“Parasite AI Has Entered the Chat”: Parasitology Finally Leads the Field in Clinical Microbiology

Marc Roger Couturier Ph.D., D(ABMM)

Generated with AI · February 29, 2024 at 10:18 AM

October 23, 2025

Disclosures

Relevant:

- Techcyte – research reagents, collaboration

Less relevant:

- Seegene – Scientific Advisory Board
- Biorad – Scientific Advisory Board
- Genetic Signatures – speaker fees, clinical trials activities
- biomérieux – consultant, research support, speaker fees, stock ownership, spousal income
- The College of American Pathologists – Microbiology Resource Committee
- American Society for Clinical Pathology – educational committee, examination committee

Practical:

- ARTIFICIAL INTELLIGENCE is **NOT** intelligent! It needs guidance & direction to reach a set goal

Objectives

- Review the use of traditional parasitology testing for gastrointestinal parasites
- Recognize the value and role of AI for trichrome stain interpretation and screening
- Recognize the diagnostic yield and role of wet-mount screening with AI
- Understand other emerging applications of AI in microbiology

Microscopy for Parasites

- **Pros**:
  - Detect anything you can see
  - Fun!
- **Cons**:
  - Insensitive
  - Requires well-trained personnel
  - Maintaining competence
  - Time-consuming
  - Scope fatigue/burnout/retiring workforce…lack of new interest

Ova & Parasite Exam

- Standard O&P (most conventional parasites)
  - **Wet mount stain:** specimen + iodine
  - **Trichrome stain**: specimen on slide + stain

***Coccidia & *Cryptosporidium* stain:**
(modified acid fast or safranin)
Same process as trichrome (not done on all O&Ps)

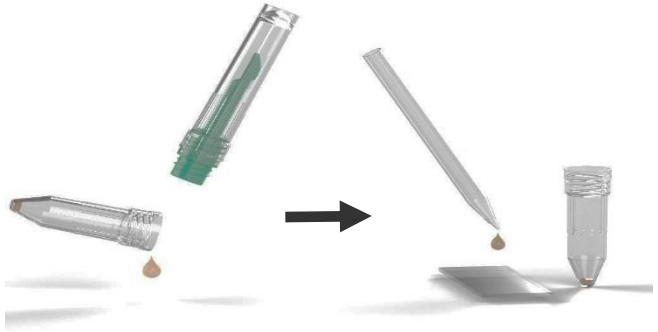
O&P Use

- Recommended: 3 specimens/patient
  - Reasonable exposure/risk
- Reality: EVERYONE with diarrhea (exaggeration)
- ~120k orders/year
  - ~240k preps/examinations

Content credentials
Generated with AI · November 20, 2023 at 1:03 PM

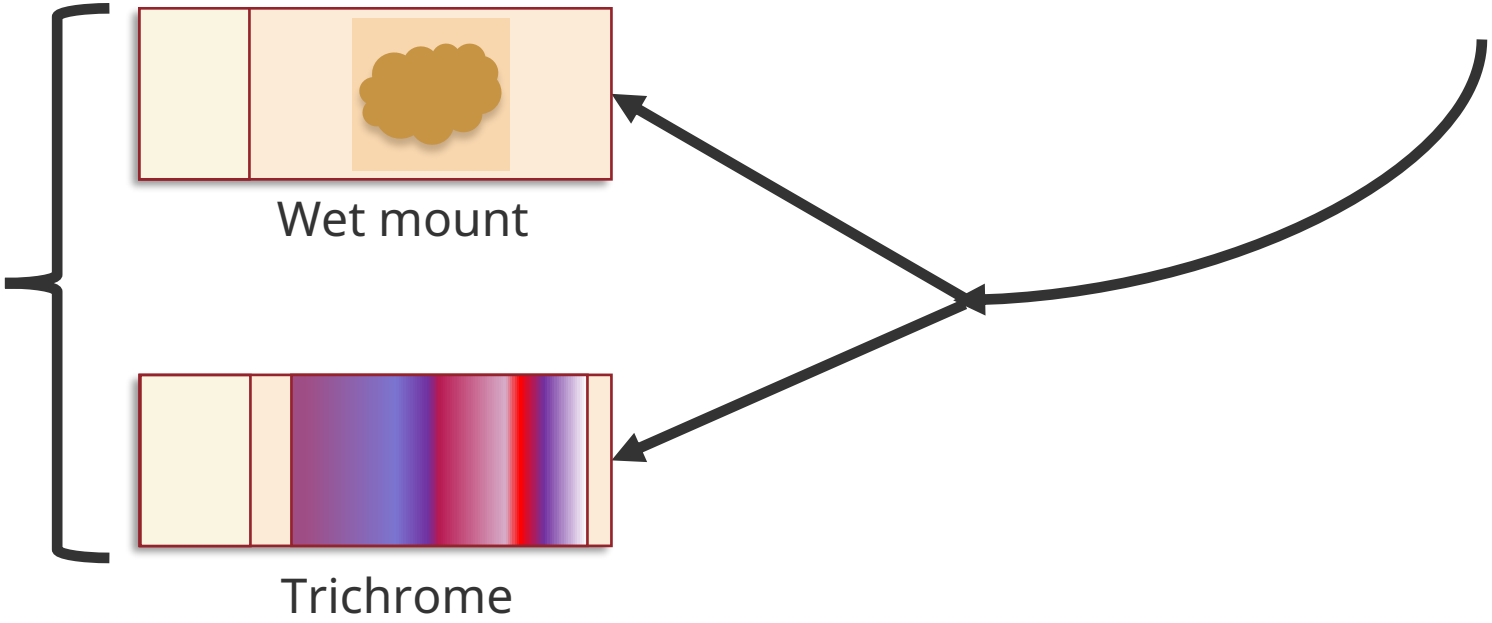
Preparation for an O&P

Spin at 400 *x g* for 2 minutes

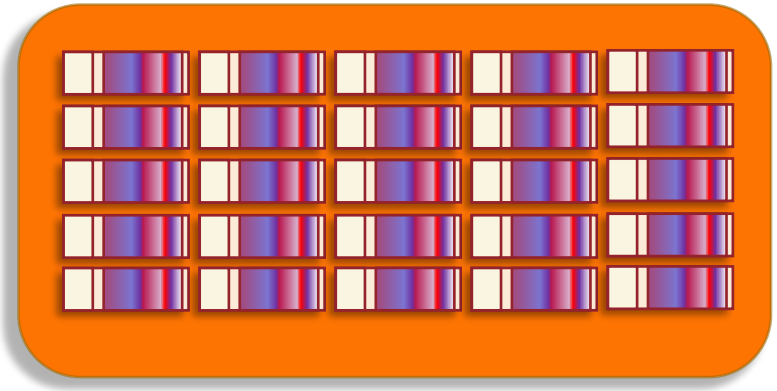


Decant

Prepare Slides



Reading an O&P Run



- 30 trichrome slides
- 30 wet mounts

✓ ~2.5 – 3 hours/run
✓ ~98% negative
✓ Positives back-read

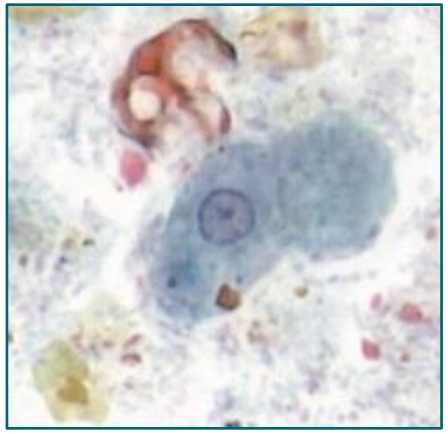
2-5 min/slide (technologist variable)

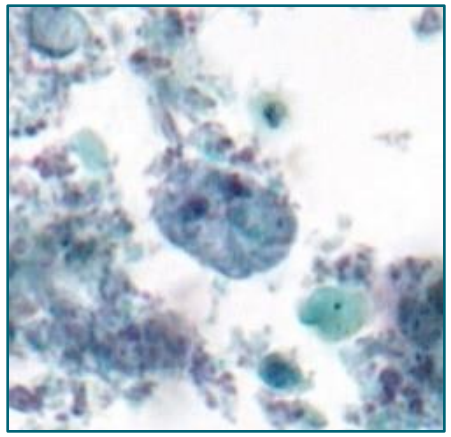
“Questionable artifacts” can take longer

Concerns for O&P Reading

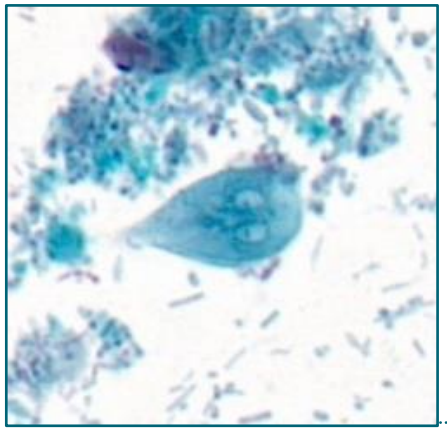
- ✓Eye strain
- ✓Neuromuscular strain
- ✓Burnout/low Satisfaction
- ✓ Decreased Accuracy
  - Individual
  - Time of day
  - Workload

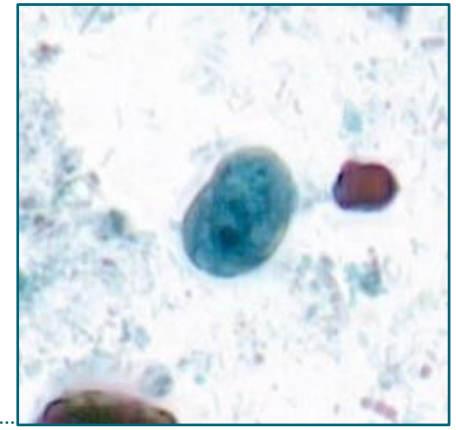
Content credentials
Generated with AI · November 20, 2023 at 1:05 PM





Digital imaging & machine learning can make this process more efficient & accurate?



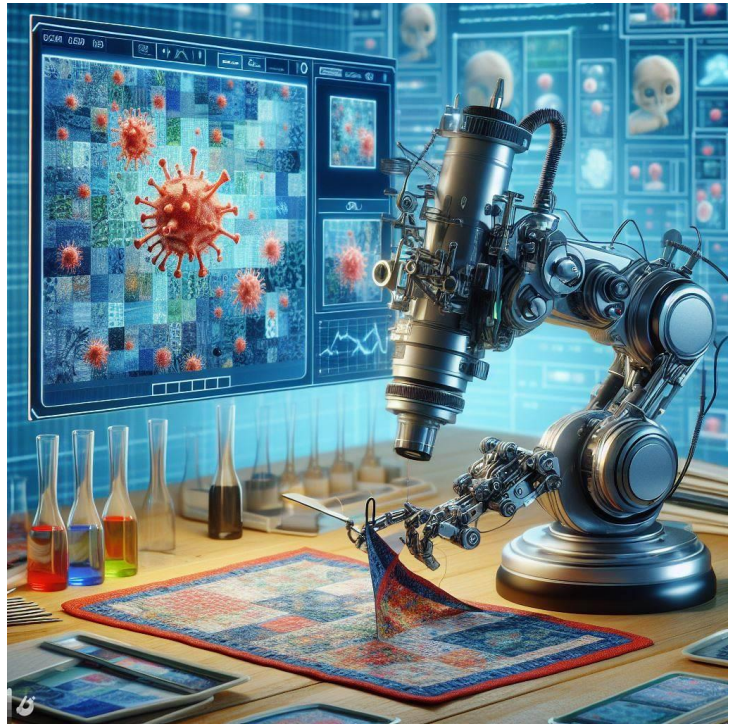


Digital Imaging

Capture images & “thread” into virtual slide

Must be:

- ✓High resolution
- ✓User friendly
- ✓Equal or better than microscopy
- ✓Time-efficient for scans



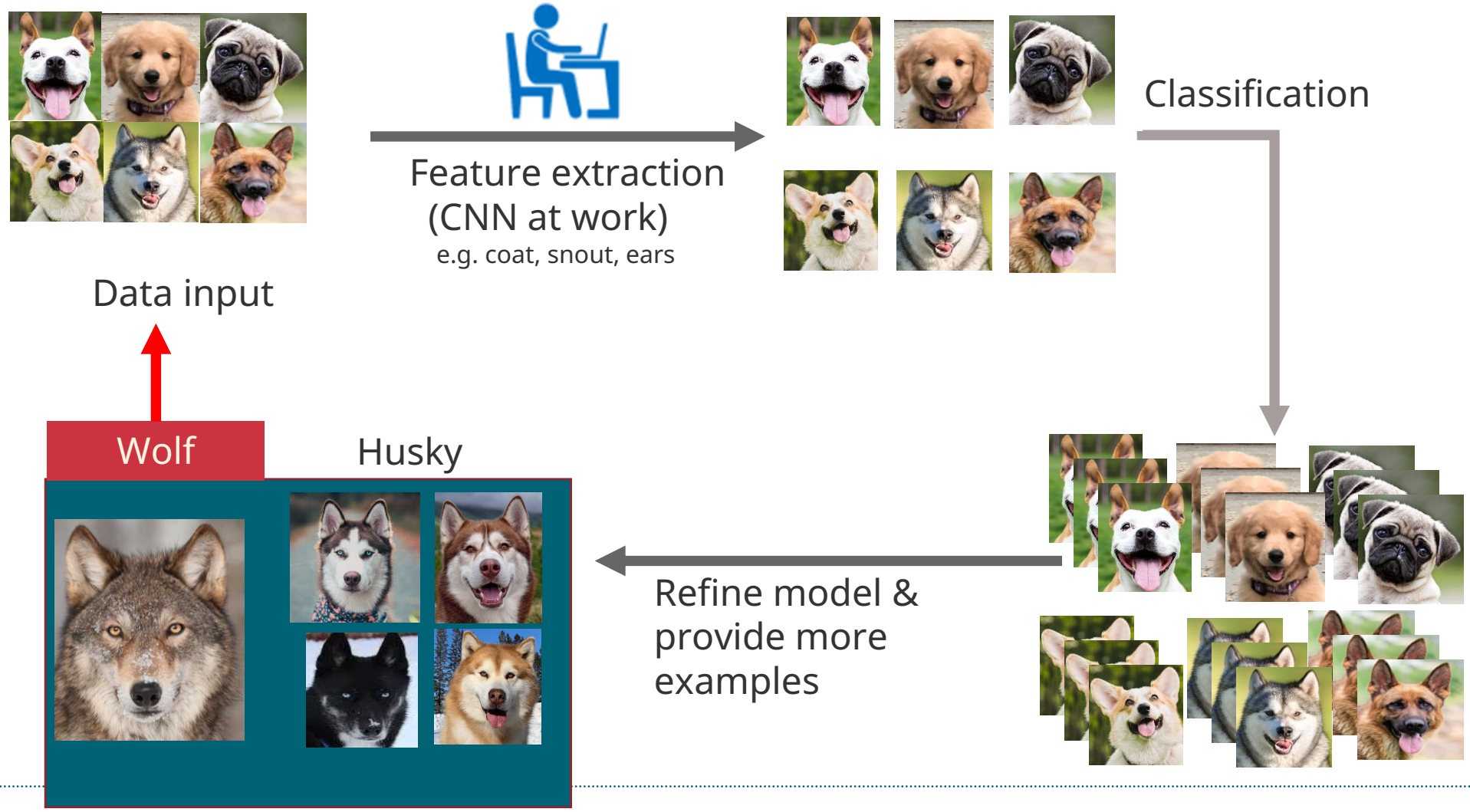
Content credentials
Generated with AI · November 20, 2023 at 1:20 PM

Think Google Image Search

- “Ok Google” show me a husky

Now show me more huskies

Machine Learning & Convolutional Neural Network (CNN) – Simplified



Supervised Learning

- Expert boxes organisms = “truth”
- Software eventually predicts organisms
  - Expert confirms or denies
- Software runs iterations
  - Expert remediates software…software learns
- ~ >1000 remediated examples: predictions = accurate

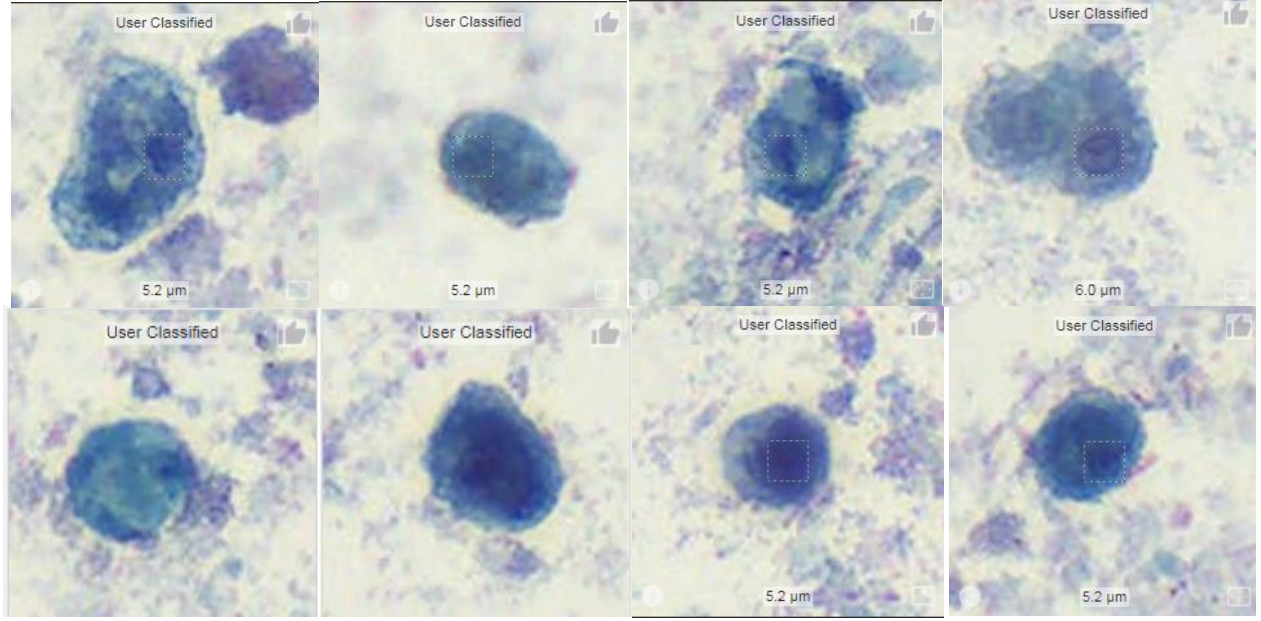

Jess Kohan

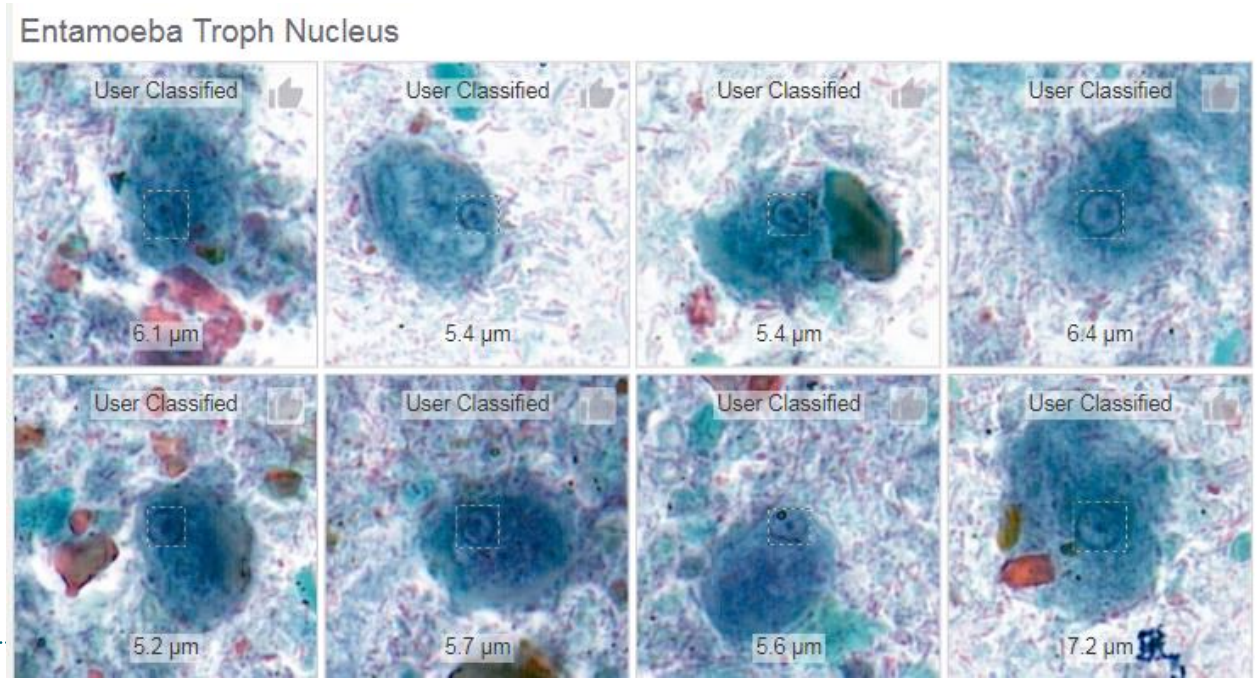

Katie Knight


‘The’ Blaine Mathison

3DHISTECH Pannoramic 250

- 80X virtual magnification
- 250 slide capacity
- Extended focus
  - Automated “good depth” image
- BUT - Slides load on angle (problem for wet-mounts)





Motic scanner

vs

3D HISTECH Scanner

Wish List Metrics for Success (circa 2018)

✓Faster

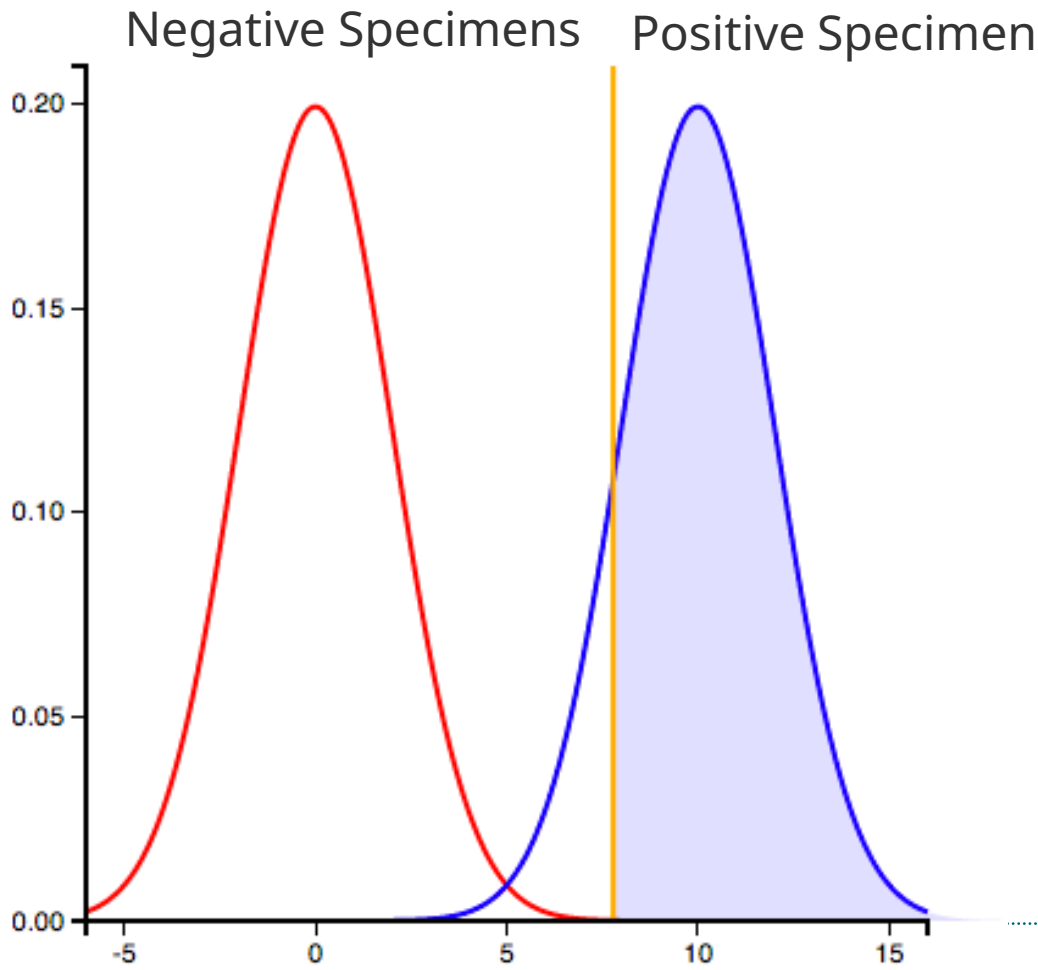
✓Easier

✓Less hands on

Goal: Screen out 70% of negative specimens w/no microscope.

Content credentials
Generated with AI · November 20, 2023 at 1:33 PM

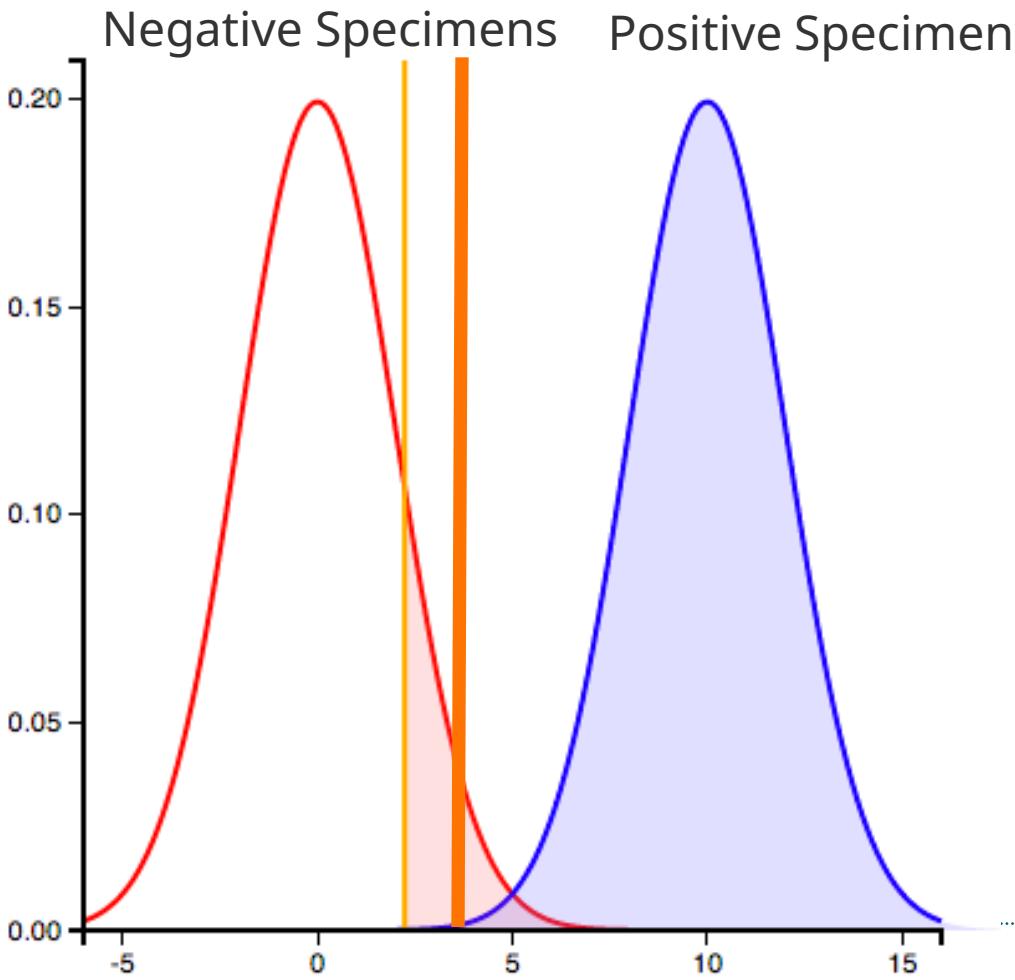
Perfect Specificity, Lower Sensitivity…



- Everything identified is true
- Will miss some positives

Courtesy Rick Smith, Technicyte

Perfect Sensitivity, Lower Specificity…

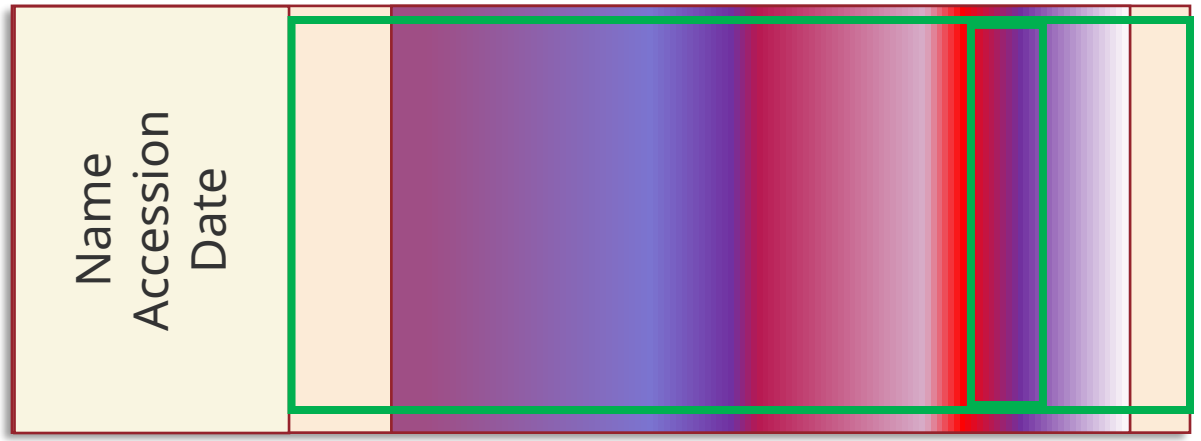


- Identifies everything
- Shows some junk, but human arbitrates it
- Find a sweet spot: catches all, but limits junk!

Courtesy Rick Smith, Technicyte

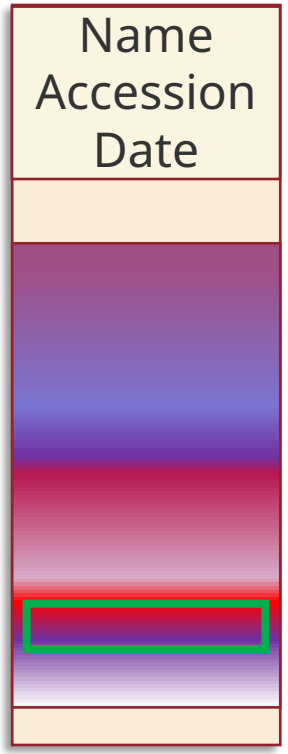
Whole Slide Scanning

- Not time-effective, not standard of care
- Theoretical slide scan area (= to manual read fields)
  - Minimize scan time & maintain equal or better accuracy than human



Are We Still Sensitive? (@ slide level)

- Serially diluted *Giardia* & *Blastocystis* in negative stool
- Duplicate slides of each dilution
  - Manual read in lab (blindly integrated into run)
  - Scanned & read by AI
- Compare analytical sensitivity with new scan area



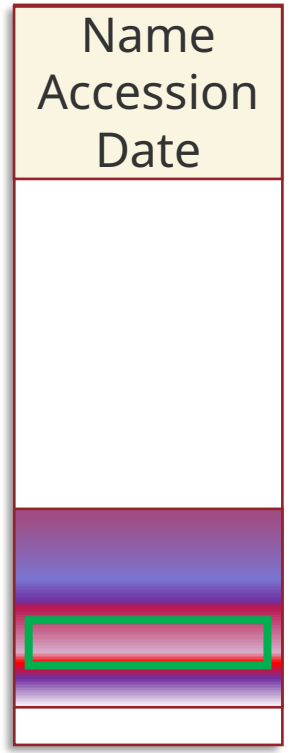
Analytical Sensitivity – Scan Area Test

Dilution	Technologist read	AI read
Neat	Giardia + Blastocystis	Giardia (276) + Blastocystis (129)
1:1	Giardia + Blastocystis	Giardia (95) + Blastocystis (19)
1:2	Giardia + Blastocystis	Giardia (68) + Blastocystis (17)
1:4	Giardia + Blastocystis	Giardia (79) + Blastocystis (46)
1:8	Negative	Giardia (70) + Blastocystis (13)
1:16	Giardia + Blastocystis (rare)	Giardia (12) + Blastocystis (10)
1:32	Negative	Giardia (16) + Blastocystis (5)
1:64	Negative	Giardia (15) + Blastocystis (2)
1:128	Negative	Giardia (9) + Blastocystis (1)
1:256	Negative	Giardia (15) + Blastocystis (1)

AI (with constrained scan region) was 4-6 fold more sensitive than a human

AI Enters Validation

- Software is locked down: **no further learning**
- "Holdout" slides used to validate software – Techcyte (commercial partner)
- ARUP validates w/ validation slide set
  - Development >12 months, validation < 2 weeks
- Train lab
- Go Live (invisible to anyone external)



Limit of Detection

- Human: No dilutions series (n=4) detected below 1:16 dilution
- AI: Detected all to 1:256

Content credentials
Generated with AI · November 20, 2023 at 12:43 PM

Slide-Level Accuracy

- False Positive: AI images cannot be excluded as “False” without review of slide.

O&P Examination

CNN Model Analysis

	Positive	Negative
Positive	86	2
Negative	1	104

Positive percent agreement: 98.88% [95% CI 93.76% to 99.98%]

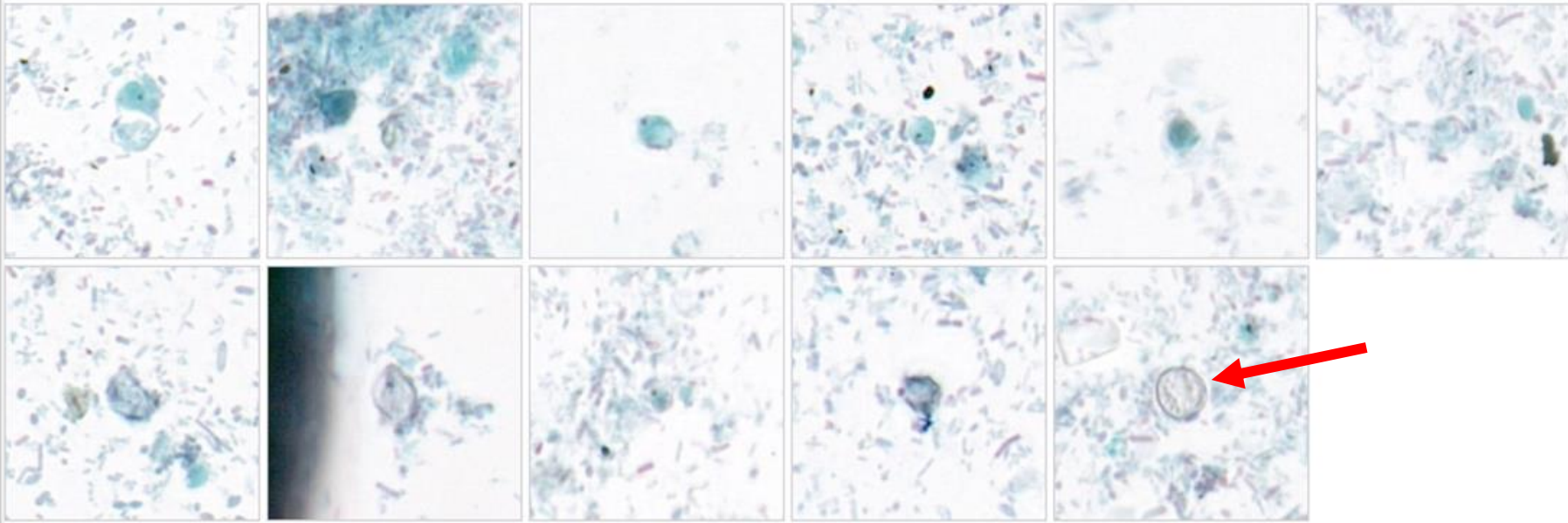
Negative percent agreement: 98.11% [95% CI 93.35% to 99.77%]

Mathison et al. 2020 *J Clin Microbiol*

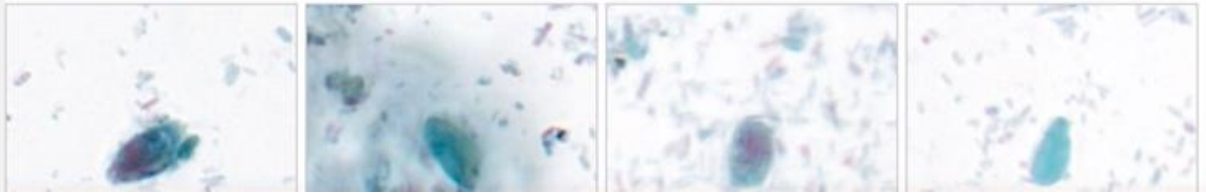
Cyclospora in Trichrome NOT *Blastocystis* (*circa* Aug. 2019)

	count	total	present
Fecal Smear			
	0	32	
Blastocystis sp.			
	12		☐
Giardia duodenalis			
	0	6	
Giardia Cyst			
	4		☐
Giardia Troph			
	2		☐
Endolimax/Iodamoeba Troph			
	2		☐
Entamoeba hartmanni			

Blastocystis sp.

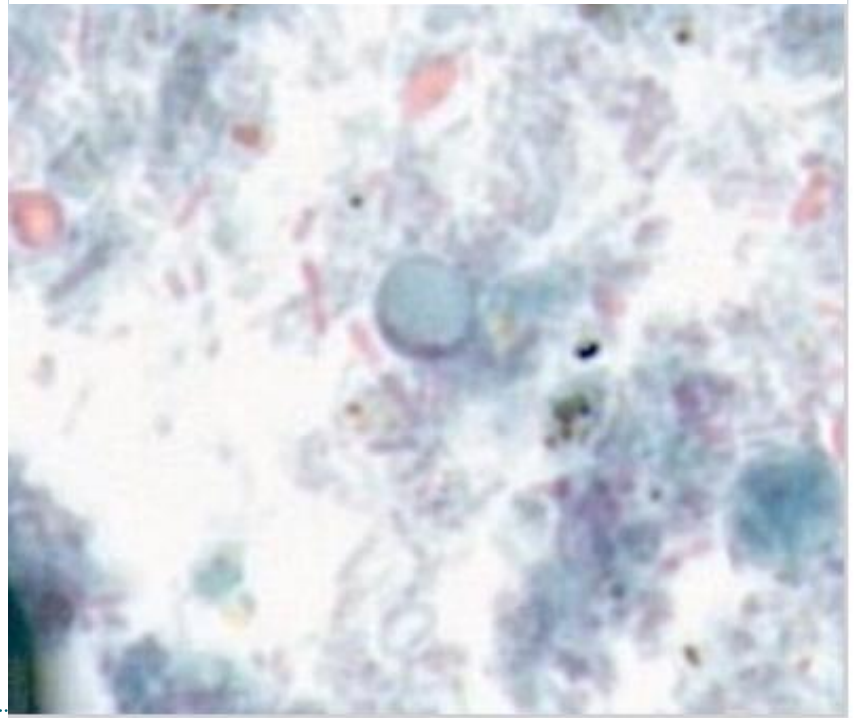


Giardia Cyst

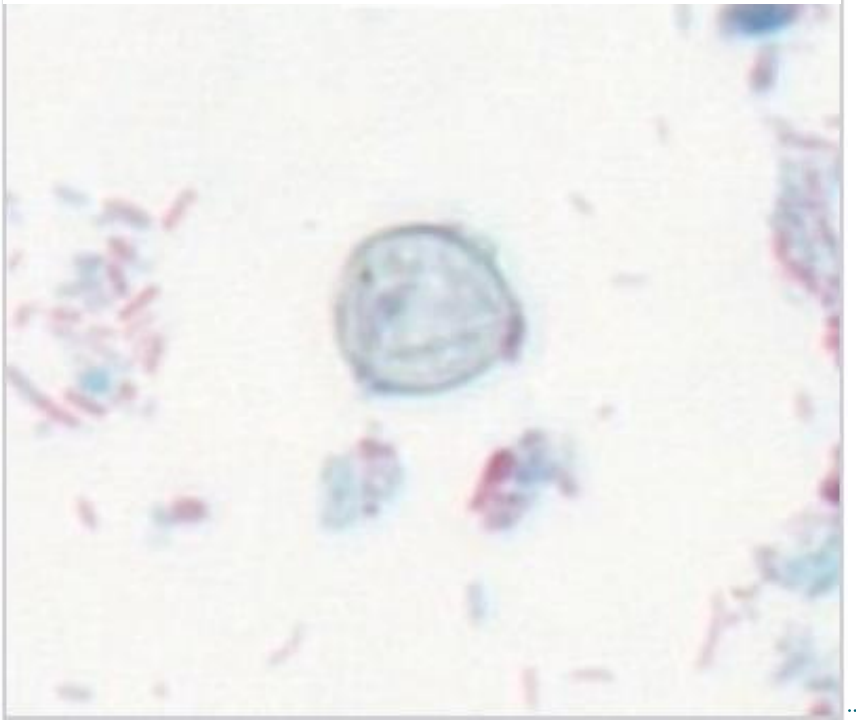


Cyclospora in Trichrome NOT *Blastocystis*

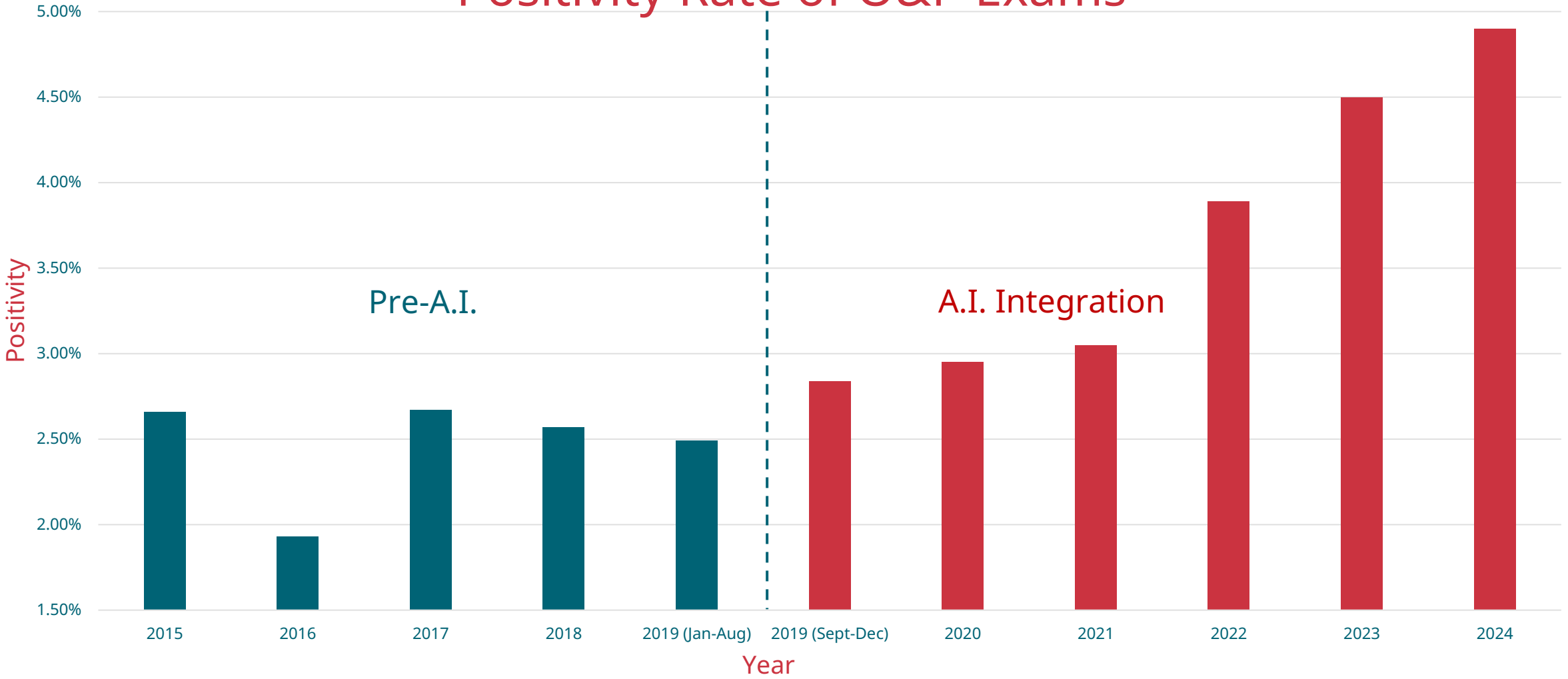
Blastocystis



Cyclospora

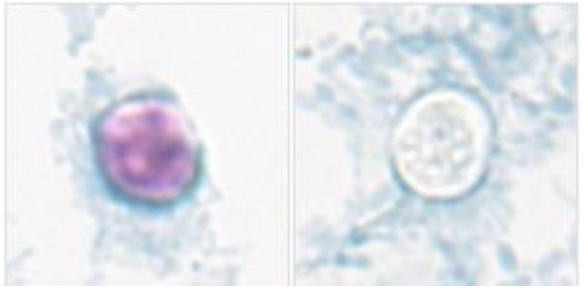


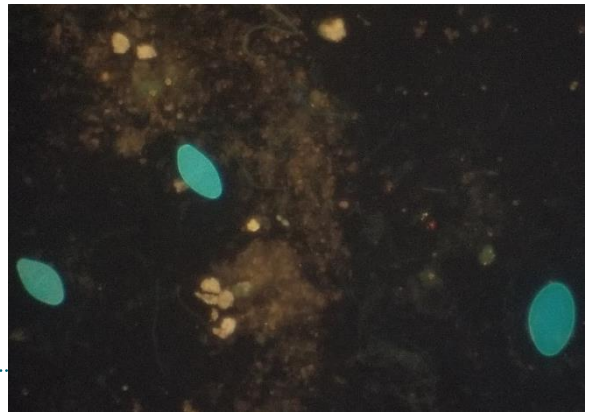
Positivity Rate of O&P Exams



Modified Acid Fast v1 –
step 2 toward complete stool parasite AI

- Stain for *Cryptosporidium, Cyclospora,* & *Cystoisospora*
  - *Cyclospora* does not retain trichrome stain well
    - "Ghost" forms can be detected by human…but difficult
  - *Cystoisospora* better detected by wet-mount (bright field & UV)
    - Rare, not trained
      (in progress v2 & wet-mount)





MAF - Validation Summary

- 20 *Cryptosporidium* / 20 *Cyclospora* / 100 Negative

		Original Results: Positive	Original Results: Negative
Software Analysis	**Positive**	40*	3
	Negative	0	97

*one slide positive for *C. cayetanensis* was backread as the software detected suspect *Cryptosporidium* (false positive)

Positive percent agreement: 100% [95% CI 91.19% to 100.00%]

Negative percent agreement: 97.0% [95% CI 91.48% to 99.38%]

Mathison *et al.* In Preparation

MAF Limit of Detection

Same trend as trichrome

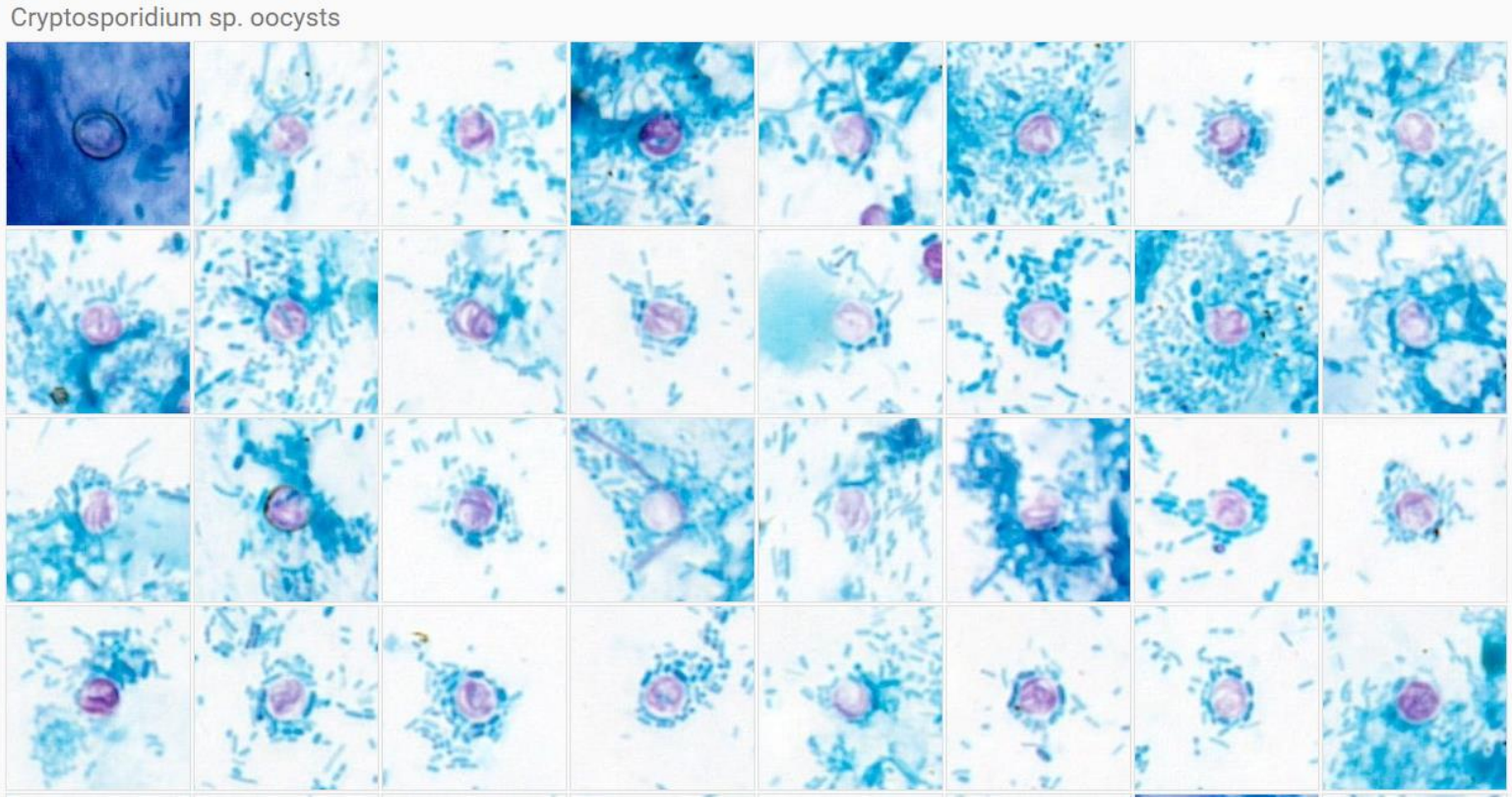
- Human: 1:1, 1:2, & 1:8
- AI: 1:256 (n=2) & 1:512 (n=1)

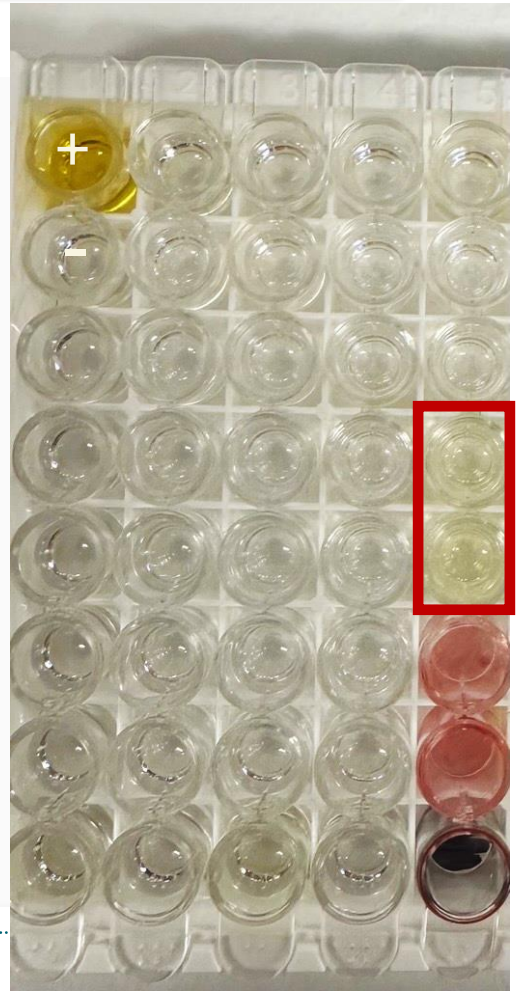
Clinical lab integration early 2021

Mathison *et al.* In Preparation

PCR -/Ag- vs Microscopy +

	count	total	present
Human Fecal Modified Acid Fast (PARAST)	0	590	
Cryptosporidium sp. oocysts	585	585	☑
Cyclospora cayetanensis oocysts	5	5	☐
Prevalence Region OPFEC	11	11	



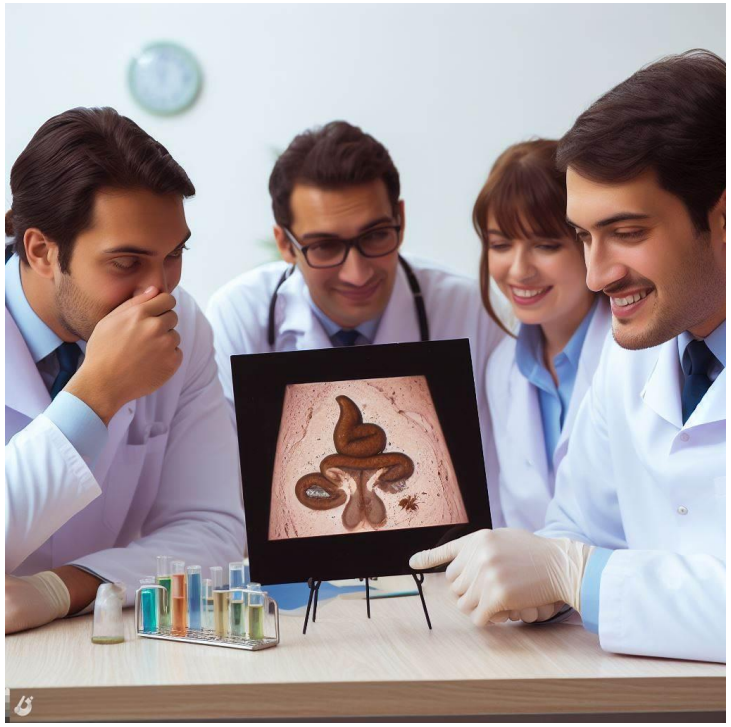


User Look at Trichrome

https://app.techcyte.com/worklist?sort=-created_at&status=processing_complete&assigned_to=-%2Cme

Content credentials
Generated with AI · November 21, 2023 at 8:13 AM

Wet-mount exam development
Part 3 of total O&P AI

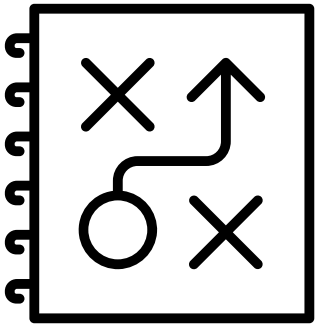


Prompt: “A sneak preview of stool wet mount slide being shown to a group of pathologists”

Content credentials **Generated with AI** · November 20, 2023 at 2:04 PM

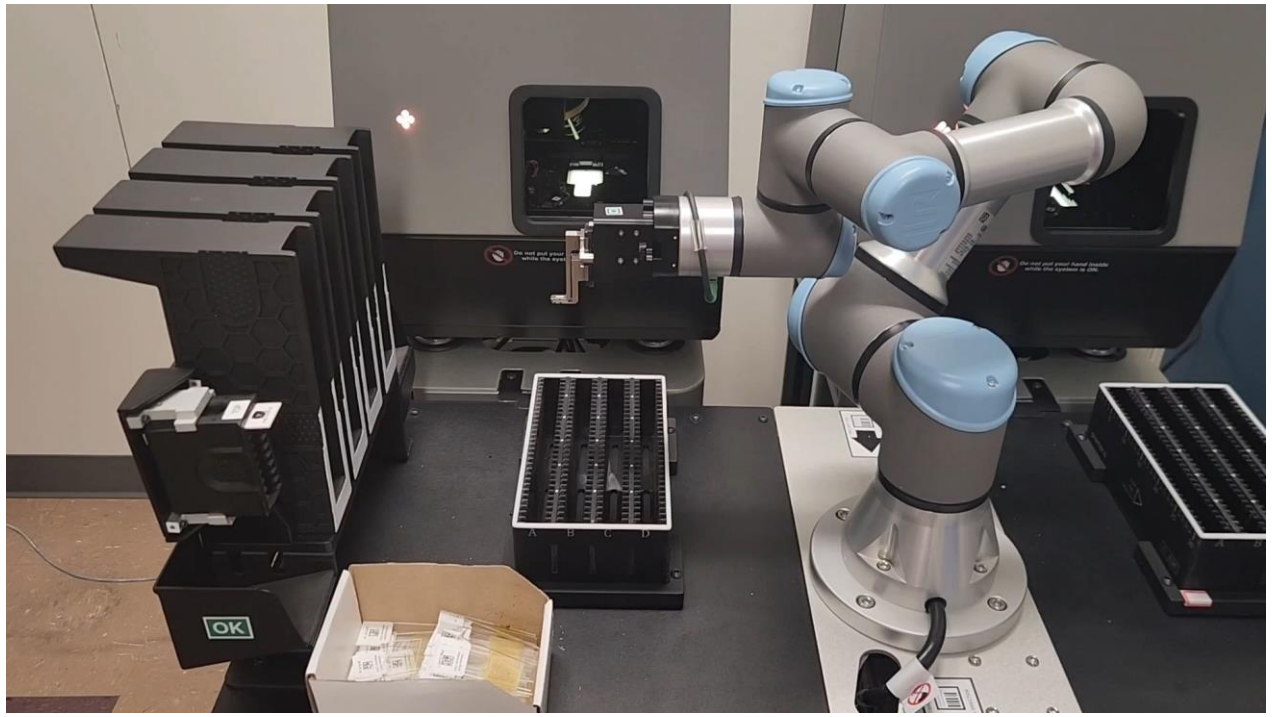
Practical challenges

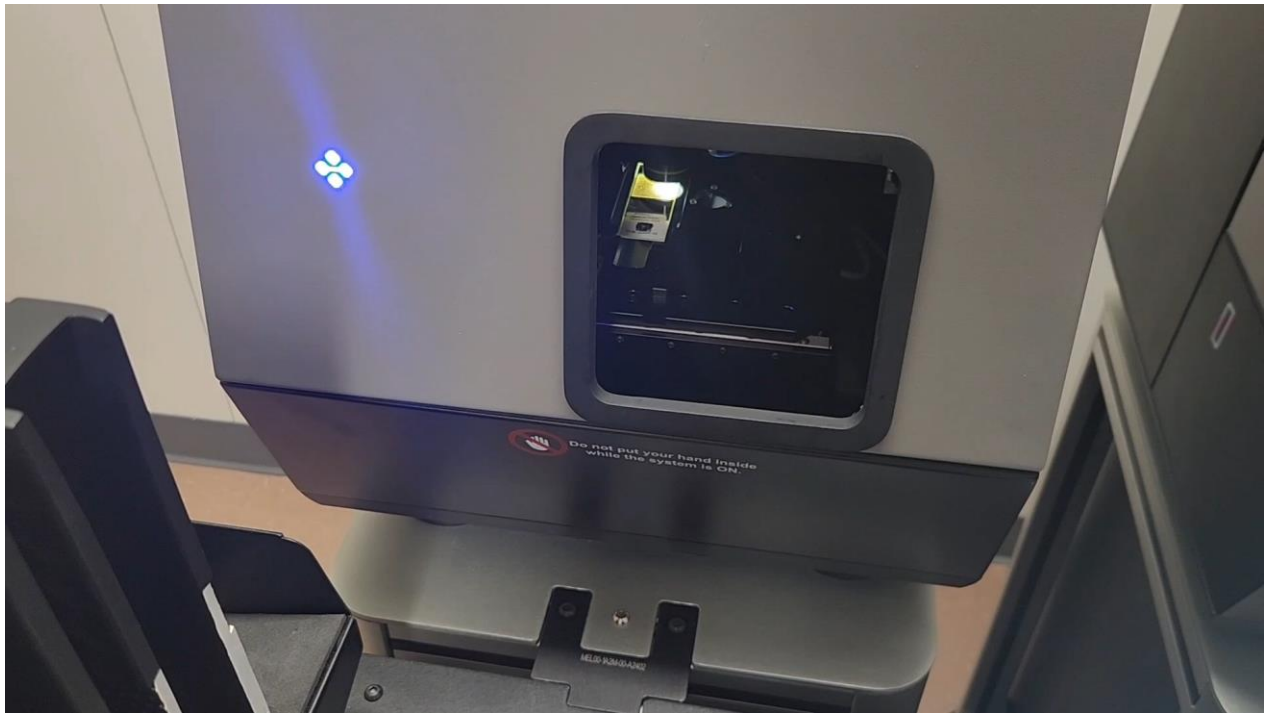
1. Scanner: 3DH loads at an angle (spills)
2. “Depth” of specimen
3. Dry time: iodine mounts can dry fast (~20-30 mins)
4. Brownian motion & resolution: things float too fast & grainy textures



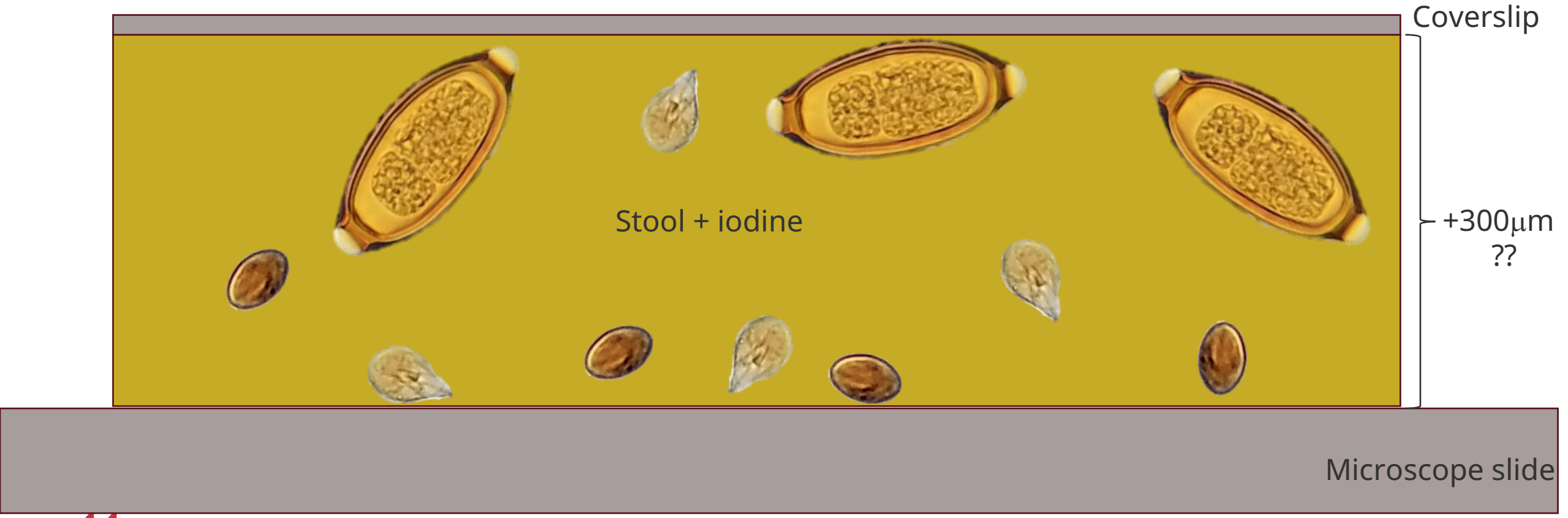
Pramana spectralHT

Pramana spectralHT





Depth and focus issues



Modified Mounting Medium

- Iodine: dries fast & grainy backgrounds
- Fluidity: scanning challenges
- Solution: (Trial & error) homogenized iodine & glycerol medium

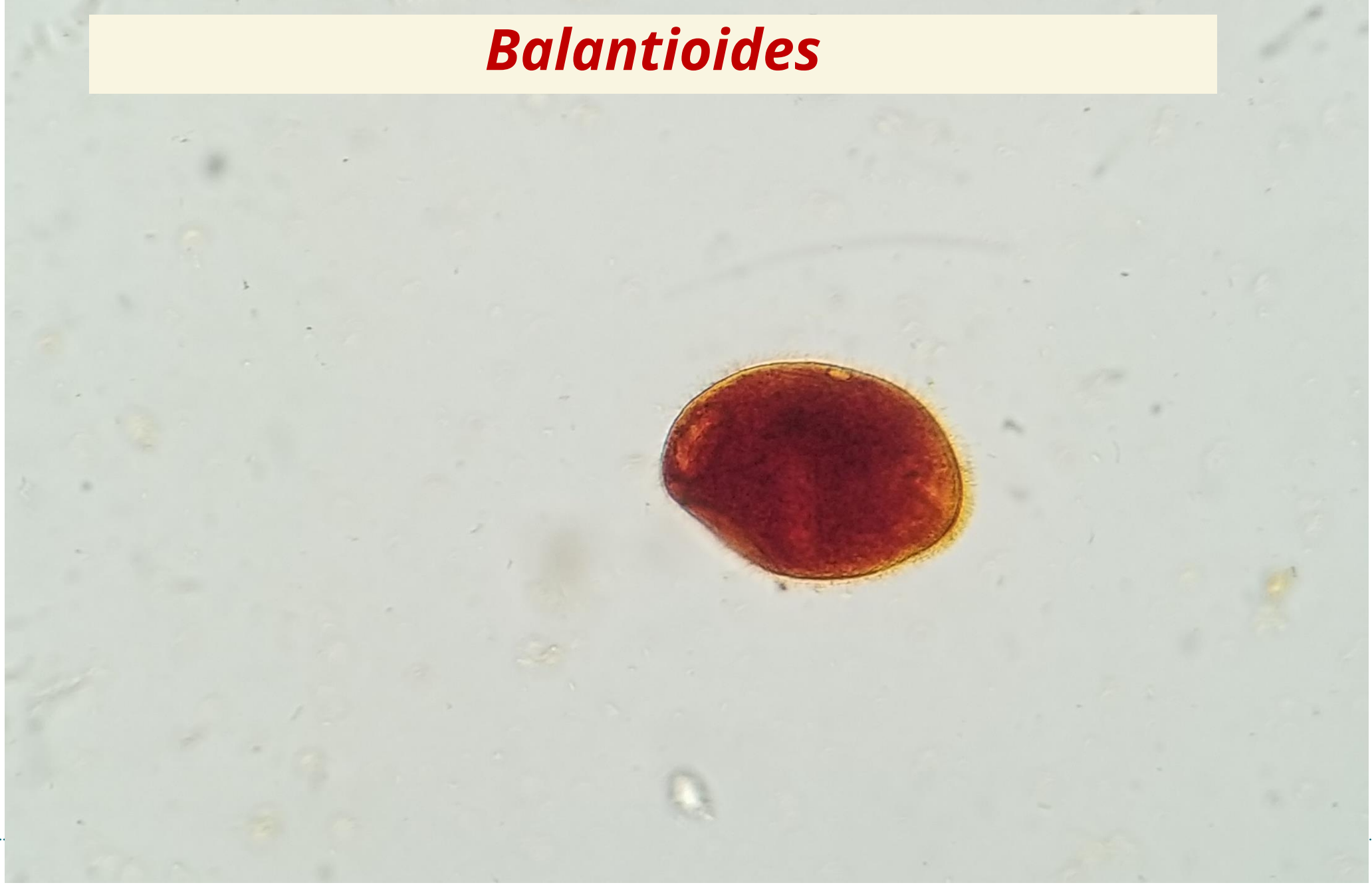
Chilomastix

Giardia

Strongyloides

Trichuris

Balantioides



Training & Validation Set

- Fixatives: Formalin, Alcorfix, TOTAL-FIX, EcoFix, SAF, Unifix
- Origin: ARUP, Mayo, CDC, Africa, Asia, Europe
- Concentration method: Vertical filtration, ethyl acetate sedimentation, gravity filtration

Training Set Data

Category (class)	No. of unique scans per class	No. of unique examples per class
Blastocystis species	131	1968
Entamoeba species non-hartmanni cysts	168	1401
Entamoeba species non-hartmanni trophozoites	116	1650
Endolimax nana cysts	92	1964
Iodamoeba buetschlii cysts	61	1474
Miscellaneous Small Protozoans[1]	182	3116
Giardia duodenalis cysts	83	3611
Giardia duodenalis trophozoites	51	1782
Chilomastix mesnili cysts	63	1438
Chilomastix mesnili trophozoites	28	1546
Balantioides coli cysts	133	466
Balantioides coli trophozoites	65	1398
Cyclospora species oocysts	23	1813
Cystoisospora belli oocysts	17	1296
Ascaris lumbricoides fertile eggs	134	983
Ascaris lumbricoides infertile eggs	183	894
Trichuris trichiura eggs	207	1037
Hookworm/Trichostrongylus eggs	421	1268
Strongyloides species L1 larvae	33	1215
Paracapillaria philippinensis eggs	201	1044
Enterobius vermicularis eggs	246	796
Fish Tapeworm eggs (Diphyllobothrium-complex)	333	987
Taenia species eggs	97	1283
Rodentolepis nana eggs	58	1018
Hymenolepis diminuta eggs	224	1023
Schistosoma mansoni eggs	262	1088
Schistosoma japonicum eggs	719	989
Paragonimus species eggs	116	1044
Fasciola species/Fasciolopsis buski eggs	219	504
Clonorchis sinensis/Opisthorchis species eggs	28	1095
Background/Artifacts	1778	38339

Mathison et. al.
Accepted, JCM.

Accuracy: Initial

Target 10+ & 10 -

Organism	Positive Accuracy	Negative Accuracy
Dientamoeba fragilis	9/10 (90%)	99/100 (99%)
Giardia duodenalis	10/10 (100%)	100/100 (100%)
Endolimax nana	10/10 (100%)	99/100 (99%)
Cyclospora species	10/10 (100%)	100/100 (100%)
Entamoeba hartmanni	10/10 (100%)	99/100 (99%)
Blastocystis species	15/15 (100%)	100/100 (100%)
Chilomastix mesnili	6/10 (60%)	99/100 (99%)
Entamoeba species	10/10 (100%)	99/100 (99%)
Iodamoeba buetschlii	10/10 (100%)	99/100 (100%)
Cystoisospora belli	10/10 (100%)	100/100 (100%)
Balantioides coli	10/10 (100%)	100/100 (100%)
Ascaris lumbricoides	9/10 (90%)	100/100 (100%)
Trichuris trichiura	8/10 (80%)	100/100 (100%)
Hookworm/*Trichostrongylus* sp.	10/10 (100%)	100/100 (100%)
Fish Tapeworm	9/10 (90%)	100/100 (100%)
Taenia species	10/10 (100%)	100/100 (100%)
Enterobius vermicularis	10/10 (100%)	100/100 (100%)
Strongyloides species	9/10 (100%)	100/100 (100%)
Rodentolepis nana	10/10 (100%)	100/100 (100%)
Hymenolepis diminuta	10/10 (100%)	100/100 (100%)
Schistosoma mansoni	10/10 (100%)	100/100 (100%)
Paracapillaria philippinensis	10/10 (100%)	100/100 (100%)
Paragonimus species	10/10 (100%)	100/100 (100%)
Fasciola sp./*Fasciolopsis buski*	10/10 (100%)	100/100 (100%)
Clonorchis/*Opisthorchis* spp.	10/10 (100%)	100/100 (100%)
Schistosoma japonicum	5/10 (50%)	100/100 (100%)
Total Agreement	250/265 (94.3%)	94/100 (94%)

Mathison et. al.
Accepted, JCM.

Accuracy: Resolved

66% increased diagnostic yield

Organism	Positive	Negative
Dientamoeba fragilis	11/11 (100%)	102/103 (99%)
Giardia duodenalis	26/26 (100%)	103/104 (99%)
Endolimax nana	21/21 (100%)	102/103 (99%)
Cyclospora species	11/11 (100%)	103/104 (99%)
Entamoeba hartmanni	12/12 (100%)	102/103 (99%)
Blastocystis species	61/61 (100%)	103/110 (94%)
Chilomastix mesnili	13/16 (81%)	102/104 (98%)
Entamoeba species	49/49 (100%)	102/112 (91%)
Iodamoeba buetschlii	20/20 (100%)	102/104 (98%)
Cystoisospora belli	10/10 (100%)	103/103 (100%)
Balantioides coli	13/13 (100%)	103/103 (100%)
Ascaris lumbricoides	17/18 (95%)	103/104 (99%)
Trichuris trichiura	30/30 (97%)	103/103 (100%)
Hookworm/*Trichostrongylus* sp.	26/26 (100%)	103/103 (100%)
Fish Tapeworm	10/10 (100%)	103/103 (100%)
Taenia species	10/10 (100%)	103/103 (100%)
Enterobius vermicularis	11/11 (100%)	103/103 (100%)
Strongyloides species	17/18 (94%)	103/104 (99%)
Rodentolepis nana	13/13 (100%)	103/103 (100%)
Hymenolepis diminuta	10/10 (100%)	103/103 (100%)
Schistosoma mansoni	10/10 (100%)	103/103 (100%)
Paracapillaria philippinensis	10/10 (100%)	103/103 (100%)
Paragonimus species	10/10 (100%)	103/103 (100%)
Fasciola sp./*Fasciolopsis buski*	10/10 (100%)	103/103 (100%)
Clonorchis/*Opisthorchis* spp.	10/10 (100%)	103/103 (100%)
Schistosoma japonicum	9/9[2] (100%)	103/103 (100%)
Misc. Small Protozoans[1]	22/22 (100%)	102/111 (92%)
Total Agreement	472/477 (98.9%)	Variable by target*

Mathison et. al.
Accepted, JCM.

Relative Limit of Detection

	Entamoeba					
	Series A [8 years exp.]		Series B [<1 year exp.]		Series C [3.5-4 years exp.]	
Dilution	Software	Technologist	Software	Technologist	Software	Technologist
Neat	Detected (n=185)	Detected	Detected (n=261)	Detected	Detected (n=141)	Detected
1:1	Detected (n=99)	Detected (n=2)	Detected (n=101)	Detected	Detected (n=120)	Detected
1:2	Detected (n=75)	Detected (rare)	Detected (n=70)	Detected (rare)	Detected (n=44)	Detected
1:4	Detected (n=25)	Detected (rare)	Detected (n=40)	Detected	Detected (n=26/27)	Detected
1:8	Detected (n=10)	Detected (n=2)	Detected (n=6)	Not Detected	Detected (n=16)	Detected
1:16	Detected (n=2/3)	Not Detected	Detected (n=3)	Not Detected	Detected (n=2)	Not Detected
1:32	Detected (n=2)	Not Detected	Detected (n=2)	Not Detected	Detected (n=1)	Detected (suspicious)
1:64	Detected (n=1)	Not Detected	Detected (n=1/2)	Not Detected	Detected (n=3)	Not Detected
1:128	Not Detected	Not Detected	Not Detected	Detected (possible, rare)	Not Detected	Not Detected
1:256	Not Detected	Not Detected	Detected (n=1?)	Not Detected	Not Detected	Not Detected
1:512	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected

Mathison et. al.
Accepted, JCM.

Relative Limit of Detection

	Trichuris trichiura					
	Series A [8 years exp.]		Series B [<1 year exp.]		Series C [3.5-4 years exp.]	
Dilution	Software	Technologist	Software	Technologist	Software	Technologist
Neat	Detected (n=49)	Detected	Detected (n=49)	Detected	Detected (n=45)	Detected
1:1	Detected (n=12)	Detected	Detected (n=15)	Detected	Detected (n=22)	Detected
1:2	Detected (n=10)	Detected	Detected (n=16)	Detected	Detected (n=11)	Detected
1:4	Detected (n=1)	Not Detected	Detected (n=5)	Detected (rare)	Detected (n=9)	Detected
1:8	Detected (n=1)*	Not Detected	Detected (n=1)*	Not Detected	Detected (n=1)	Not Detected
1:16	Not Detected	Not Detected	Detected (n=1)	Not Detected	Not Detected	Not Detected
1:32	Not Detected	Not Detected	Detected (n=1)	Not Detected	Not Detected	Not Detected
1:64	Detected (n=1)	Not Detected	Not Detected	Detected (rare)**	Not Detected	Not Detected
1:128	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
1:256	Detected (n=1)	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
1:512	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected

Mathison et. al.
Accepted, JCM.

Relative Limit of Detection

	Ascaris lumbricoides					
	Series A [8 years exp.]		Series B [<1 year exp.]		Series C [3.5-4 years exp.]	
Dilution	Software	Technologist	Software	Technologist	Software	Technologist
Neat	Detected (n=23)	Detected	Detected (n=23)	Detected	Detected (n=23)	Not Detected
1:1	Detected (n=3)	Detected	Detected (n=7)	Detected	Detected (n=12)	Detected
1:2	Detected (n=5)	Detected	Detected (n=1/2)	Detected	Detected (n=5)	Detected
1:4	Detected (n=1)	Not Detected	Detected (n=2)	Detected	Detected (n=1)	Not Detected
1:8	Detected (n=2)	Not Detected	Detected (n=1)	Detected (rare)	Not Detected	Not Detected
1:16	Detected (n=1)	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
1:32	Not Detected	Detected (n=1)*	Not Detected	Not Detected	Not Detected	Not Detected
1:64	Not Detected	Not Detected	Not Detected	Detected (possible, rare)*	Not Detected	Not Detected
1:128	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
1:256	Not Detected	Not Detected	Detected (n=1)	Not Detected	Not Detected	Not Detected
1:512	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected

Mathison et. al.
Accepted, JCM.

Relative Limit of Detection

Mathison et. al.
Accepted, JCM.

	Hookworm					
	Series A [8 years exp.]		Series B [<1 year exp.]		Series C [3.5-4 years exp.]	
Dilution	Software	Technologist	Software	Technologist	Software	Technologist
Neat	Detected (n=2)	Not Detected	Detected (n=2)	Not Detected	Detected (n=4)	Not Detected
1:1	Detected (n=2)	Detected (n=1)	Detected (n=2)	Detected (rare)	Detected (n=1)	Not Detected
1:2	Not Detected	Not Detected	Not Detected	Not Detected	Detected (n=1)	Not Detected
1:4	Not Detected	Not Detected	Not Detected	Not Detected	Detected (n=1)	Not Detected
1:8	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
1:16	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
1:32	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
1:64	Not Detected	Not Detected	Not Detected	Not Detected	Detected (n=1)	Detected
1:128	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
1:256	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
1:512	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected

User Look at Wet-mount Development/Validation

https://app.techcyte.com/worklist?sort=-created_at&status=processing_complete&assigned_to=-%2Cme

Content credentials Generated with AI · November 21, 2023 at 8:13 AM

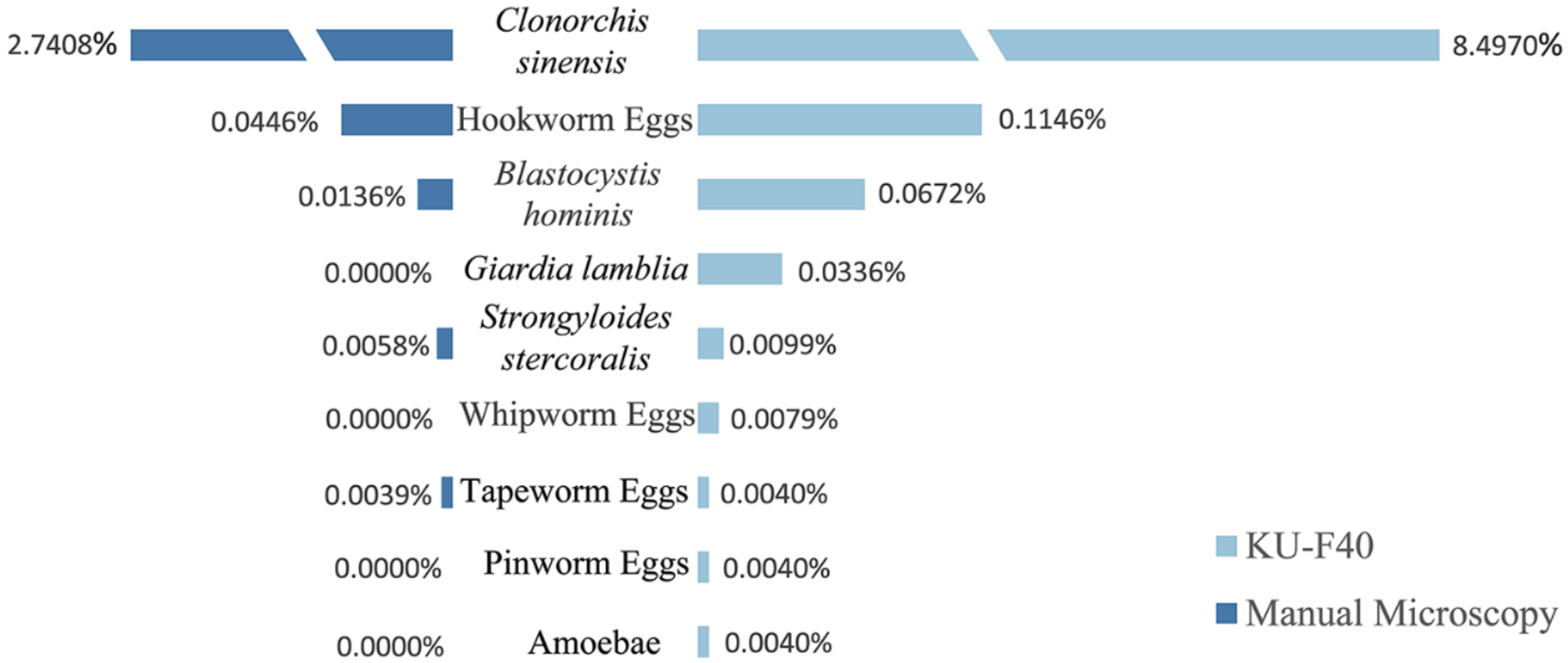
Wet-Mount Conclusions

- Excellent screening tool for positive and negative slides
- Large diversified training and validation set
- Excellent performance for all pathogens in model
- Increased diagnostic yield vs manual O&P (66% ↑)
- Increased analytic sensitivity vs humans
- Less scope time

KU-F40 Fully Automated Feces Analyzer

- Wet-mount only
- High throughput
- Multiple focal depth imaging
- Flotation and sedimentation
  - +/- iodine
- Currently O-US

KU-F40 System retrospective study

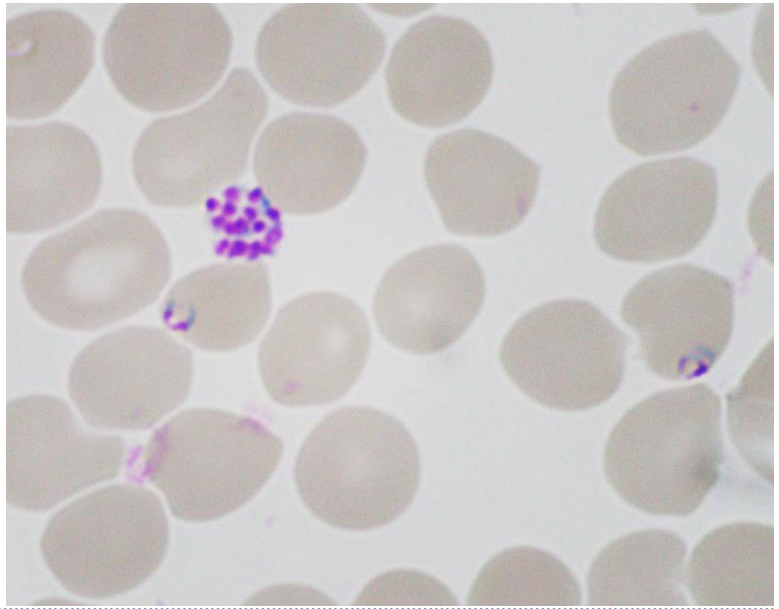


Tornado diagram for parasite (egg) species detection levels by manual microscopy and KU-F40. Note: Due to the significant difference in detection levels between *Clonorchis sinensis* eggs and other parasites (eggs), an open section is used to represent the omitted portion of the actual detection level

Huang et al. Nature Scientific Reports 15, 2025

Blood smears

- Giemsa stains for malaria
- Early findings: Imperfect sensitivity, high specificity (for *Plasmodium* sp.)
- Challenges
  - Species-level ID for 4 species is poor
    - Some systems just do *P. falciparum* and *P. vivax*
  - Does not detect other blood parasites
- Commercial example(s) – EasyScan GO, miLab MAL



A.I. Here and Now in Microbiology

- Culture plate interpretation – colony predictions
- Gram stain interpretation
- AFB stains
- AST interpretation
- Pap smear interpretation
- Nugent score vaginal Gram stains

Acknowledgments

R&D

- **Blaine Mathison**
- **Katie Knight**
- **Jessica Kohan**
- Jonia Cook
- Kim Frizzell
- Dr. Adam Barker

TechCyte

- **John Walker**
- Ken Dixon
- Jill Potts
- Fallon Markow
- Kellie Hicken
- Ben Cahoon
- Ben Martin
- Rick Smith
- Rob Fotheringham

ARUP Parasitology Lab

- Madison Sant
- Alicia Backman
- Cole Neider
- Garrin Abbott
- Ryan Jensen
- Everyone else who embraced it

Thank You

MaineHealth

ARUP LABORATORIES

Questions?

Marc.couturier@mainehealth.org