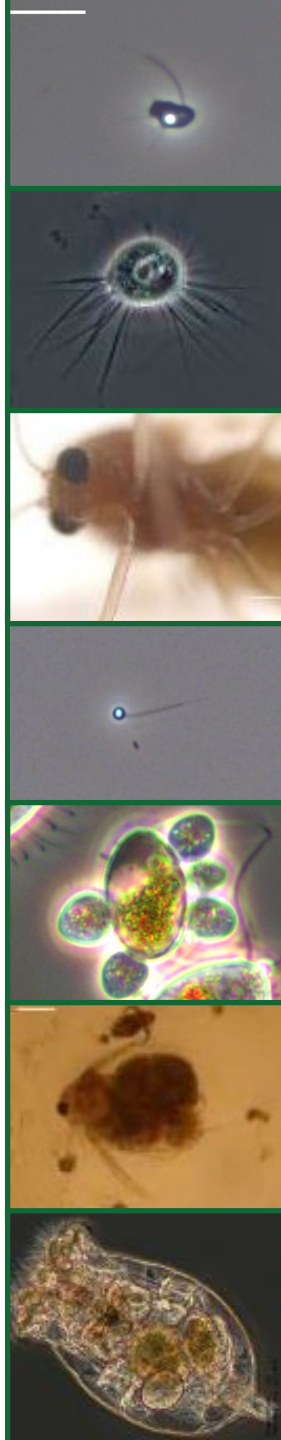
Barriers to Scale: Algae Crop Protection Workshop

Session 3 Report Out: Pest Models: Understanding Pest Life Cycles and Infection Mechanisms

Moderator: Philip Lee

Rapporteur: Blake Hovde



Post panel discussion highlights

- Session themes: Large diversity of pests
  - What is the pest? and How do we mitigate it? -> Foundational work/basic biology
- Todd Lane:
  - Identification vs detection (different things) and Basic vs Applied Systems (Isolates/axenic/cryopreserved vs Active algae growers)
  - Strain collections contain very few PEST species
  - General threat species vs Narrow host range
- Shawn Starkenburg:
  - Pest ID and Pest biology understanding (Vampirovibrio and FD111 models)
  - Degree of pathogenicity in specific strains? Ecoli, bacillus, some strains are pathogenic
  - Informatics and genomics tools
- Tim James:
  - Natural habitats and pests - Natural ecology has been under explored
  - Several parasites are emerging as consistent across continents
  - CZEUM Detabase – w/ Public interface – Systematic collection of parasites
  - Unculturable/pure cultured pest challenges



Group Participants

1. Lauren Illing, BCS / BETO, strategic workshop planning, facilitation and report development

2. Blake Hovde - Los Alamos National Lab, Algal genomics and pond metagenomics

3. Amanda Barry/Sandia National Labs/microalgae biochemistry and molecular biology

4. Joshua Podlevsky /Sandia National Labs -- researcher / molecular and microbiology employing CRISPR

5. Chuck Smallwood / Sandia National Labs / Systems Biology, Biochemistry, and Microbiome Research

6. Todd Lane, Sandia National Labs, Crop protection, pest detection and countermeasures

7. Shawn Starkenburg, Los Alamos National Laboratory, Pest genomics and diagnostics

8. Rhona Stuart, Lawrence Livermore National Lab--PI, Research Scientist/microalgal ecophysiology, microbi

9. Daniel Fishman - U.S. Department of Energy/meeting host

10. Zackary Johnson, Duke University, Marine Algae Industrialization Consortium (MAGIC), marine algae culti

11. Fritz Vorisek, University of Kentucky CAER, Staff Scientist

12. Ghazala Butt, Associate Professor at Department of Botany, GC University Lahore, algal culturing and taxonomy

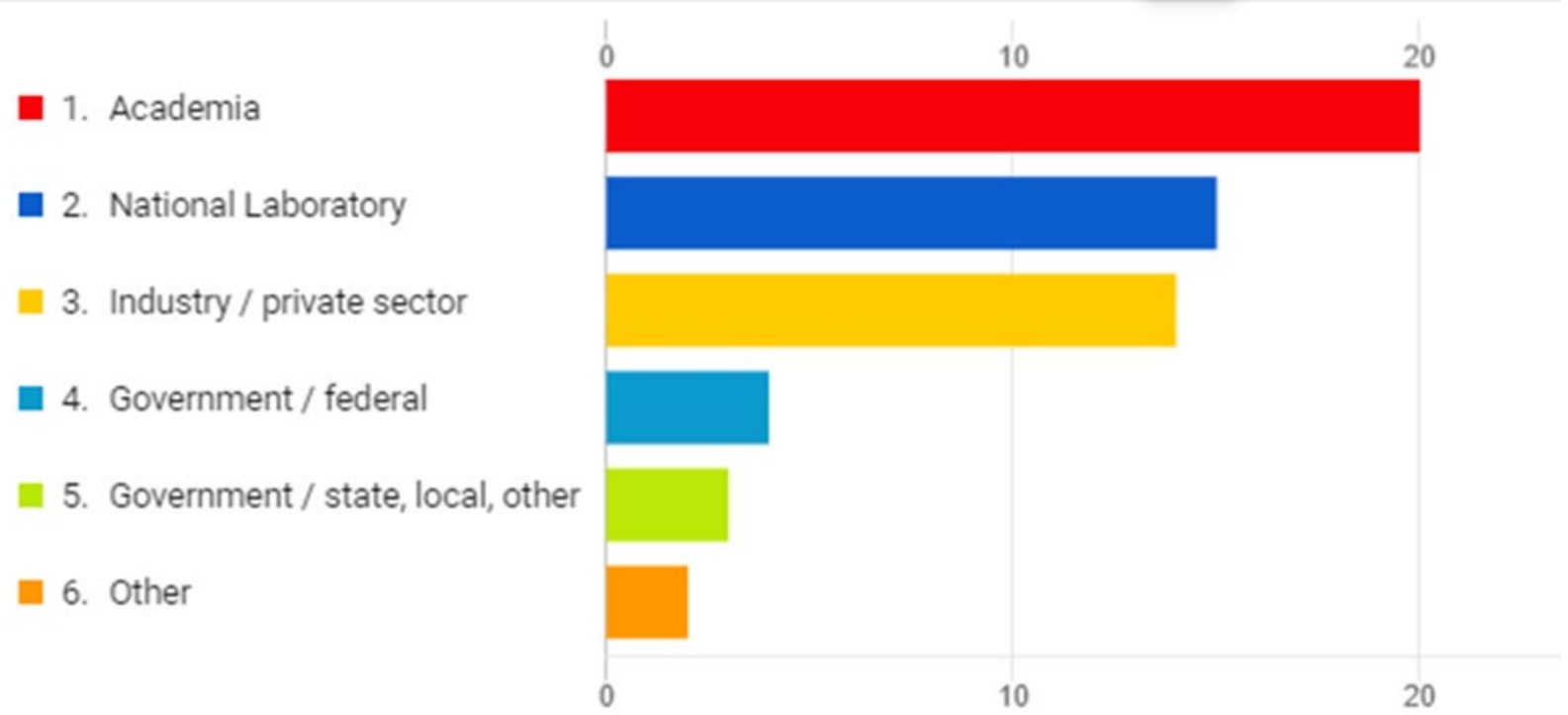
13. Tim James, Department of Ecol. & Evolutionary Biology, University of Michigan

14. David Smernoff, HelioBioSys. Consortia of cyanobacteria for biomaterial and cosmetic applications

15. Christy Sterner, BETO

16. Jeri Timlin / Sandia National Labs / crop protection, detection, spectroscopy and imaging

17. Patrick Thomas, PhD student at University of Oldenburg, community ecology



18. Ryan Simkovsky, University of California San Diego, Project Scientist

19. Greg Schlensker, Avari Labs

20. Ty Samo, Lawrence Livermore National Lab, microbial ecology, microscopy

21. Philip Lee, AST/ BETO, Project monitor

22. Sanjaya Lama, PhD student, Hasselt University, Microalgae cultivation and harvesting

23. Robert Pomeroy - UC San Diego Chemistry - Analytical Chemistry

24. Ken Reardon, Colorado State University, bioprocess engineering and microbial ecology

25. Eric Mayer, LightWater Co., an algae startup in Orlando, FL

26. Adity Biswas, Associate Research Scientist at The tru Shrimp Company.

27. Fiona Harrigian, Graduate Student, BGSU, fungal parasites of algae

28. Loretta Roberson, Marine Biological Laboratory, macroalgae cultivation

29. Scott Edmundson, Research Botanist/Ecologist, Pacific Northwest National Laboratory

30. Sridharan Govindachary, Mass Cultivation and Photosynthesis Research expert

Group Discussion Highlights

Question 1: Pest Model Systems

1.2. Very little research has been done on this for macroalgae, and models take time and funding to develop.

1.2.1. I strongly agree. The interest in developing new models is driven by industry interest. It is no coincidence that most research on macroalgal diseases has been done in Asia

1.2.2. From my experience, it's often hard to successful cultivate or separate potential pests from algal cultures and develop model systems. There likely is uncharacterized mutualistic relationships, which hasn't been a priority for sponsors or industry to fund research.

1.2.3. Yes 200% agreed

Industry led priorities? Difficulty in isolation/culture

1.1. While it will always be different in the field, available lab models are sufficient to test and design mitigation

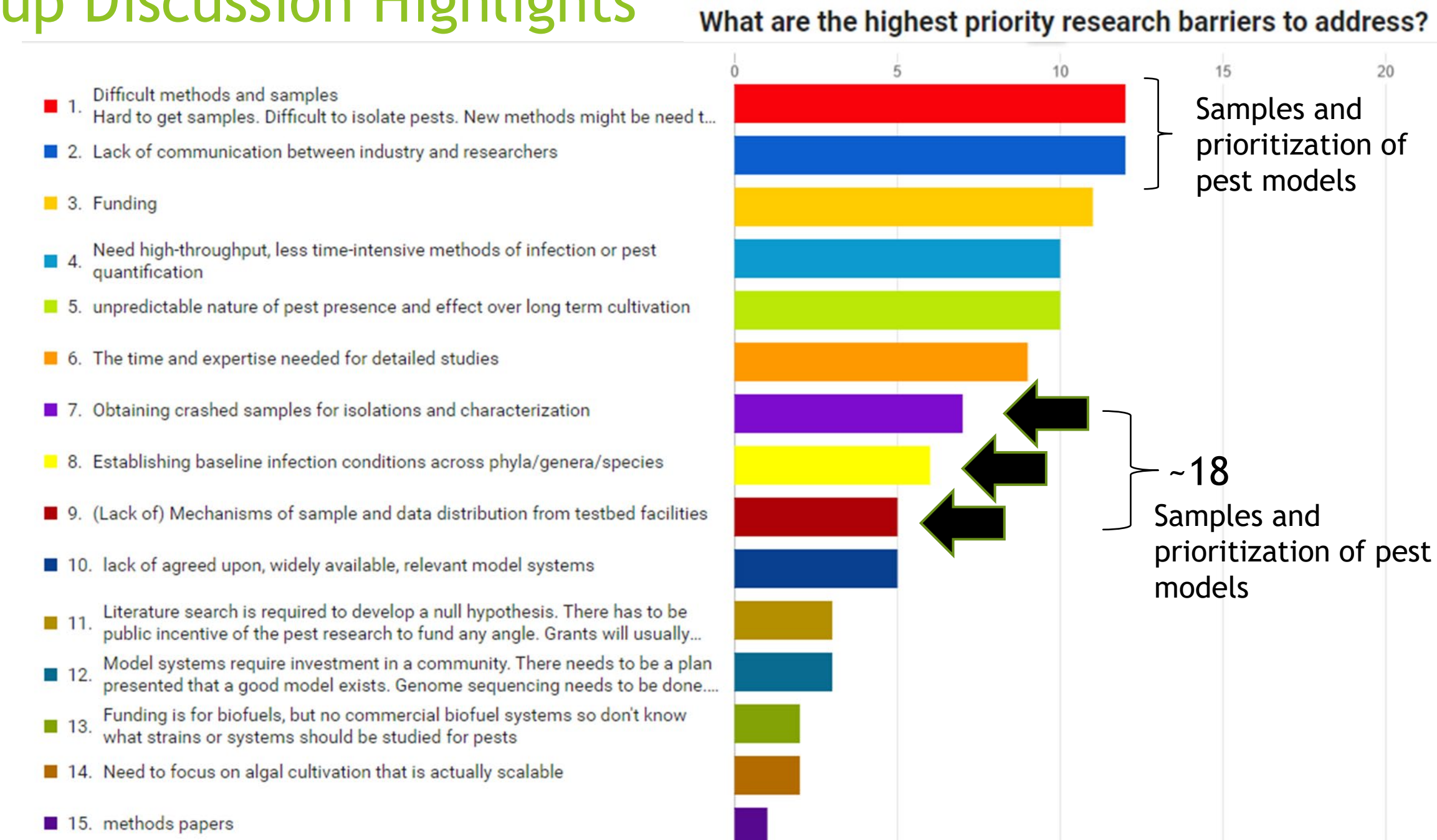
1.1.1. I strongly disagree with this. Many pests are taxa-specific or there are environmental-host interactions that change host-pest responses.

1.1.2. Unfortunately, I have to disagree. There are characteristics of field deployment that are difficult to replicate in the lab. Countermeasures are known to be defeated by environmental conditions e,g. organic load, U.V., Biodiversity, Physiochemical parameters

1.1.3. lab models are difficult to develop due to the myriad of conditions and algal microbiome landscapes in the field that are difficult to reconstitute in the lab

Strong disagreement that current models are sufficient

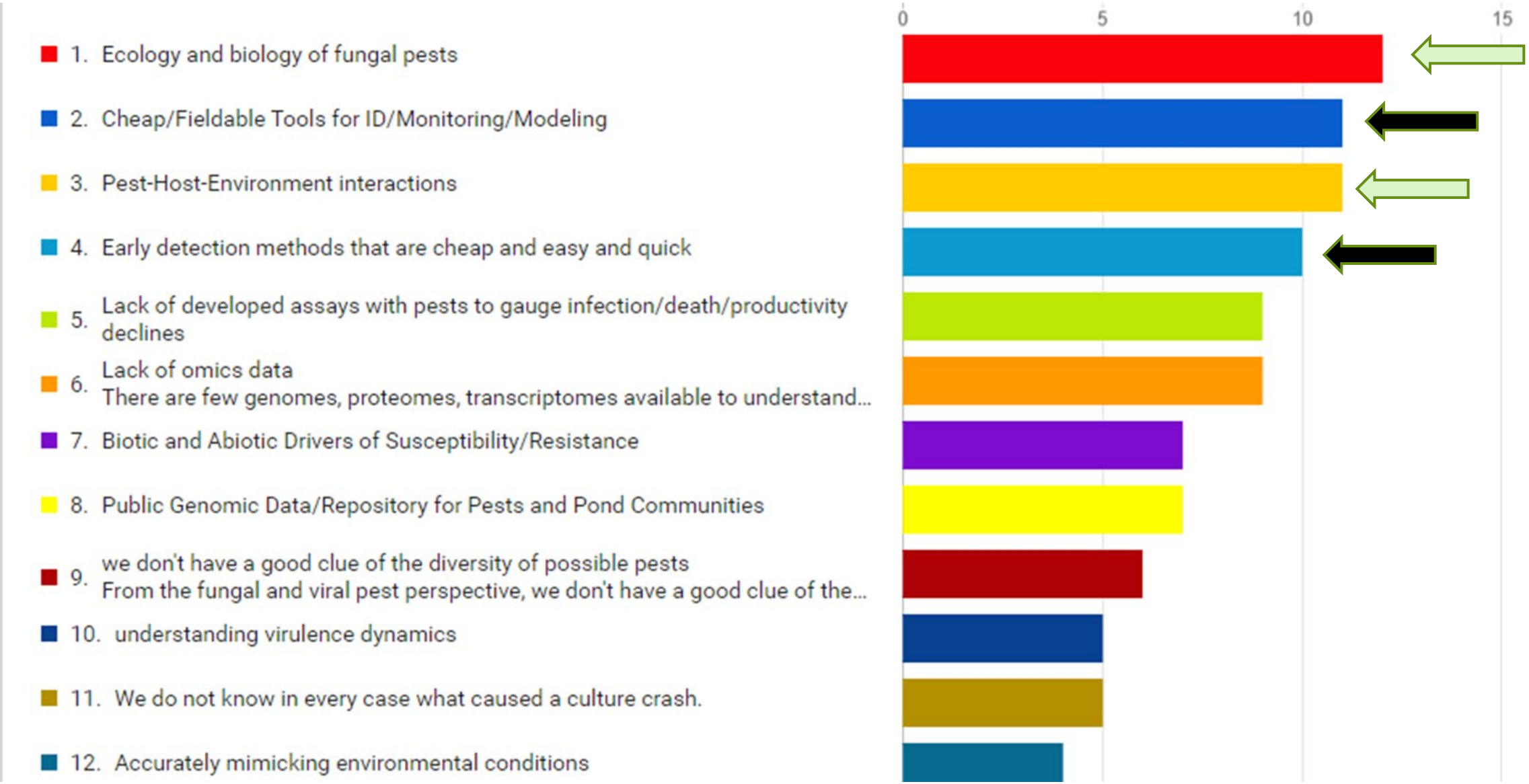
Group Discussion Highlights



Group Discussion Highli

What are the highest priority research gaps to address?

- **Question 2: Research Gaps, Barriers, and Techniques**



Themes

- **Some duplication of organisms across sites is promising**
- **Initial (historical) work largely benefited current and future pest work**
  - Benefits of Sapphire publications was emphasized
- **Public collections / pest culture collections**
- **Exploring the natural ecology (Claire and Tim)**
- How to fund these efforts?
  - Basic Science - Efforts in isolation and culturing
  - Culture collection / cryopreservation methods
  - Data repositories/public access
- How to classify things as high demand? (ie of interest for culture collections)

- Presumably a strain collection for pests would be useful. Have you discussed this with any of the collections to see if they would be interested in this? | 3

Group Discussion Highlights

Question 2: Research Gaps, Barriers, and Techniques

Priority R&D Barriers

3.1. Lack of developed assays with pests to gauge infection/death/productivity declines
Multiple selection by "priority", possible selections 3, Mean selections: 9

3.2. Early detection methods that are cheap and easy and quick
Multiple selection by "priority", possible selections 3, Mean selections: 13

3.3. Difficult methods and samples
Hard to get samples. Difficult to isolate pests. New methods might be need to be developed.
Multiple selection by "priority", possible selections 3, Mean selections: 12

3.4. Lack of communication between industry and researchers
Multiple selection by "priority", possible selections 3, Mean selections: 12

3.5. Funding
Multiple selection by "priority", possible selections 3, Mean selections: 11

3.6. Need high-throughput, less time-intensive methods of infection or pest quantification
Multiple selection by "priority", possible selections 3, Mean selections: 10

3.7. unpredictable nature of pest presence and effect over long term cultivation
Multiple selection by "priority", possible selections 3, Mean selections: 10

Priority R&D Gaps

2.1. Cheap/Fieldable Tools for ID/Monitoring/Modeling
Multiple selection by "priority", possible selections 3, Mean selections: 12

2.2. Ecology and biology of fungal pests
Multiple selection by "priority", possible selections 3, Mean selections: 12

2.3. Pest-Host-Environment interactions
Multiple selection by "priority", possible selections 3, Mean selections: 12

2.4. Lack of omics data
There are few genomes, proteomes, transcriptomes available to understand mechanisms beyond basic lifecycles
Multiple selection by "priority", possible selections 3, Mean selections: 10

2.5. qPCR

2.6. Early detection of metabolites build-up in the medium. Metabolite profiling of culture medium.

2.7. combination of culture-indepedent and culture-dependent techniques: microbiology and lab inoculations, metabarcodir

2.8. Life cycle studies in the field and in lab cultures

2.9. colorimetric metabolic assays/indicators

2.10. single cell genome sequencing, HiC