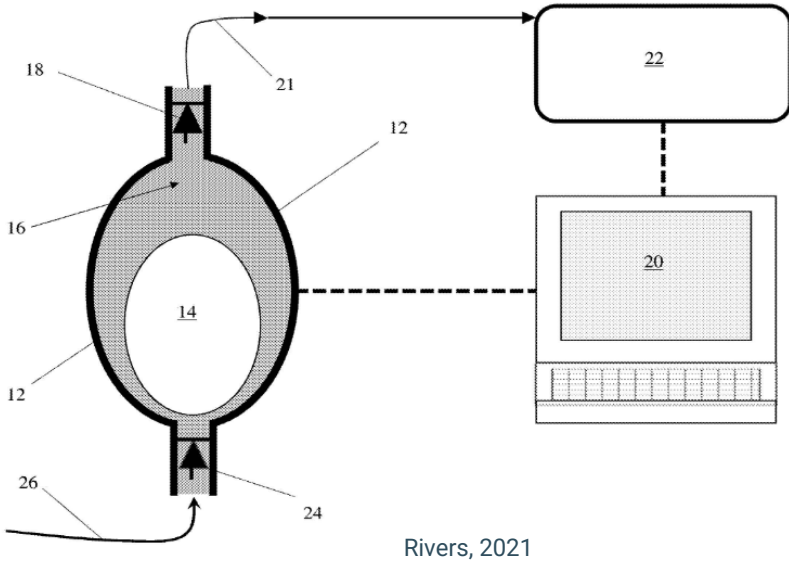
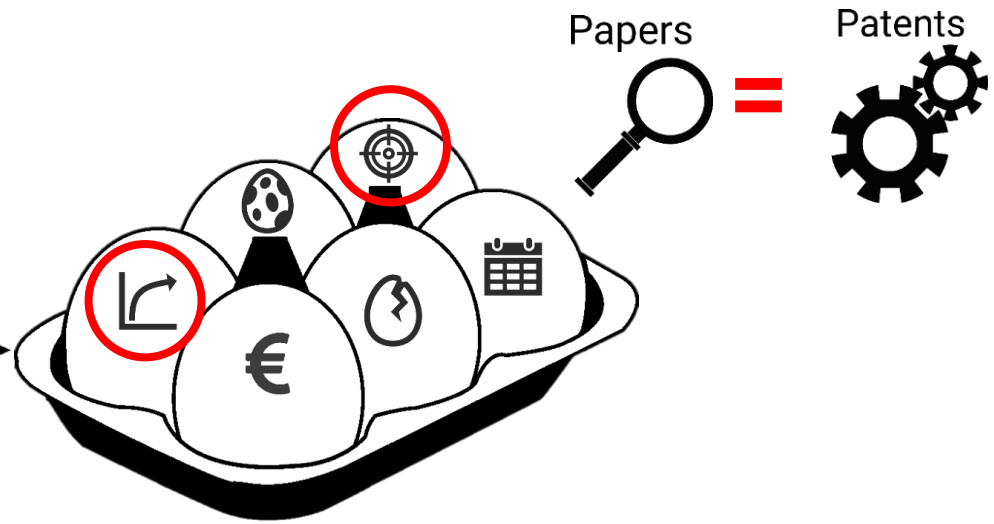
Non-optical *in ovo* sexing techniques

4. Volatile organic compounds

Corion et al., 2021



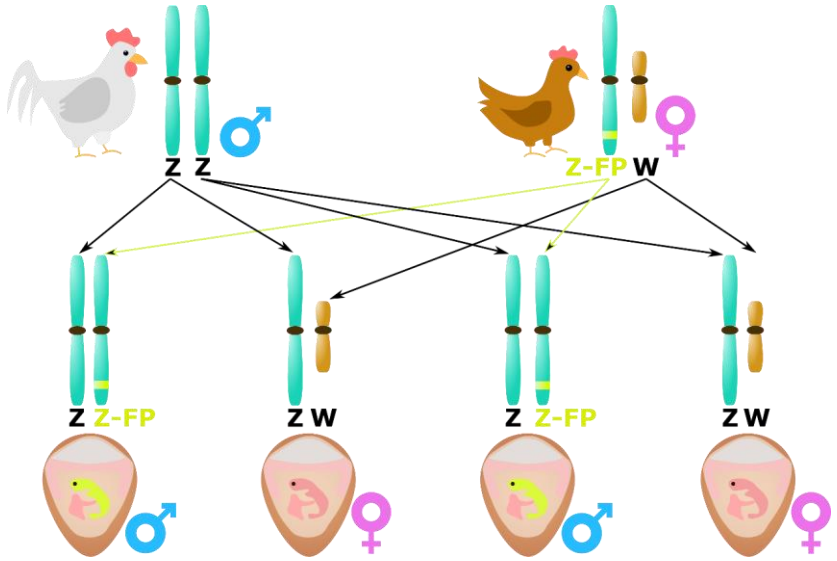
Rivers, 2021



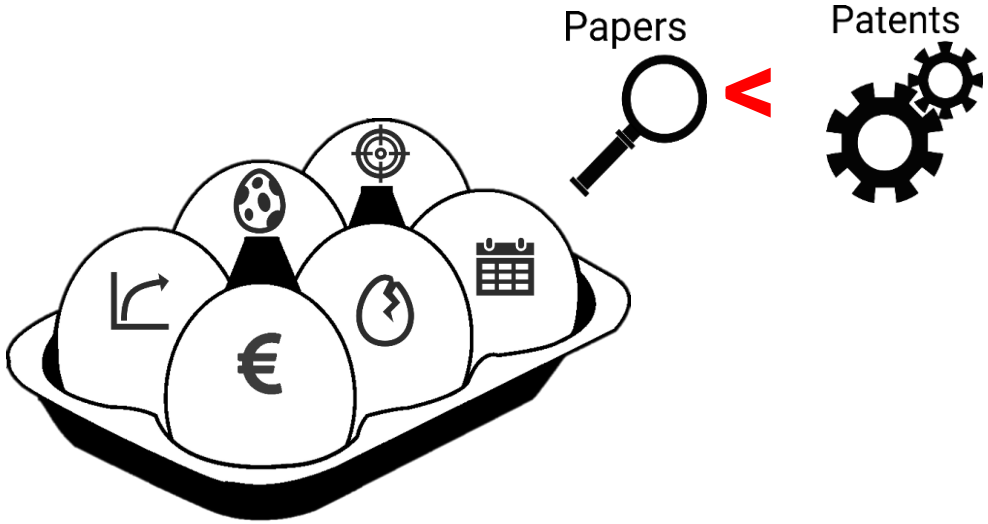
Corion, M. & Santos, S., et al. "Trends in in ovo sexing technologies: insights and interpretation from papers and patents." Journal of Animal Science and Biotechnology 14.1 (2023): 102.

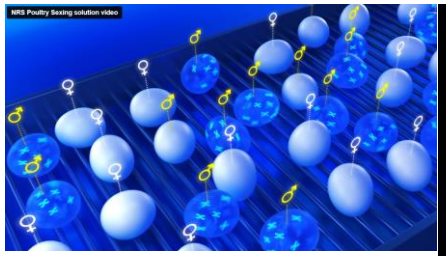
Non-optical *in ovo* sexing techniques

5. GMO



Doran et al., 2018

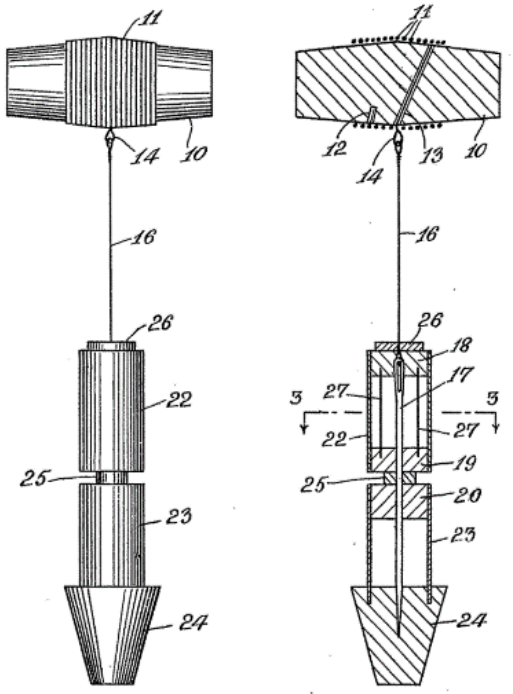




Corion, M. & Santos, S., et al. "Trends in in ovo sexing technologies: insights and interpretation from papers and patents." Journal of Animal Science and Biotechnology 14.1 (2023): 102.

Non-optical *in ovo* sexing techniques

5. Other techniques



Williams, 1920

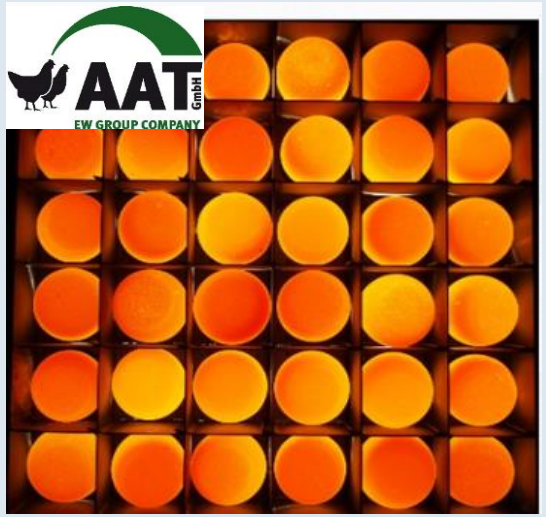
Corion, M. & Santos, S., et al. "Trends in in ovo sexing technologies: insights and interpretation from papers and patents." Journal of Animal Science and Biotechnology 14.1 (2023): 102.

Overview – Non-optical

		Colors	Accuracy	Hatchability	Early in time (day)	Throughput	Cost
Commercial	DNA analysis	✓	100%	✓	9	↓	↑ ↑
	Immunosensing	✓	98%	✓	9	↓	↑ ↑
	IMS and MS	✓	95%	✓	9	↑	↑
	GMO	✓	100%	✓	0	↑	↑
	VOC analysis	✓	?	✓	0	↓	?
	Other	✓	?	?	0	?	?

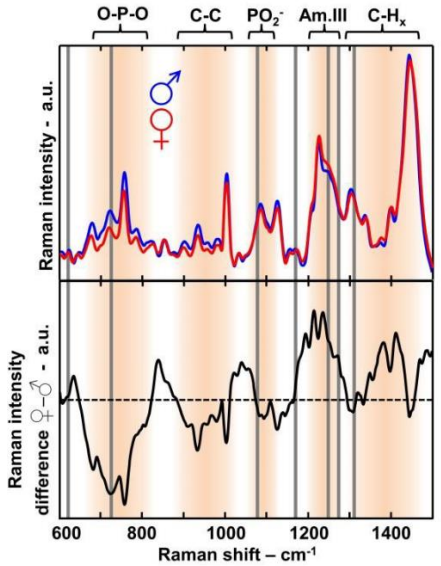
Corion, M. & Santos, S., et al. "Trends in in ovo sexing technologies: insights and interpretation from papers and patents." Journal of Animal Science and Biotechnology 14.1 (2023): 102.

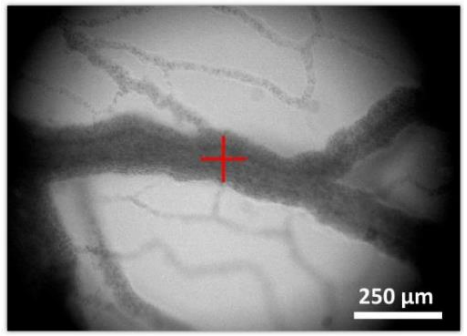
Optical



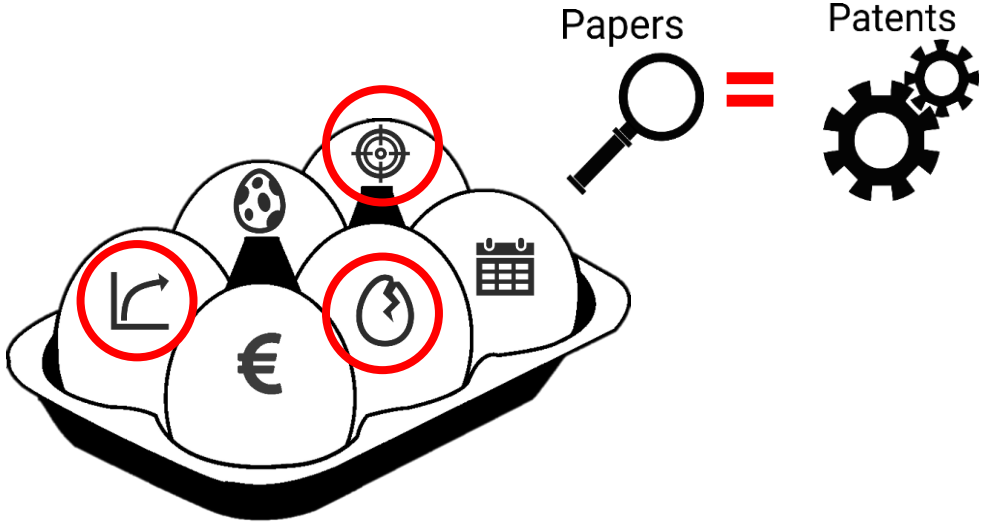
Optical *in ovo* sexing techniques

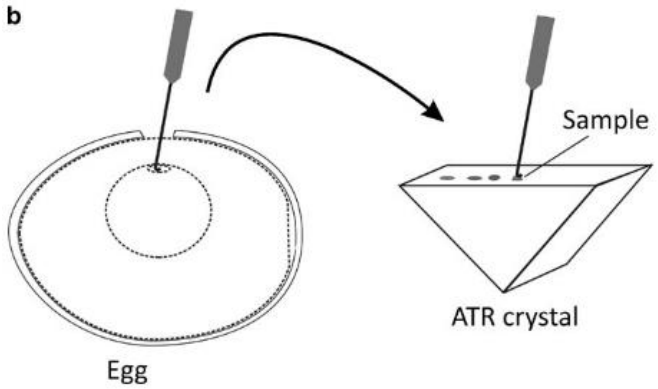
1. Raman & Fluorescence
2. Infra Red & Terahertz





Galli et al., 2018



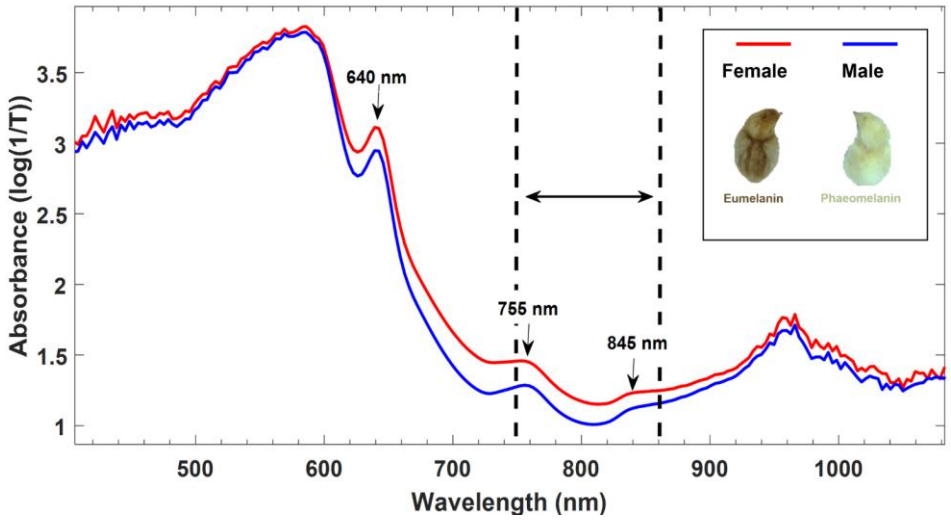


Steiner et al., 2011

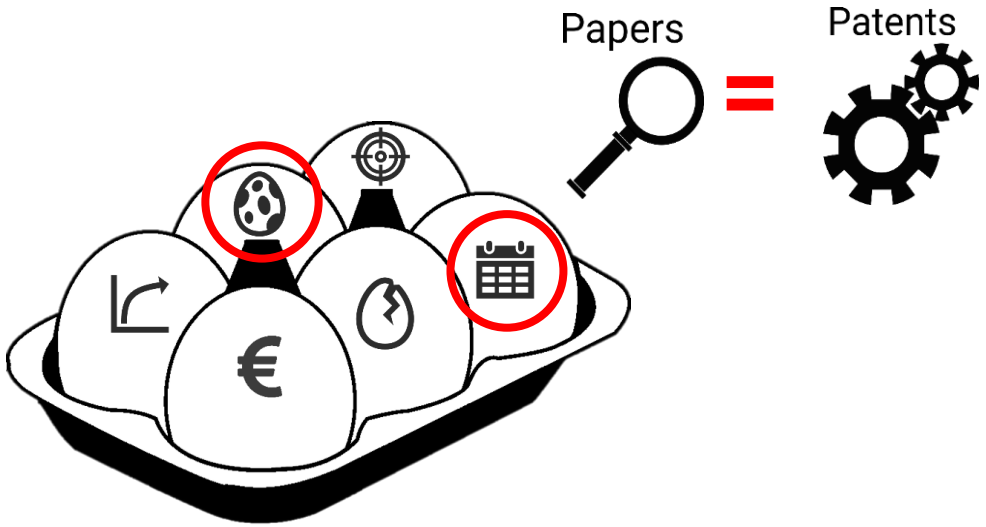
Corion, M. & Santos, S., et al. "Trends in in ovo sexing technologies: insights and interpretation from papers and patents." Journal of Animal Science and Biotechnology 14.1 (2023): 102.

Optical *in ovo* sexing techniques

3. Visible – Near IR spectroscopy



Corion et al., 2022



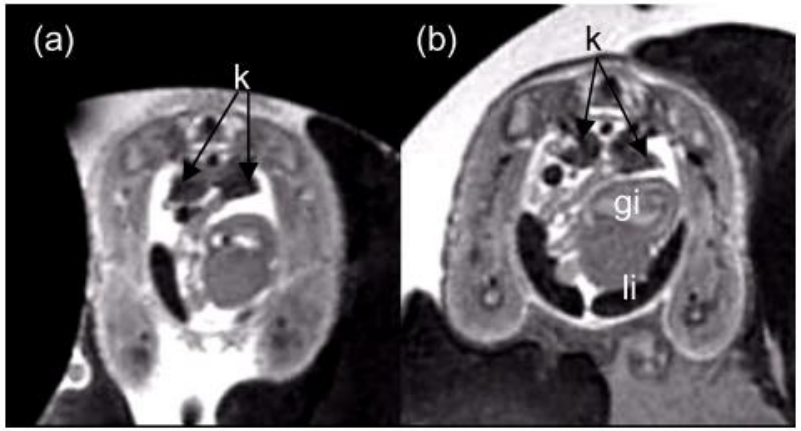
Targets

- Sex-specific coloring
- Embryonic growth rate
- Sex-related blood absorption
- Heart rate or body movement

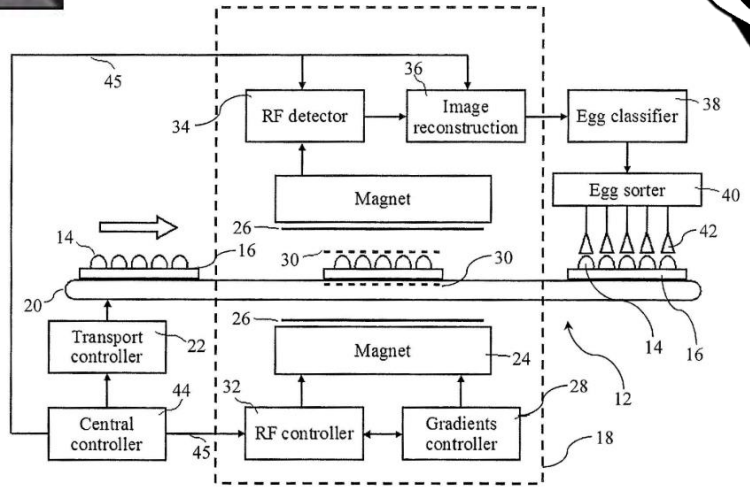
Corion, M. & Santos, S., et al. "Trends in in ovo sexing technologies: insights and interpretation from papers and patents." Journal of Animal Science and Biotechnology 14.1 (2023): 102.

Optical *in ovo* sexing techniques

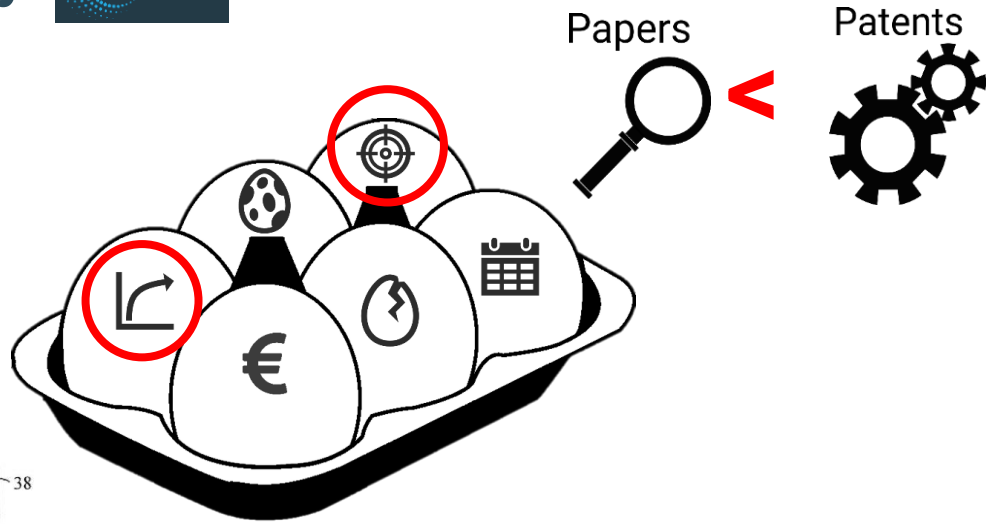
4. Nuclear magnetic resonance spectroscopy



Davenel et al., 2015



Haase et al., 2019



Corion, M. & Santos, S., et al. "Trends in in ovo sexing technologies: insights and interpretation from papers and patents." Journal of Animal Science and Biotechnology 14.1 (2023): 102.

Optical *in ovo* sexing techniques

5. Morphometric studies

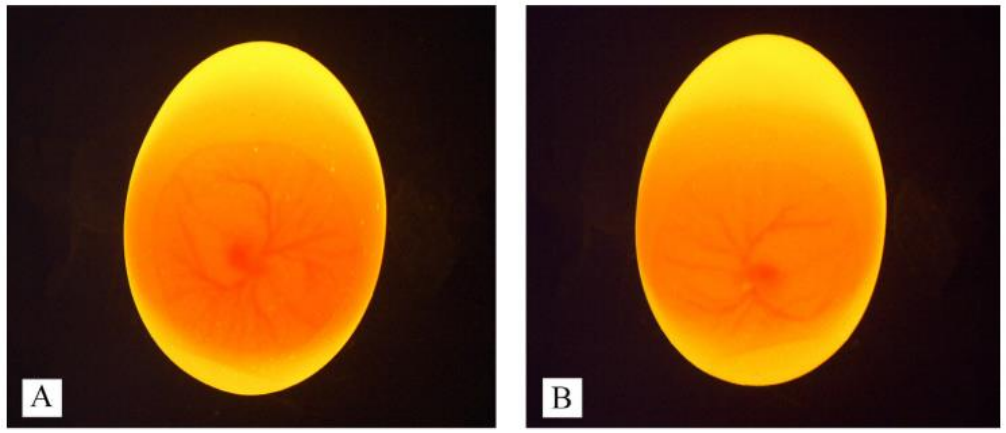
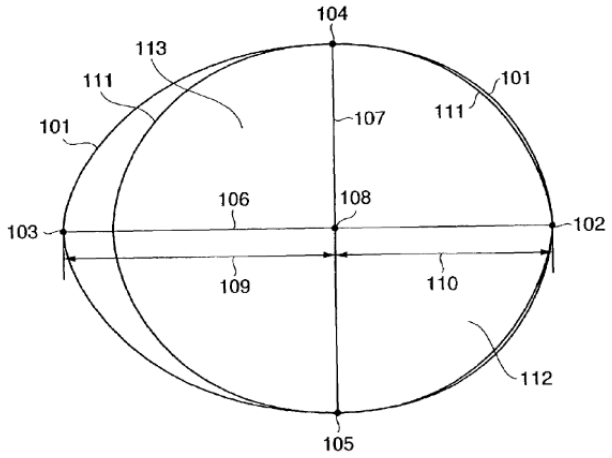
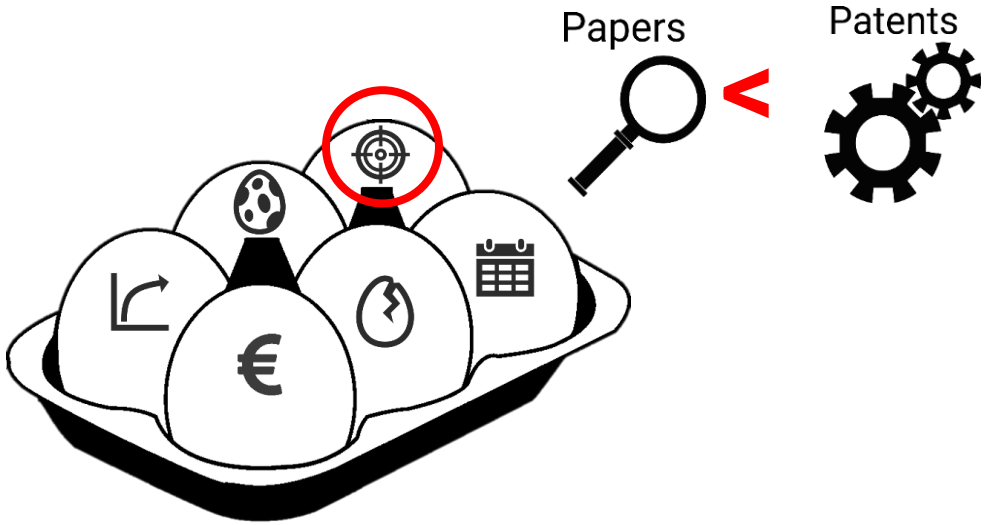


Figure 4. Machine vision images showing eggs carrying (A) male and (B) female embryos.

Zhu et al., 2021



Taniguchi, 2007



Corion, M. & Santos, S., et al. "Trends in in ovo sexing technologies: insights and interpretation from papers and patents." Journal of Animal Science and Biotechnology 14.1 (2023): 102.

Overview - Optical

		Colors	Accuracy	Hatchability	Early in time (day)	Throughput	Cost
	Raman & Fluorescence	✓	96%	✓	3.5	↓	?
	IR & THz	✓	✗	✗	0	↑	?
Commercial	Vis-NIR	✗	97%	✓	0 - 13	↑	↓
Commercial	NMR	✓	~98%	✓	12 - 18	↑ ↓	?
	Morphometric studies	✓	90%	✓	0 - 4	↑	?

Corion, M. & Santos, S., et al. "Trends in in ovo sexing technologies: insights and interpretation from papers and patents." Journal of Animal Science and Biotechnology 14.1 (2023): 102.

Applied IOS technologies in Europe

Pain perception

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

Non-optical

SELEGGT responsible solutions

~ 3-4 €/DOC
2018

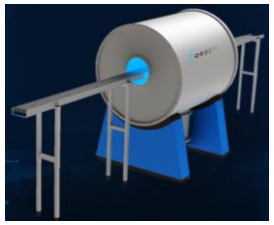
INOVO

~ 2-3 €/DOC
2020

PLANTegg

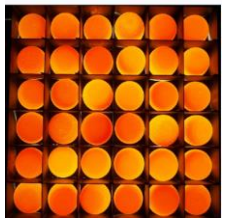
~ 4-5 €/DOC
2020

Optical



ORBEM

?? €/DOC
2023



AAT GmbH
EW GROUP COMPANY

~ 1,10 €/DOC
2019

Growing the males

~ 3-4 €/DOC

Corion, M. & Santos, S., et al. "Trends in in ovo sexing technologies: insights and interpretation from papers and patents." Journal of Animal Science and Biotechnology 14.1 (2023): 102.

Applied IOS technologies in Europe

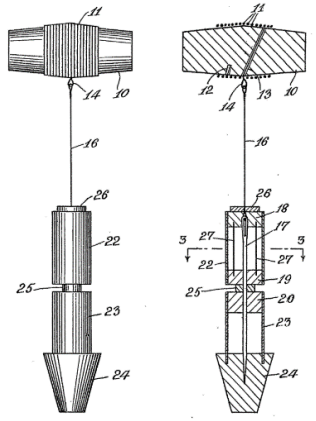
Commercially applied in ovo sexing technologies

	Non-optical			Optical	
Company (Origin)	**PLANTegg** (DE)	**Seleggt** (DE)	**In Ovo** (NL)	**Orbem** (DE)	**AAT** (DE)
Category	DNA analysis	Immunosensing	Mass Spectrometry	NMR	VIS-NIR
Day	9	9	9	12	13
Sampling	Allantoic fluid			Contactless	
Sexing accuracy	99%	97%	~95%	~98%	97%
Eggs/hour/ device	3000	3000	6500	3000	20,000
Patents	Weigel et al. [19]	Einspanier [27, 28] Meter [30, 31]	Bruins & Stutterheim [39, 40] Stutterheim et al. [41 - 43]	Haase et al. [126]	McKay [96] Hurlin [97]
Papers	NA	Weissmann et al. [33, 34]	NA	NA	Göhler et al. [11]

Corion, M. & Santos, S., et al. "Trends in in ovo sexing technologies: insights and interpretation from papers and patents." Journal of Animal Science and Biotechnology 14.1 (2023): 102.

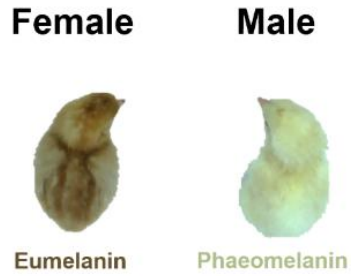
Conclusion & future perspectives

✓ Several efforts in *in ovo* sexing technologies since 1907



Williams, 1920

✓ **Optical techniques** are efficient: non-invasive and high throughput



Corion et al., 2022

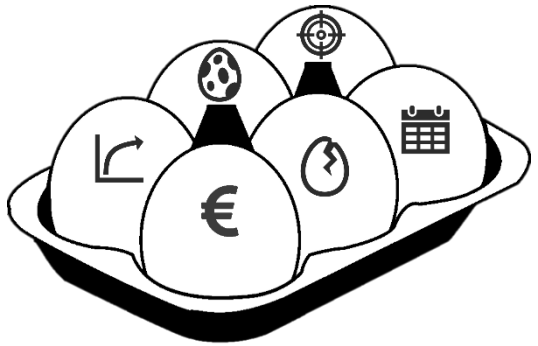
✓ DNA analysis, immunosensing, and mass spectrometry: **promising future**

Santos et al., 2023

Corion, M. & Santos, S., et al. "Trends in in ovo sexing technologies: insights and interpretation from papers and patents." Journal of Animal Science and Biotechnology 14.1 (2023): 102.

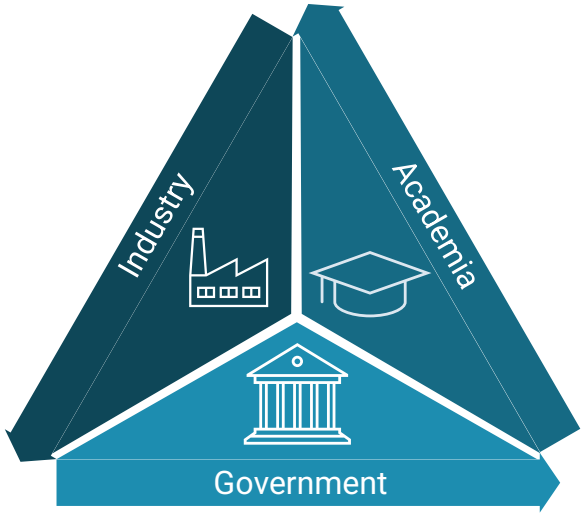
Conclusion & Future perspectives

✓ **No technology** matches all the requirements



✓ Harmony between industry, academia, and the government **is necessary**

✓ **Market performance** will offer insights into potential and expectations



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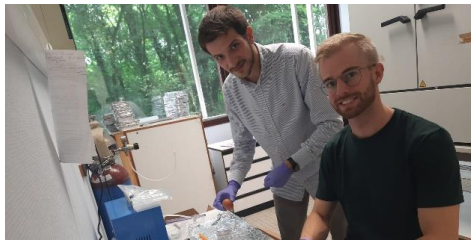
Acknowledgements



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