Understanding Operating Characteristic Curves And Sampling Plan Performance

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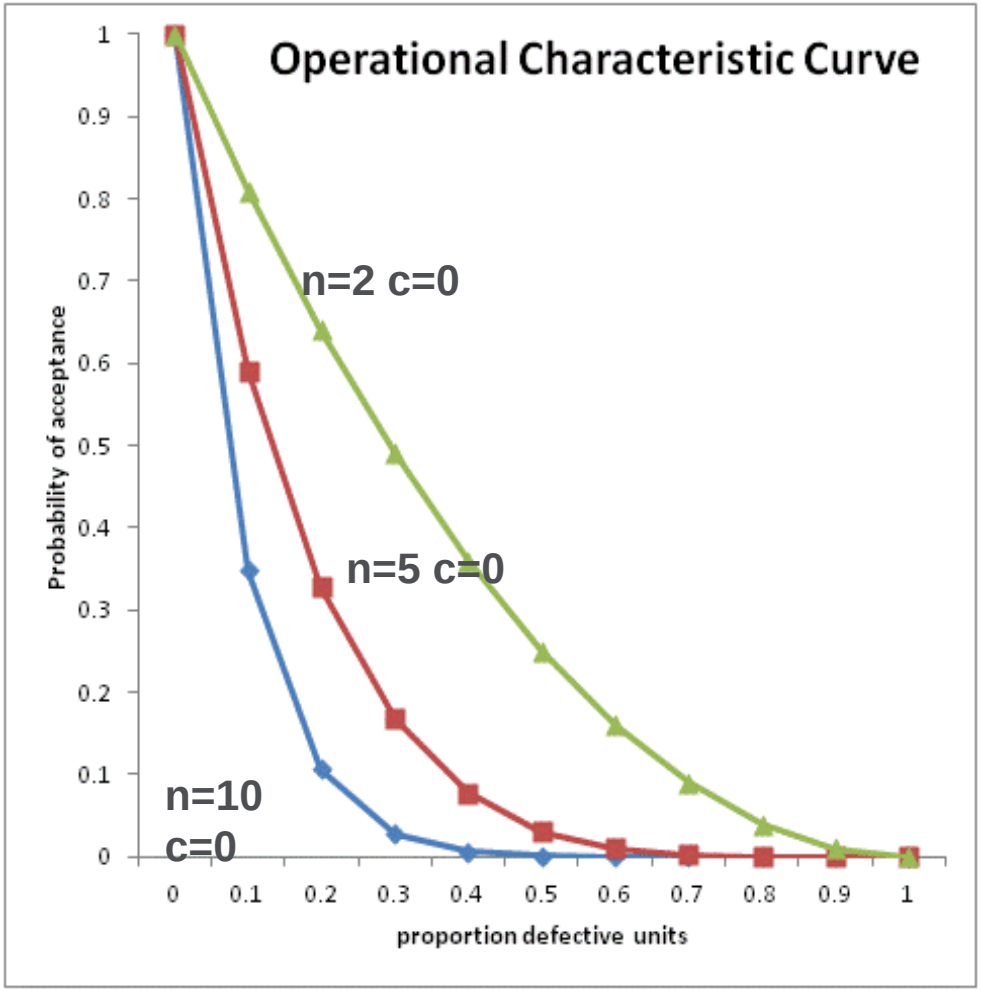
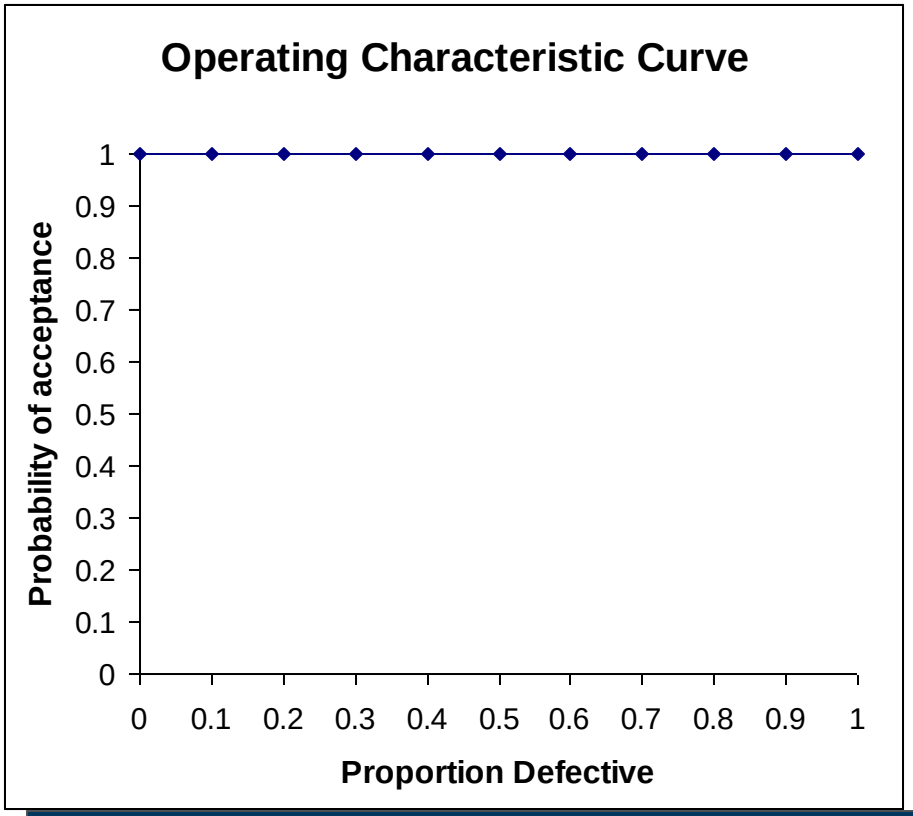
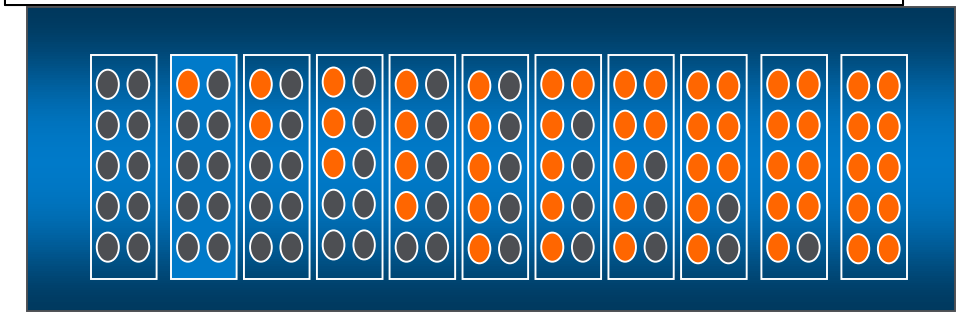
Science Director CSIRO Agriculture and Food

ICMSF Chairman since 2000

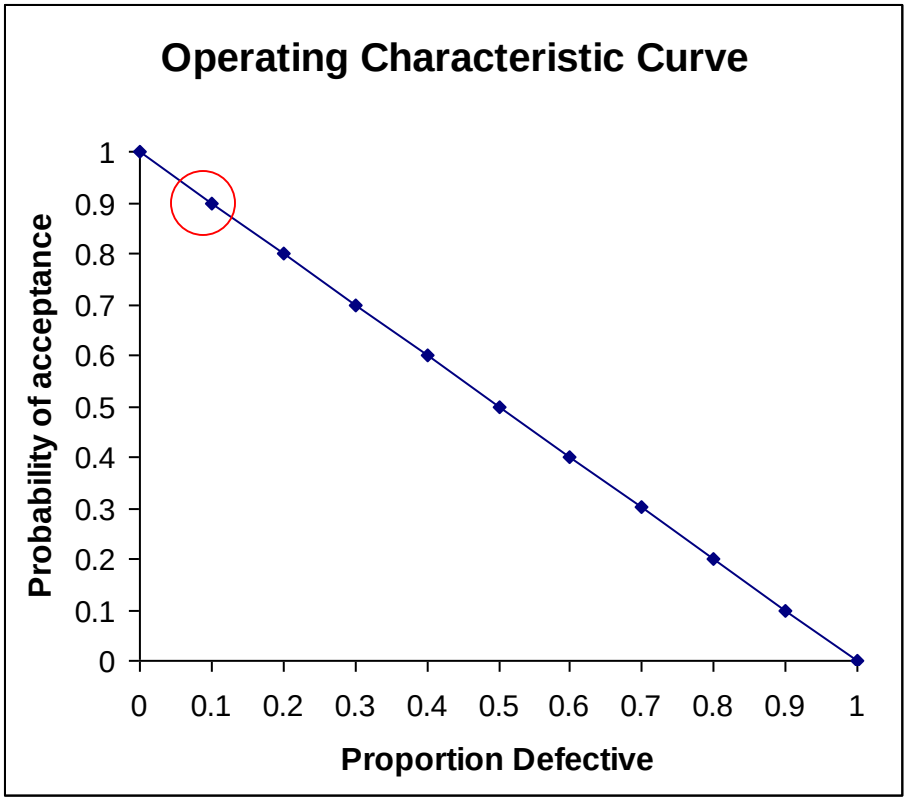
How sampling numbers and stringency affect probability of accepting a defective 'lot'

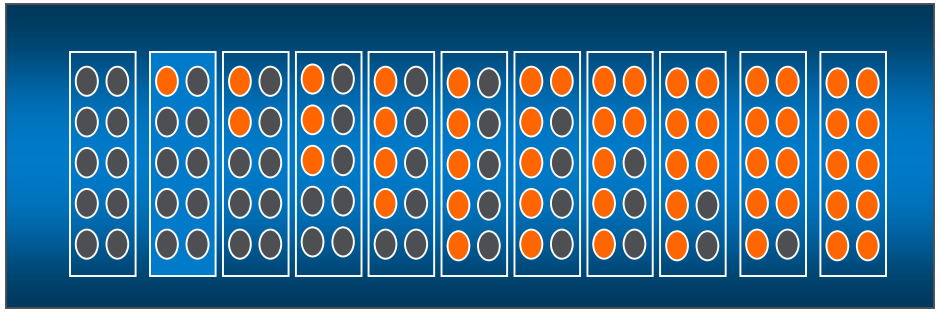



Operating Characteristic Curve
Probability of acceptance
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Proportion Defective



n=0





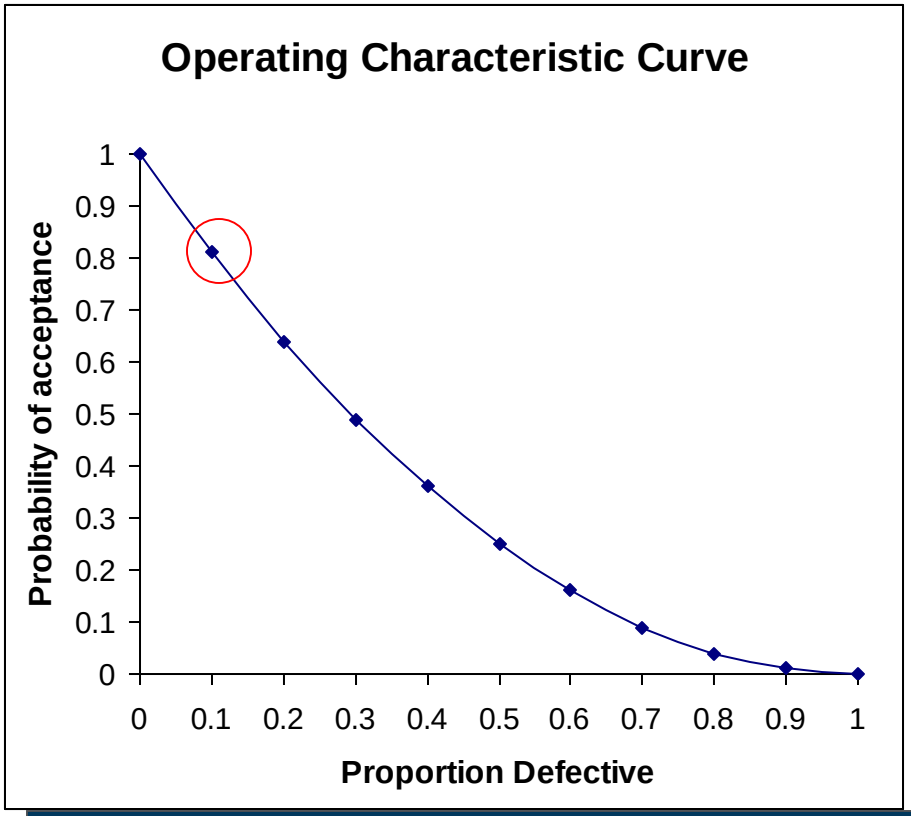
n=1

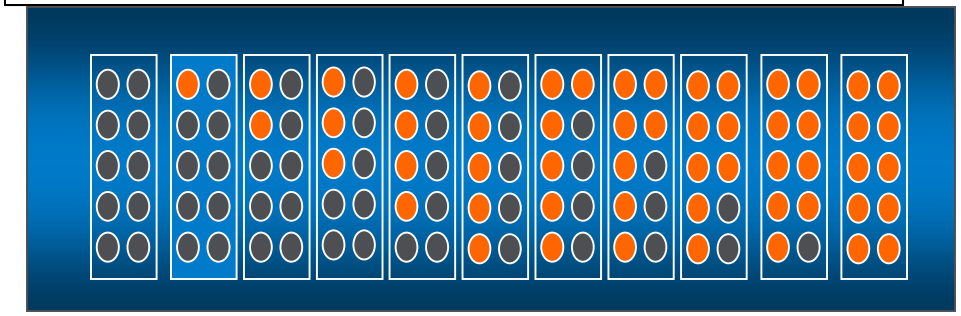
Example:

0.1 Proportion Defective

Probability of Acceptance =

0.9 = 0.9





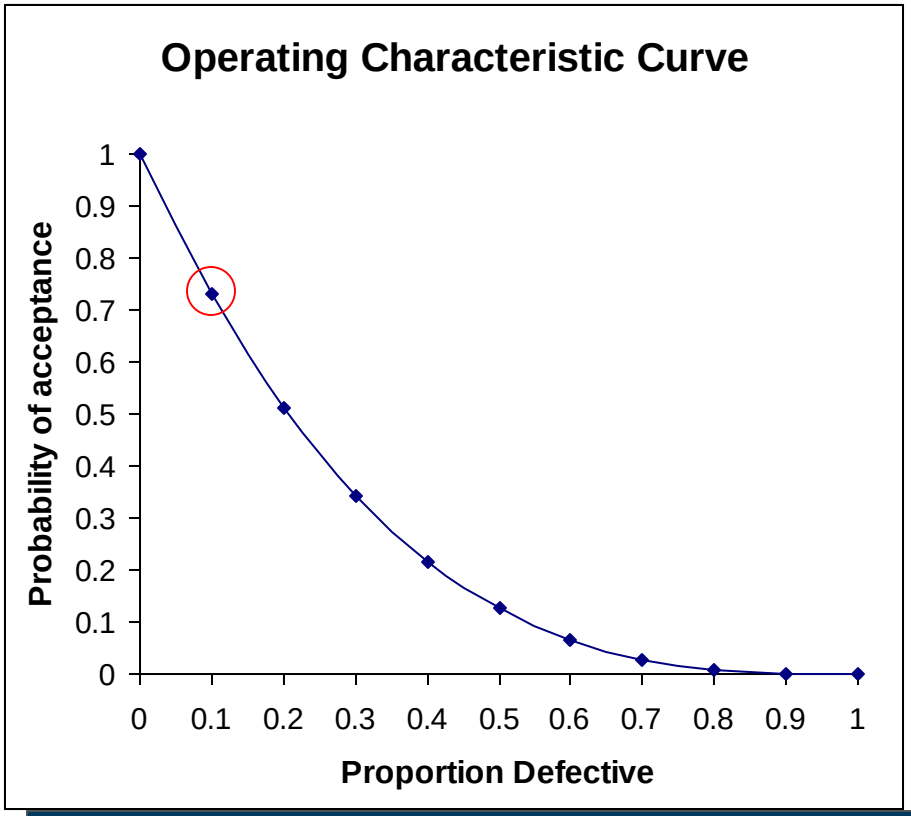
n=2

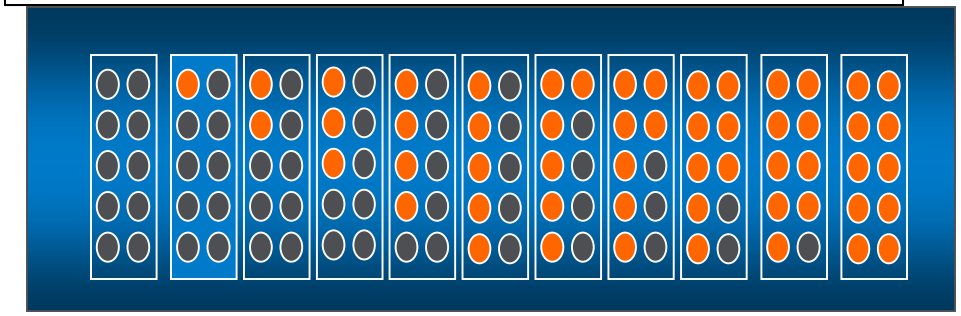
Example:

0.1 Proportion Defective

Probability of Acceptance =

0.9 x 0.9 = 0.81





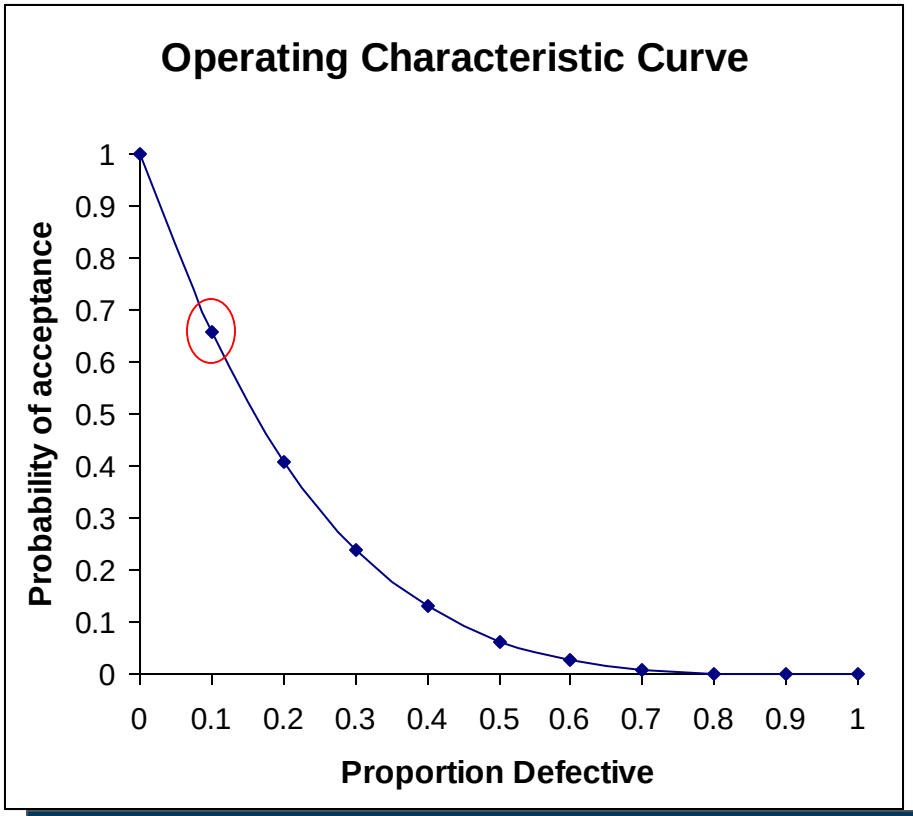
n=3

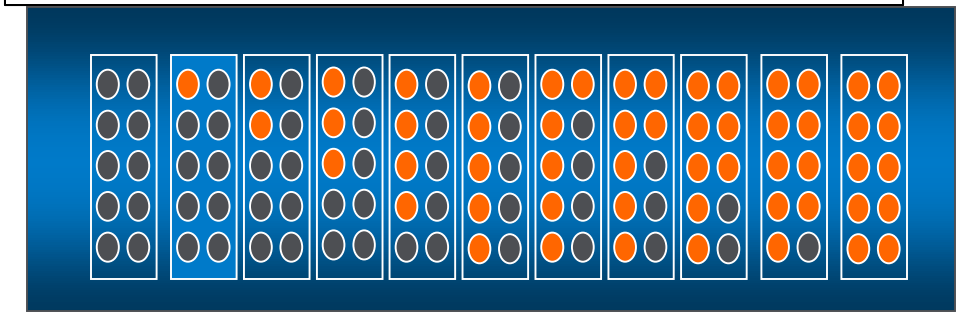
Example:

0.1 Proportion Defective

Probability of Acceptance =

0.9 x 0.9 x 0.9 = 0.73





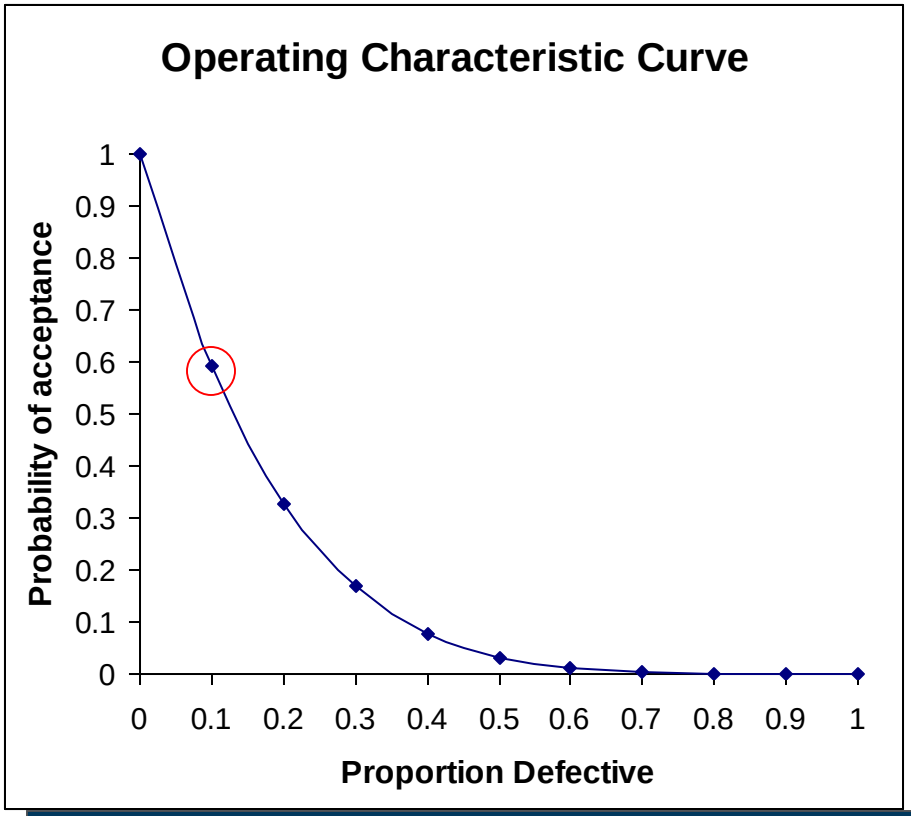
n=4

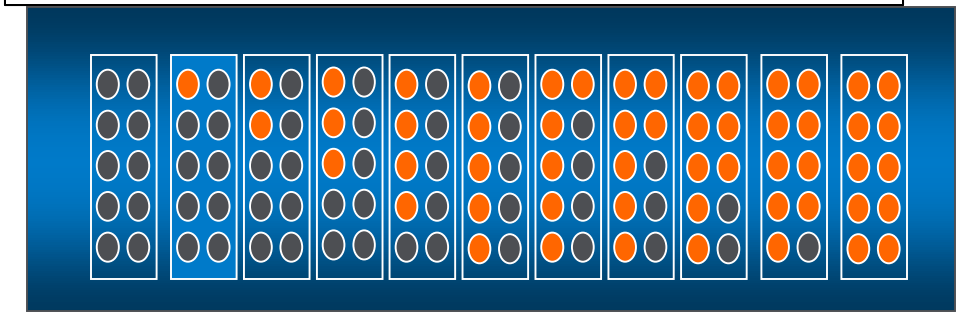
Example:

0.1 Proportion Defective

Probability of Acceptance =

0.9 x 0.9 x 0.9 x 0.9= 0.66





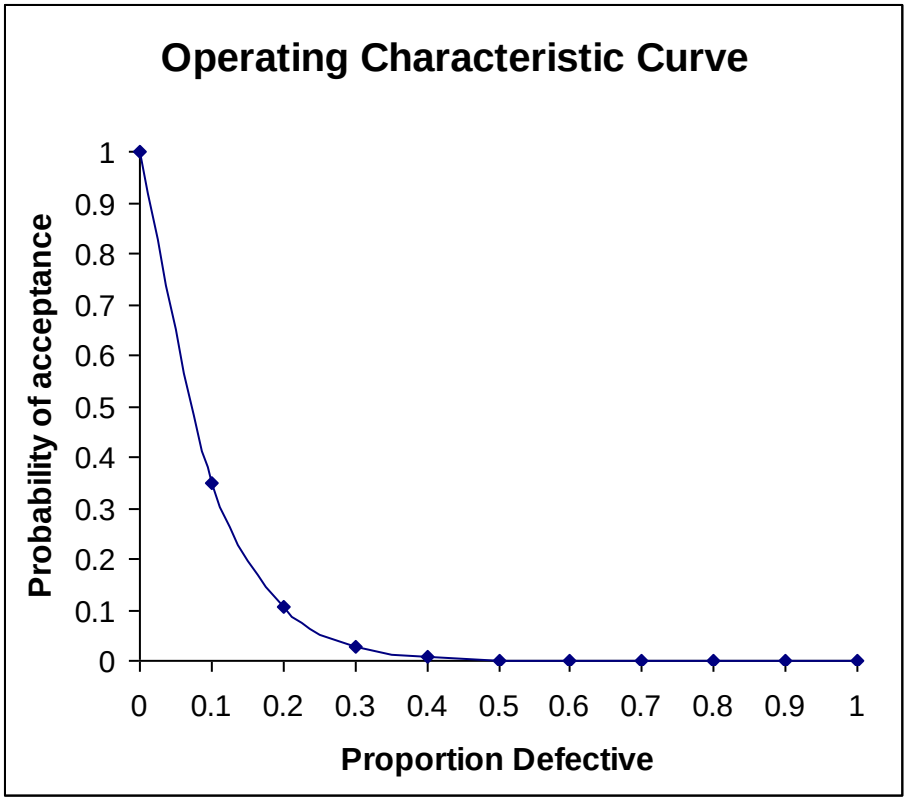
n = 5

Example:

0.1 Proportion Defective

Probability of Acceptance =

0.9 x 0.9 x 0.9 x 0.9 x 0.9 = 0.59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0.7
0.6
0.5
0.4
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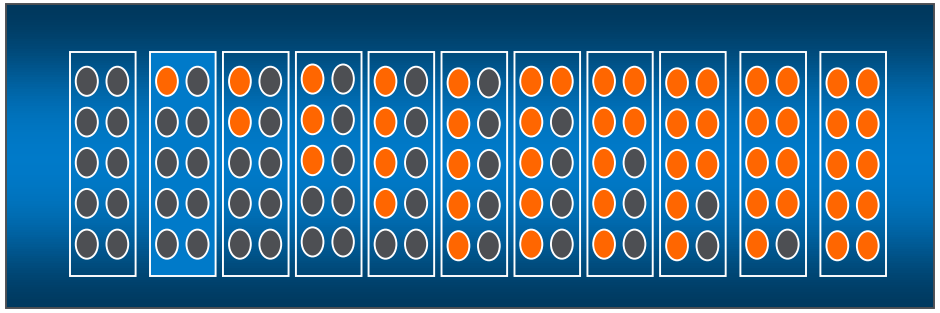
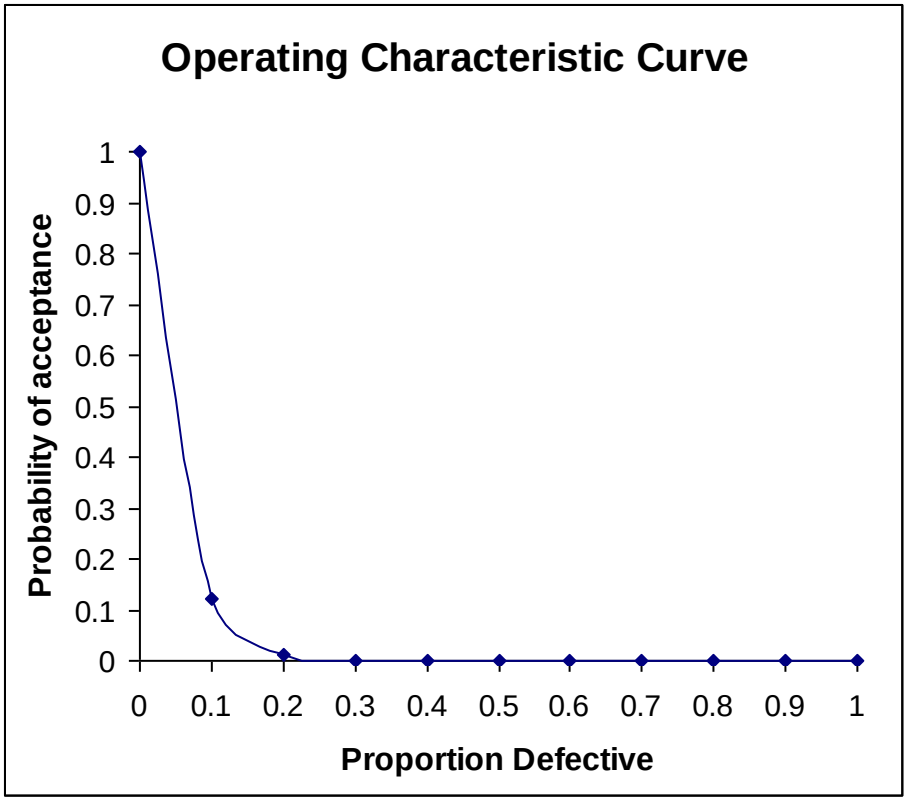
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Proportion Defective



n = 10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0.5
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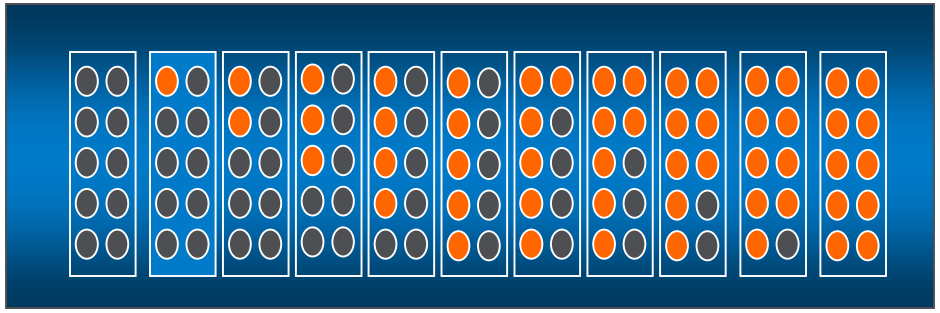
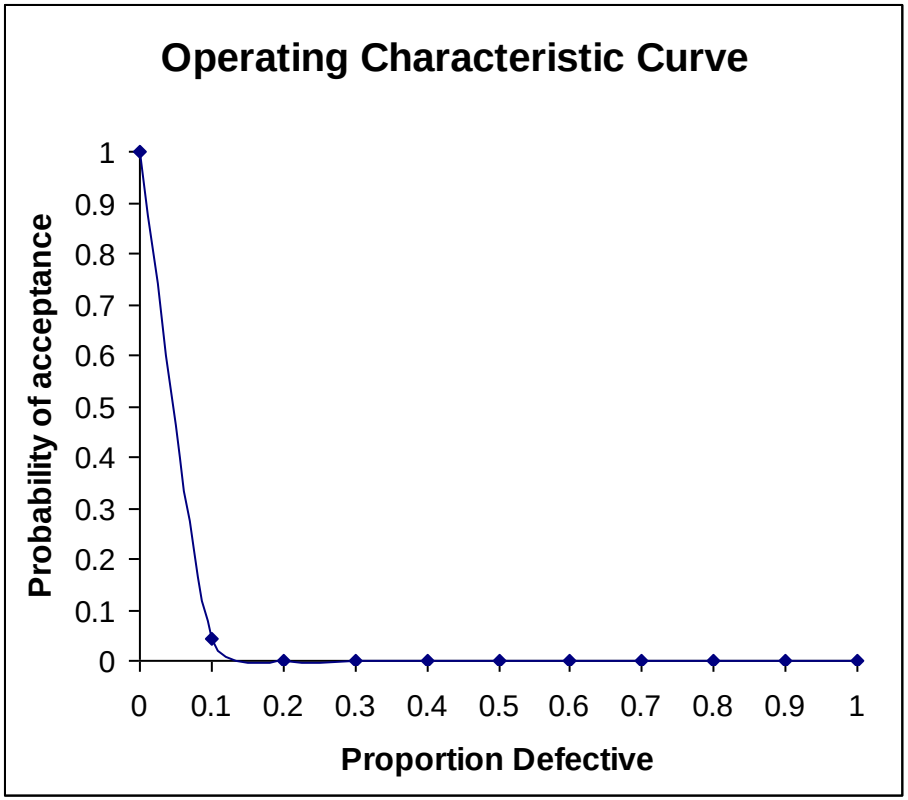
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Proportion Defective



n = 20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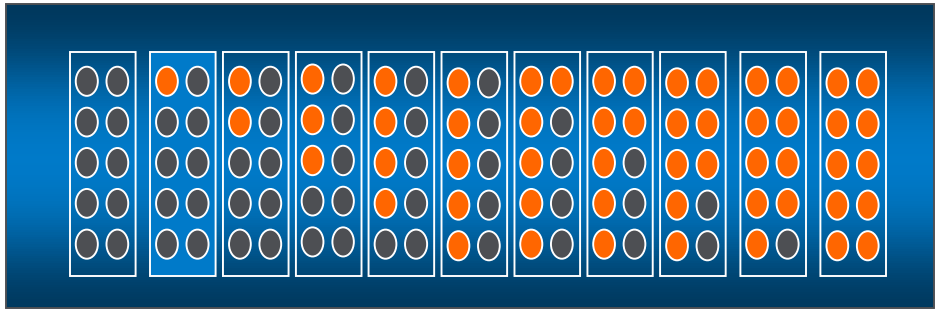
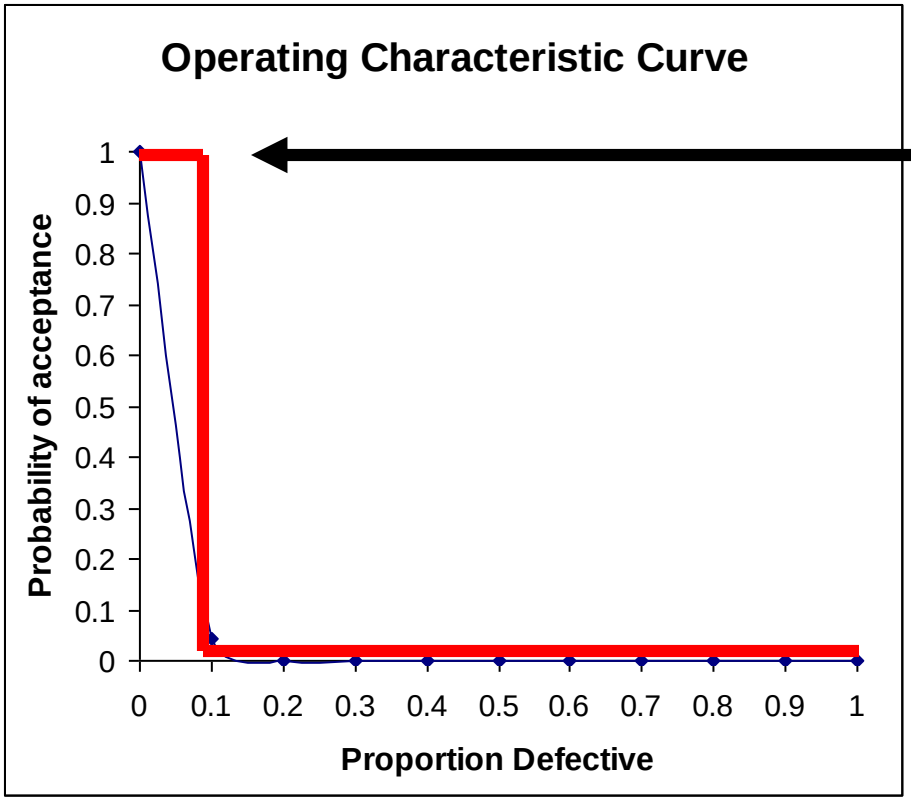
0.4
0.5
0.6
0.7
0.8
0.9
1
Proportion Defective

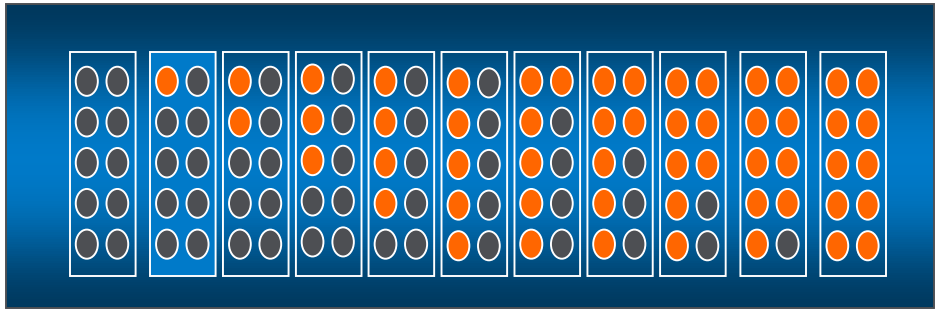


n = 30



P(acc) =1
P(rej) = 0

P(acc) =0
P(rej) = 1



‘Idealized’ Situation

Typical way of expressing performance of sampling plans

Composition of Lot		Number of Sample Units Tested				
% Acceptable	% Defective	5	10	20	60	100
98	2	.90	.82	.67	.30	.13
95	5	.77	.60	.36	.05	.01
90	10	.59	.35	.12	<	<
80	20	.17	.11	.01		
70	30	.03	.03	<		
50	50	.01	<			
40	60	<				
30	70					

Two-Class Plans (c=0): Probabilities of Acceptance

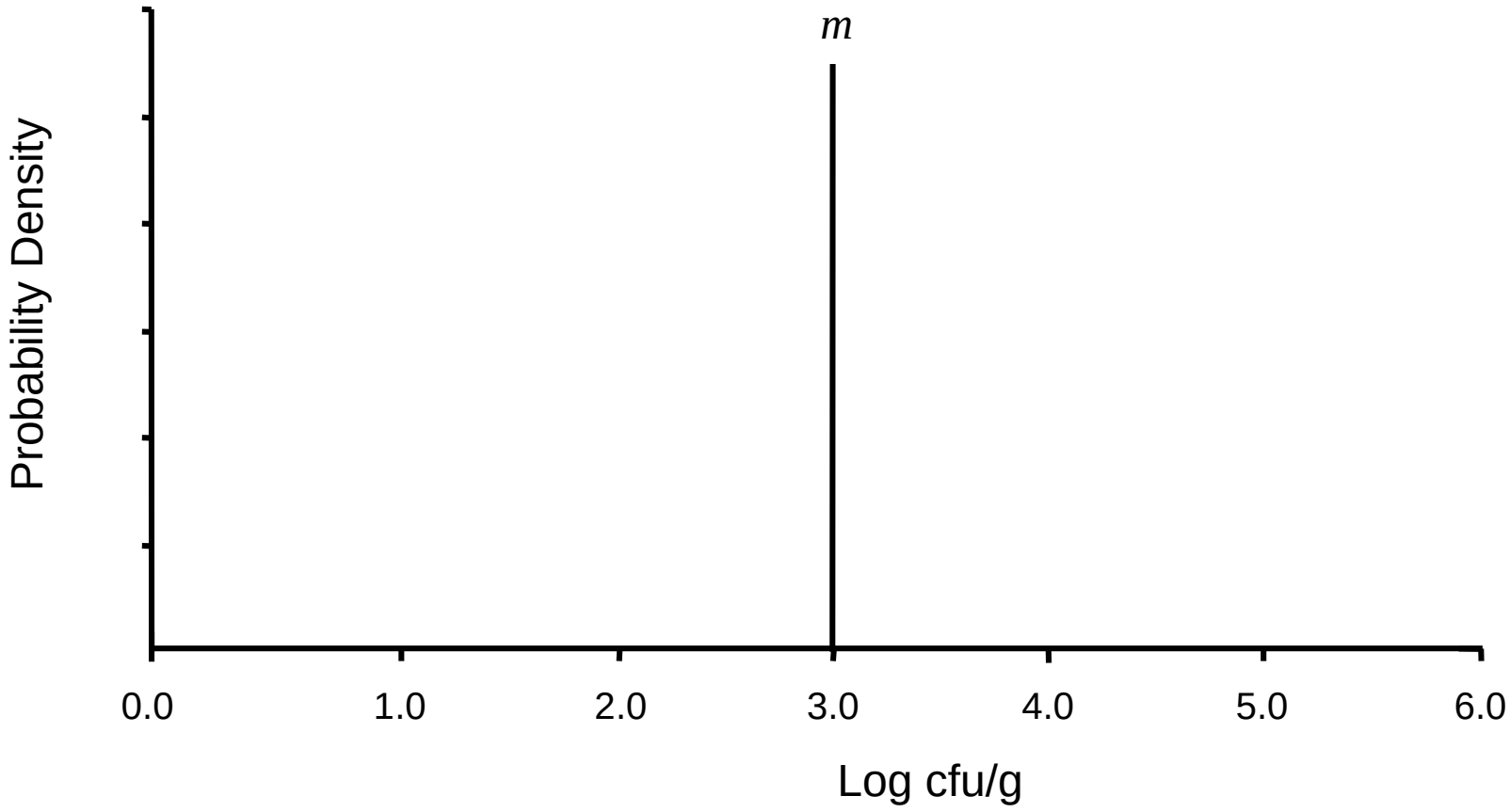
Relating the performance of a sample plan to the level a hazard controlled

Distributional assumption for sampling results
e.g. log-normal with standard deviation known from previous experience

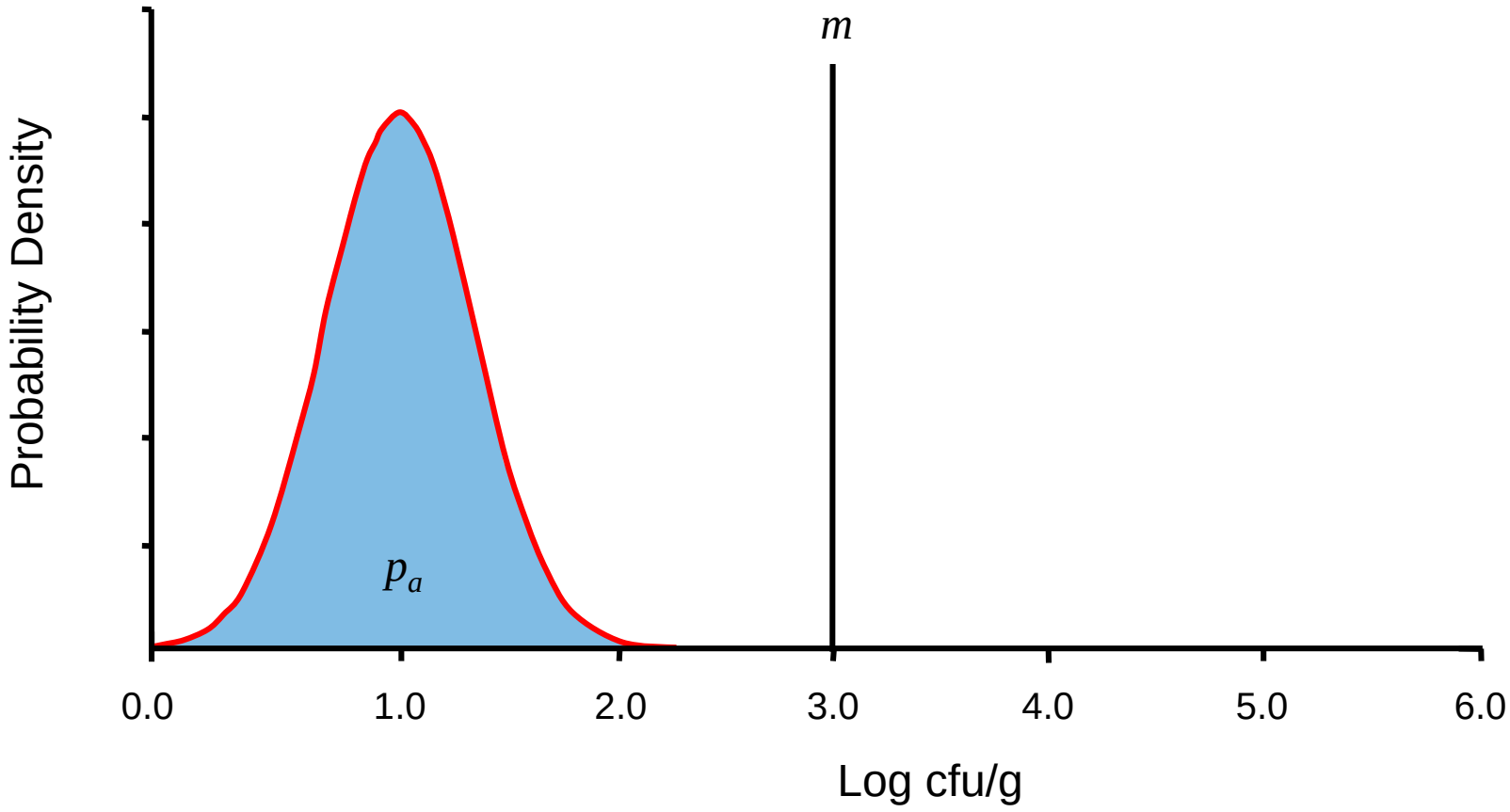
Determine proportions defective for possible mean log cfu/g

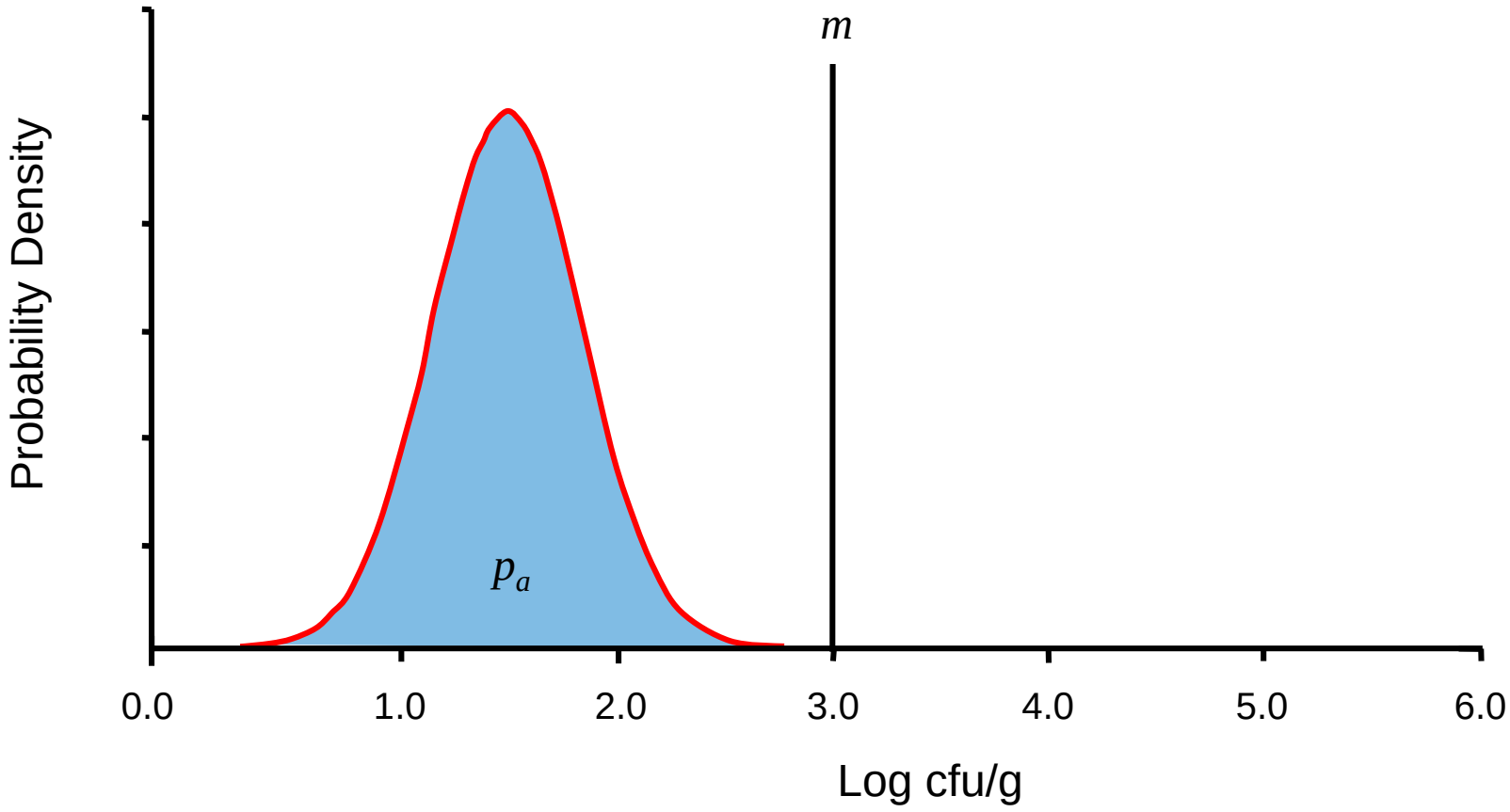
Calculate acceptance probabilities and plot against mean log cfu/g

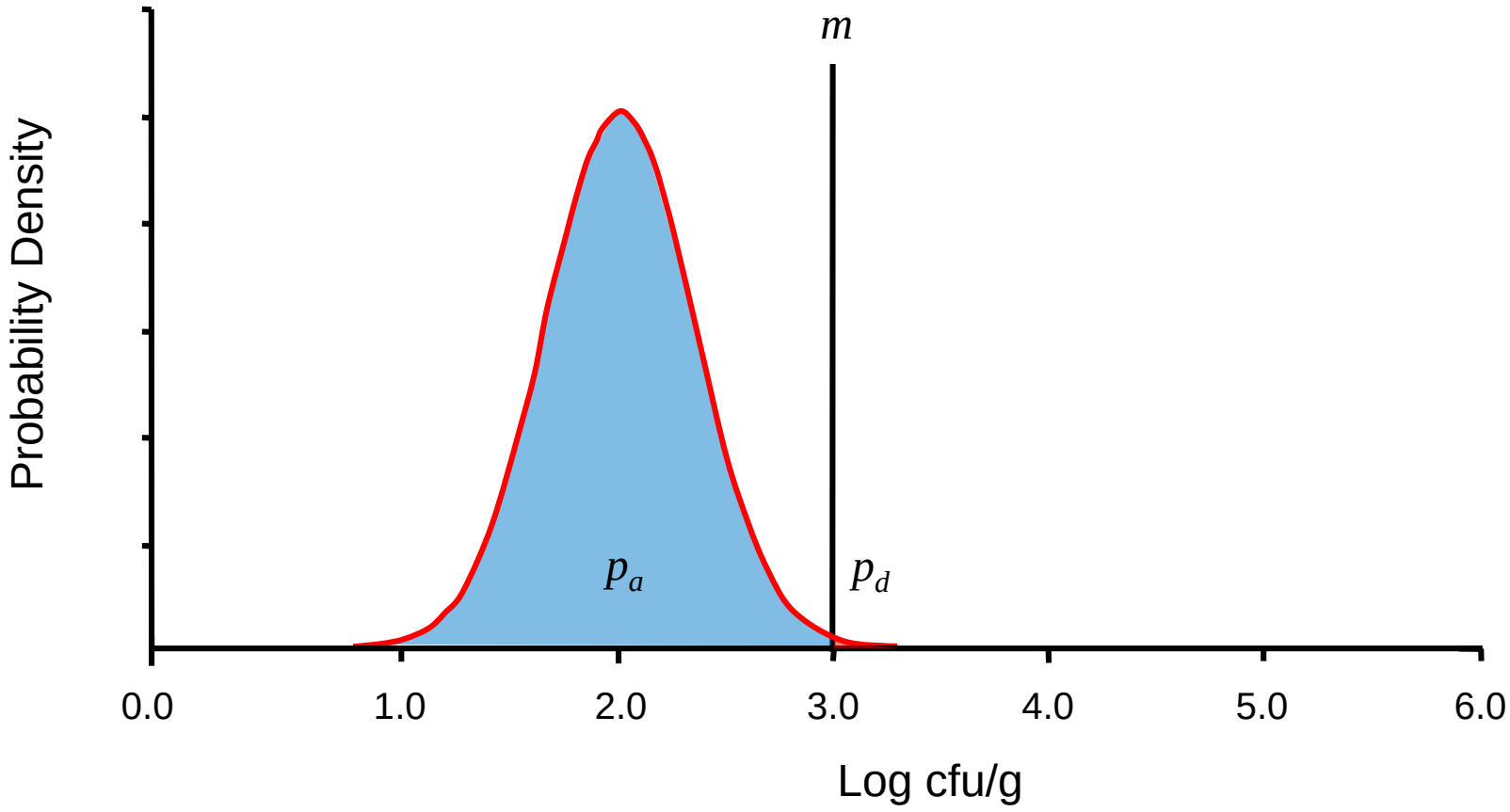
Linking the Performance of attribute sampling plans to the concentration of bacteria controlled

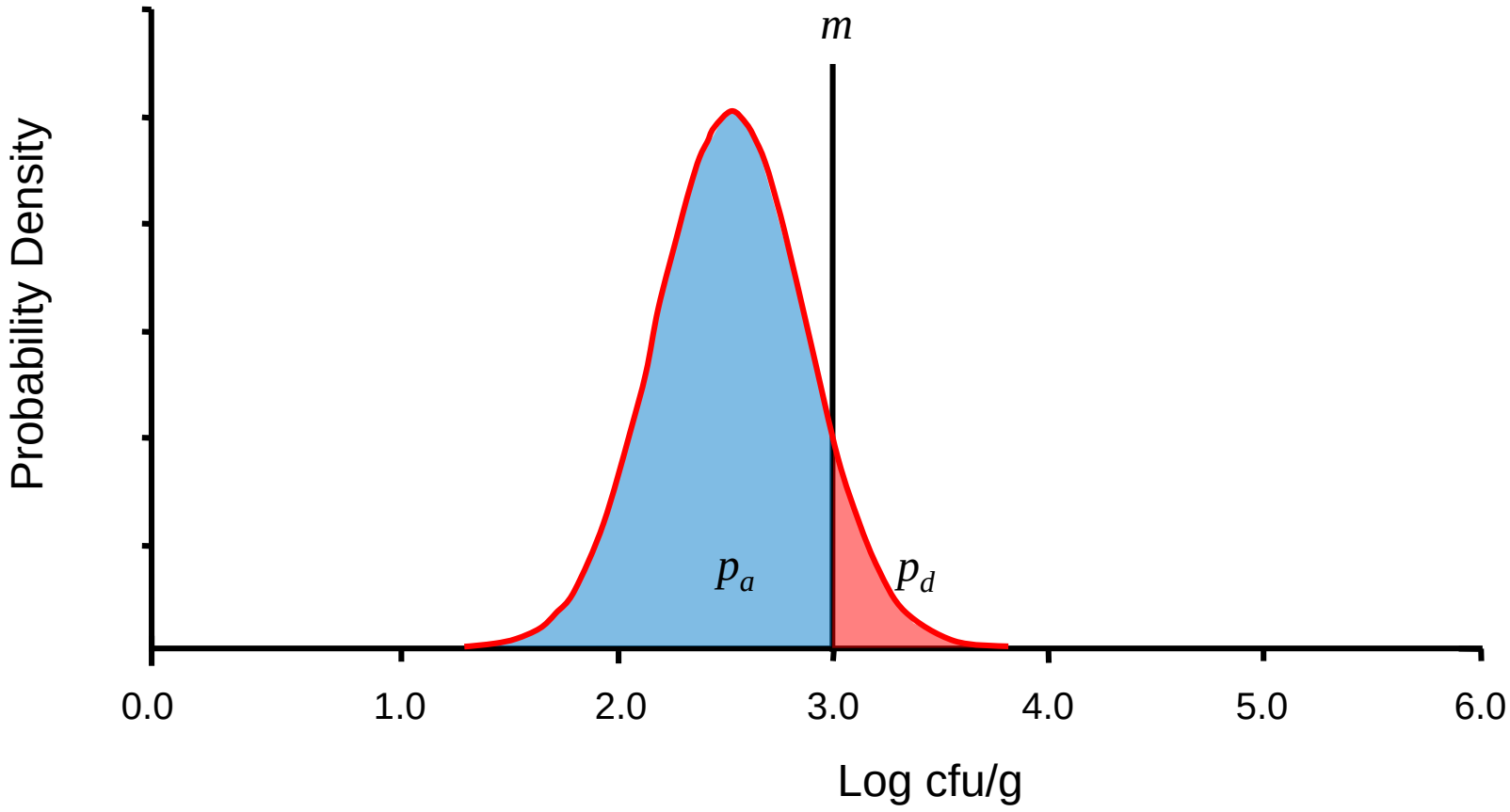


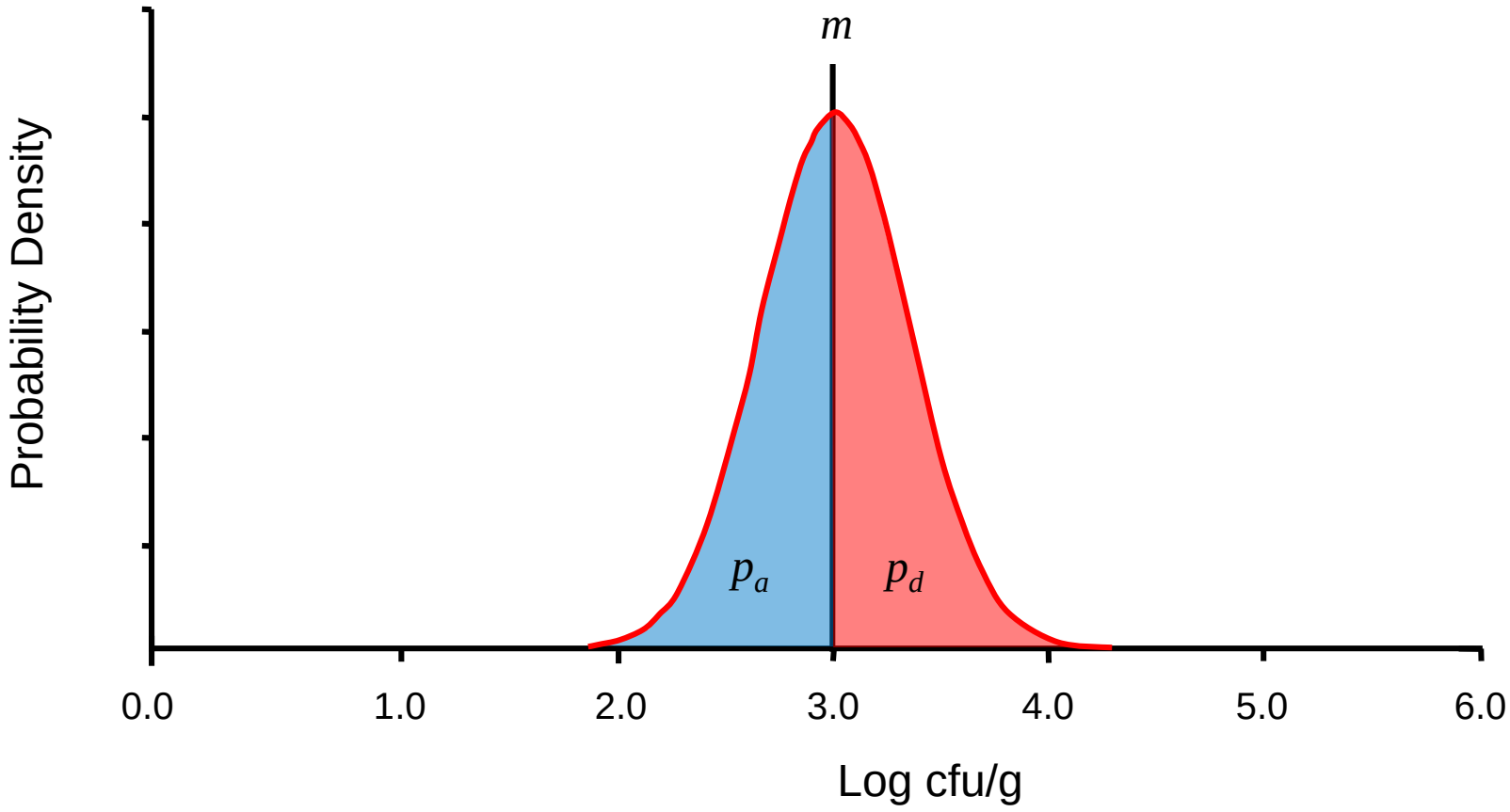
Proportion Defective

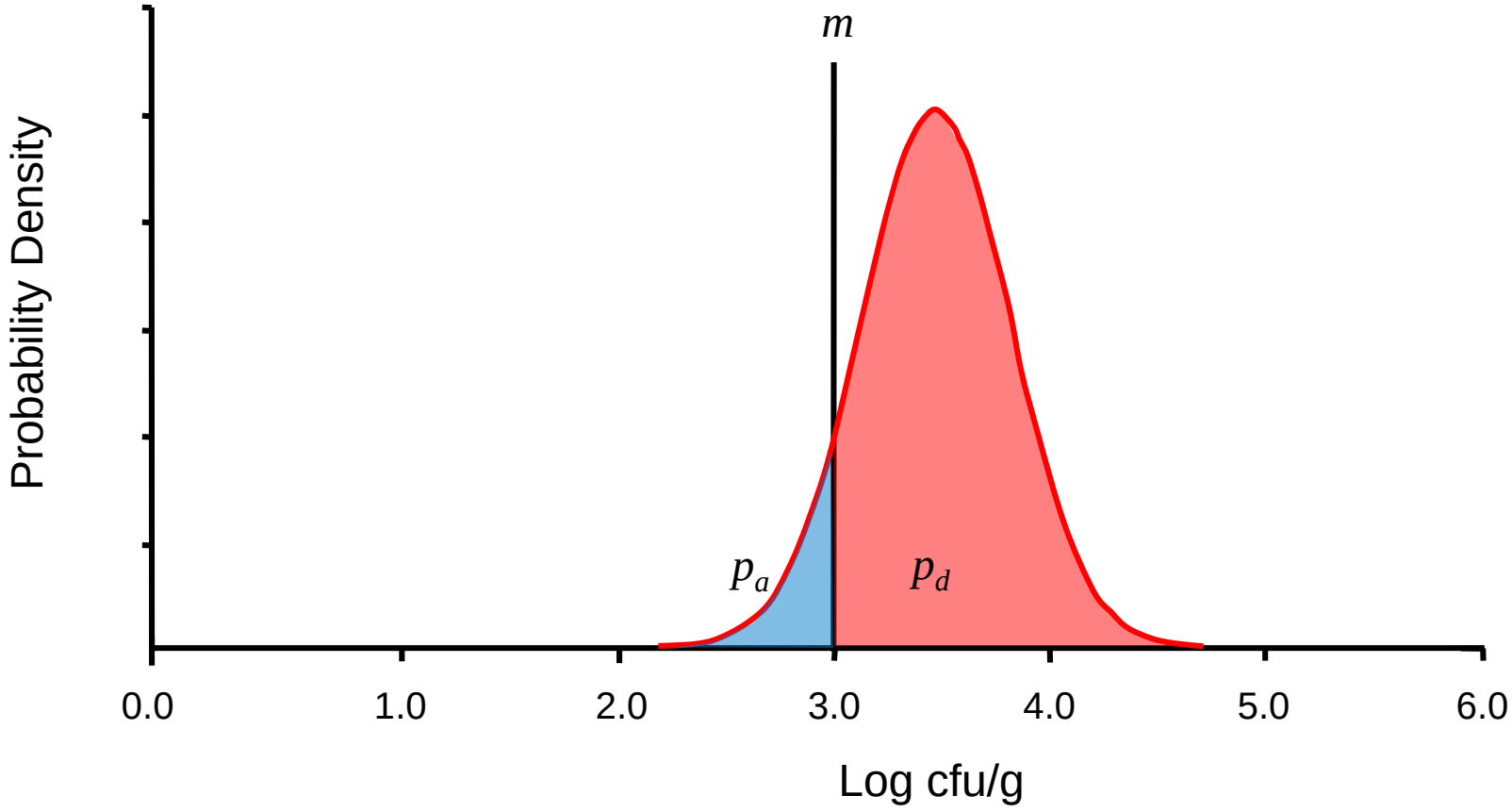


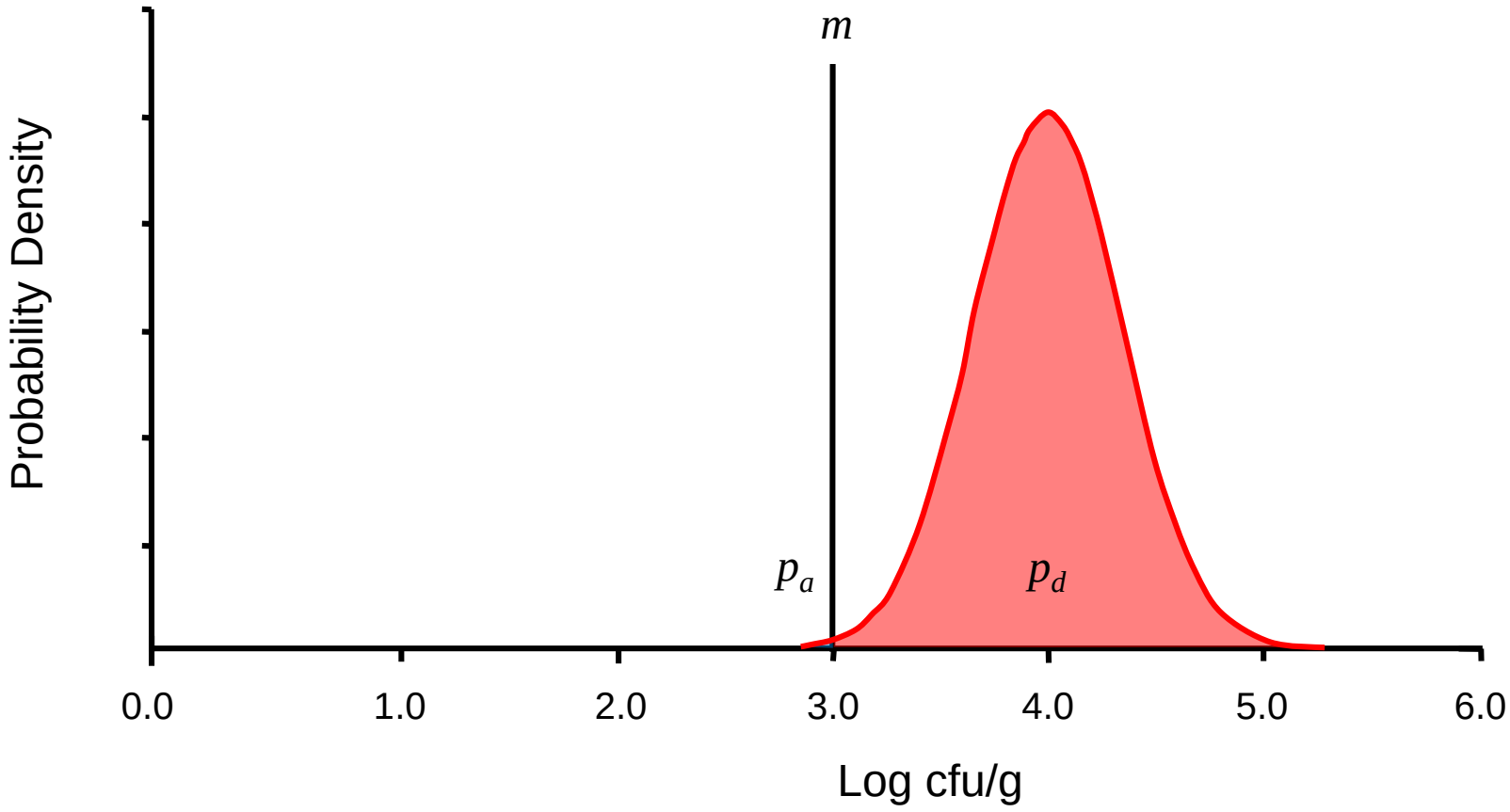

m
Probability Density
p_a
0.0
1.0
2.0
3.0
4.0
5.0
6.0
Log cfu/g

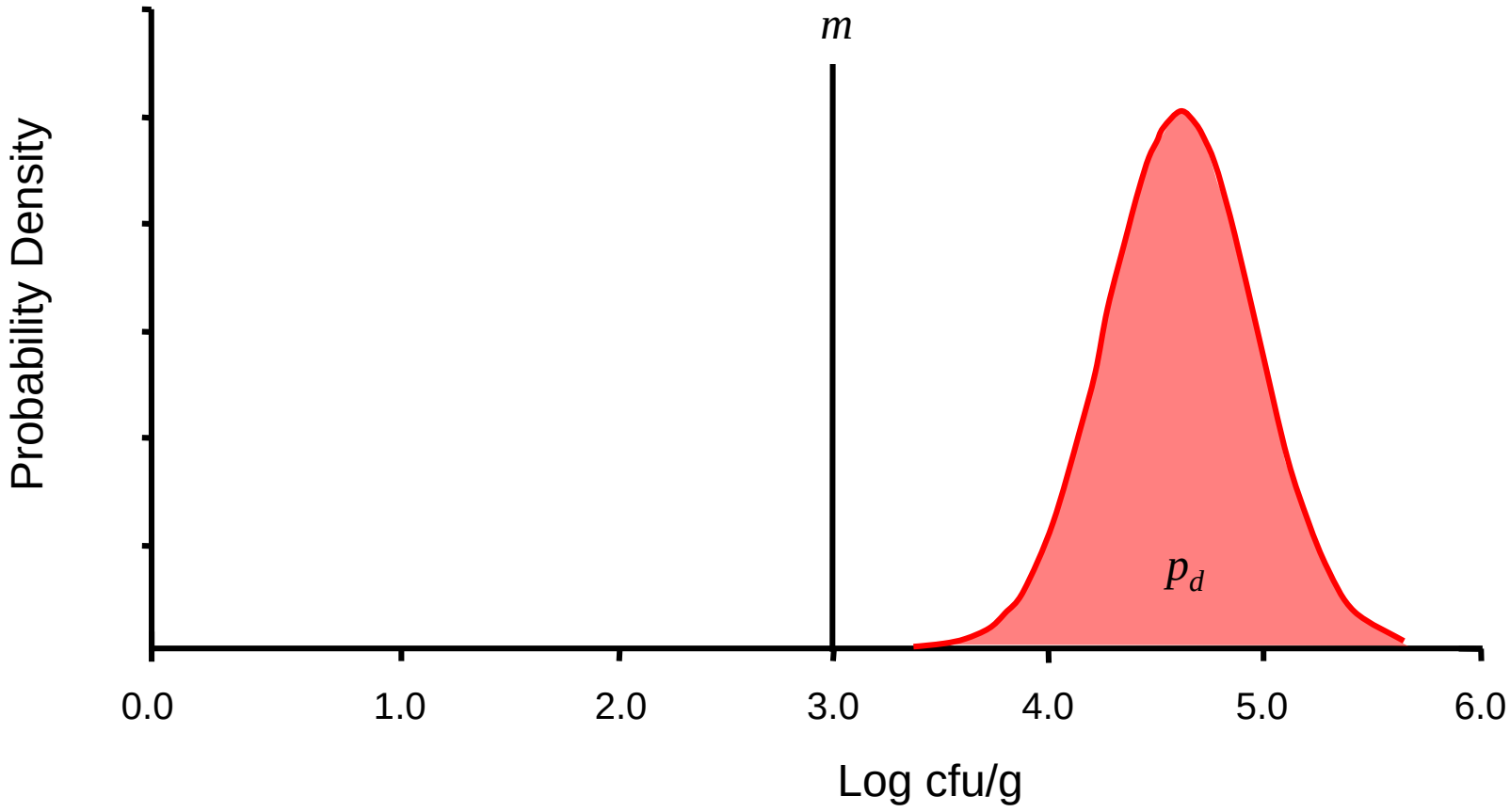

m
Probability Density
p_a
p_d
0.0
1.0
2.0
3.0
4.0
5.0
6.0
Log cfu/g

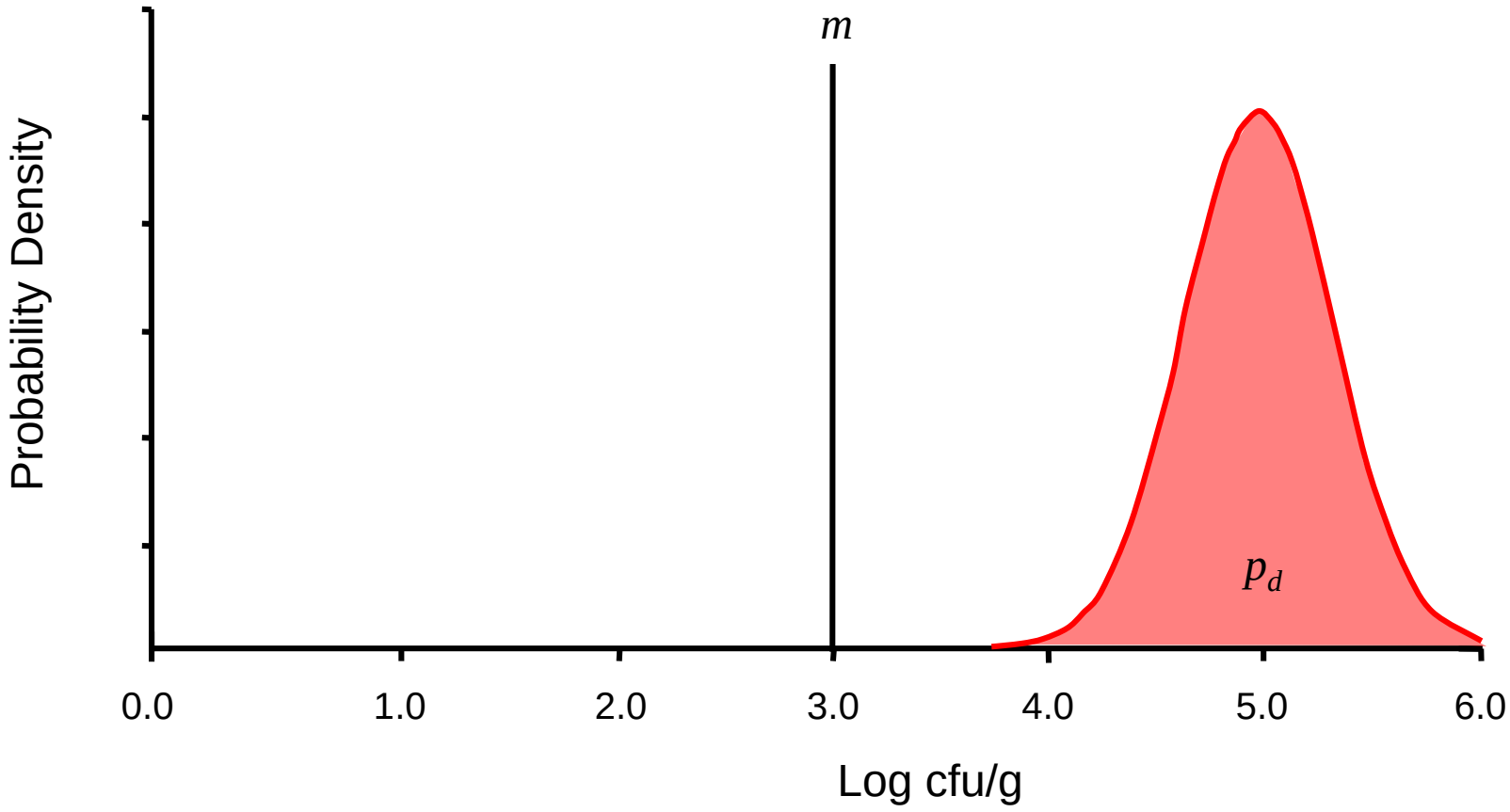

m
Probability Density
p_a
p_d
0.0
1.0
2.0
3.0
4.0
5.0
6.0
Log cfu/g


m
Probability Density
p_a
p_d
0.0
1.0
2.0
3.0
4.0
5.0
6.0
Log cfu/g


m
Probability Density
p_a
p_d
0.0
1.0
2.0
3.0
4.0
5.0
6.0
Log cfu/g


m
Probability Density
p_a
p_d
0.0
1.0
2.0
3.0
4.0
5.0
6.0
Log cfu/g


m
Probability Density
p_d
0.0
1.0
2.0
3.0
4.0
5.0
6.0
Log cfu/g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0.0
1.0
2.0
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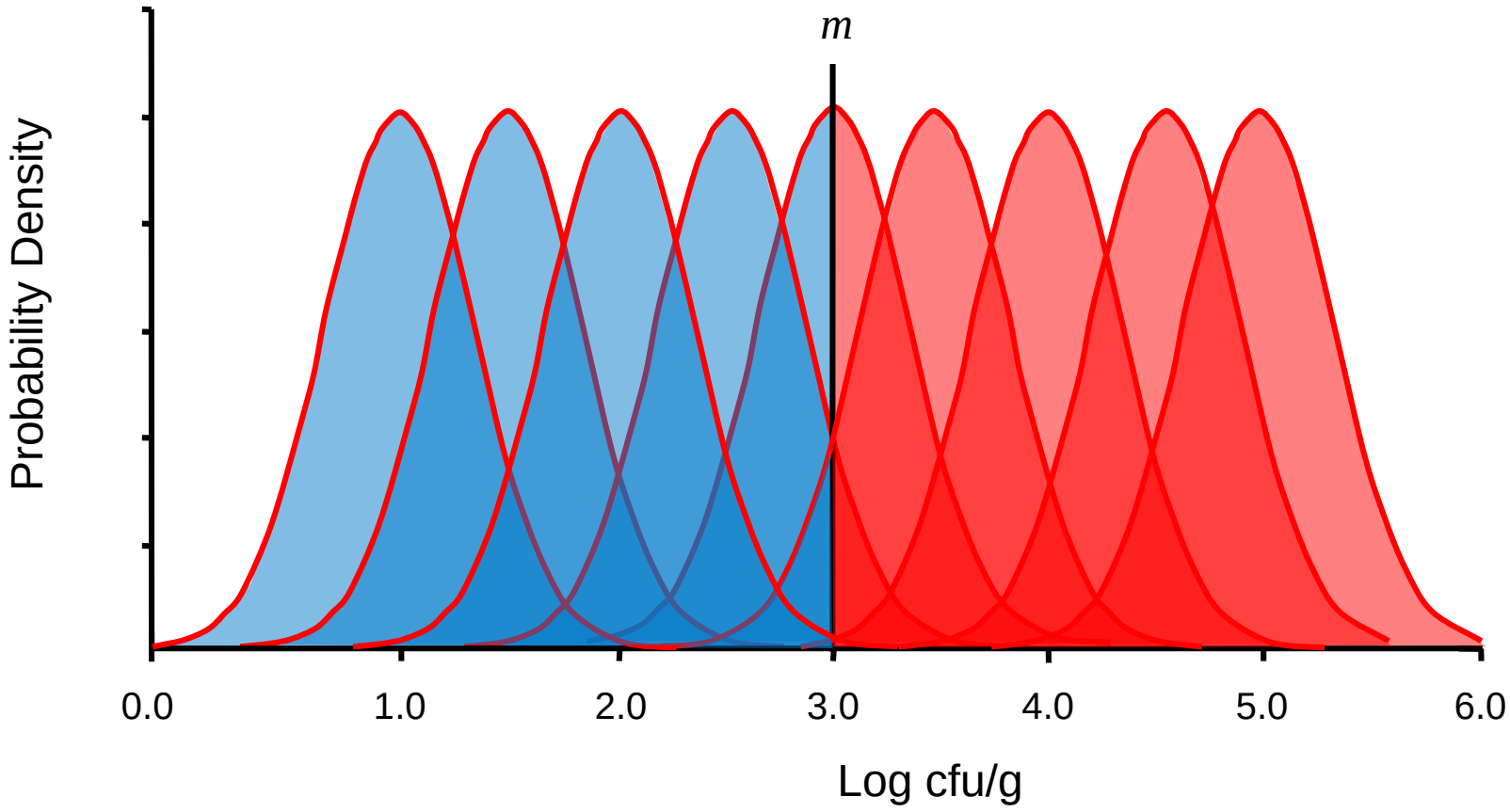
Log cfu/g


m
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0.0
1.0
2.0
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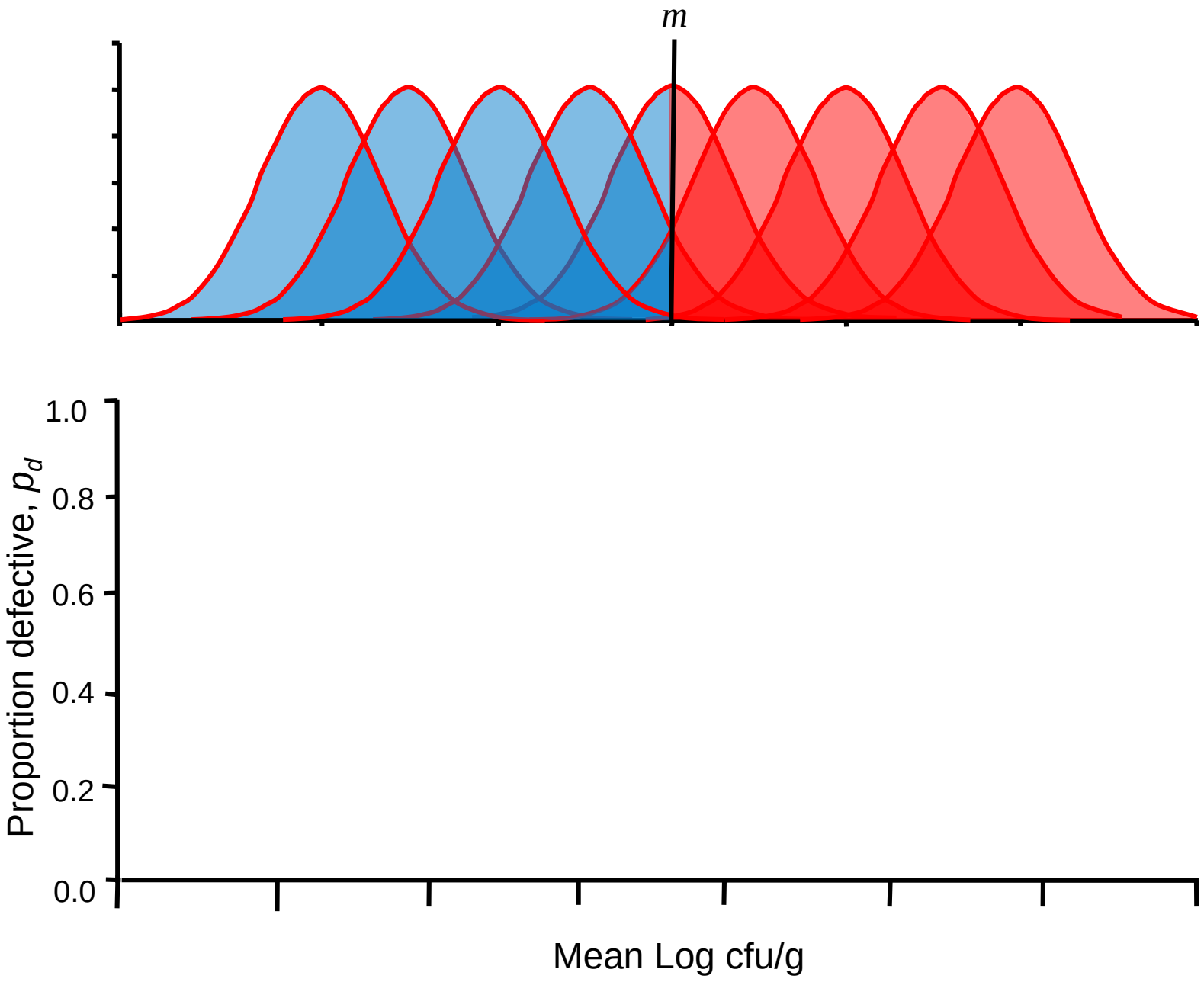
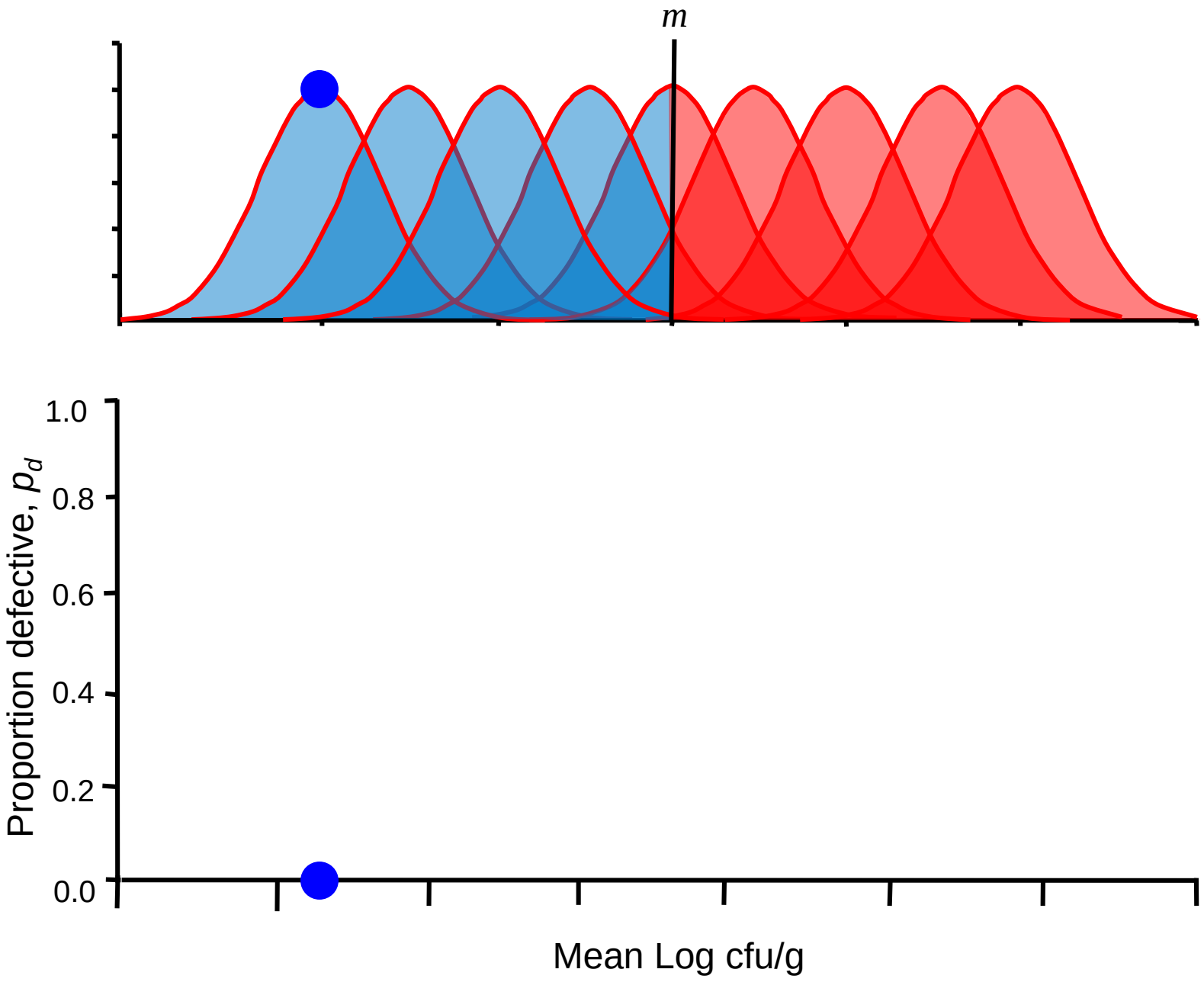
Log cfu/g


m
1.0
0.8
0.6
0.4
0.2
0.0
Proportion defective, p_d
Mean Log cfu/g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0.8
0.6
0.4
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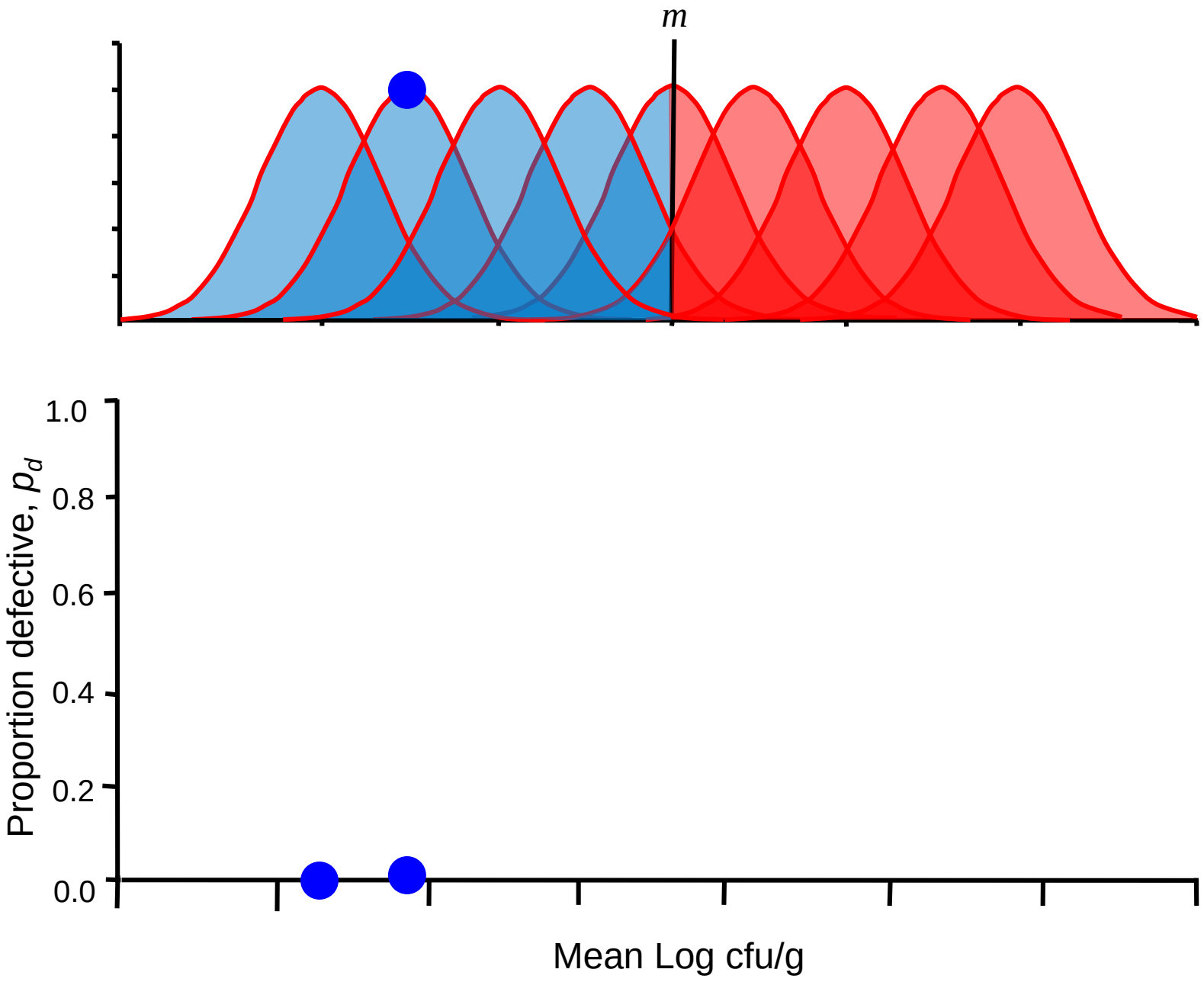
0.0
Proportion defective, p_d
Mean Log cfu/g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0.8
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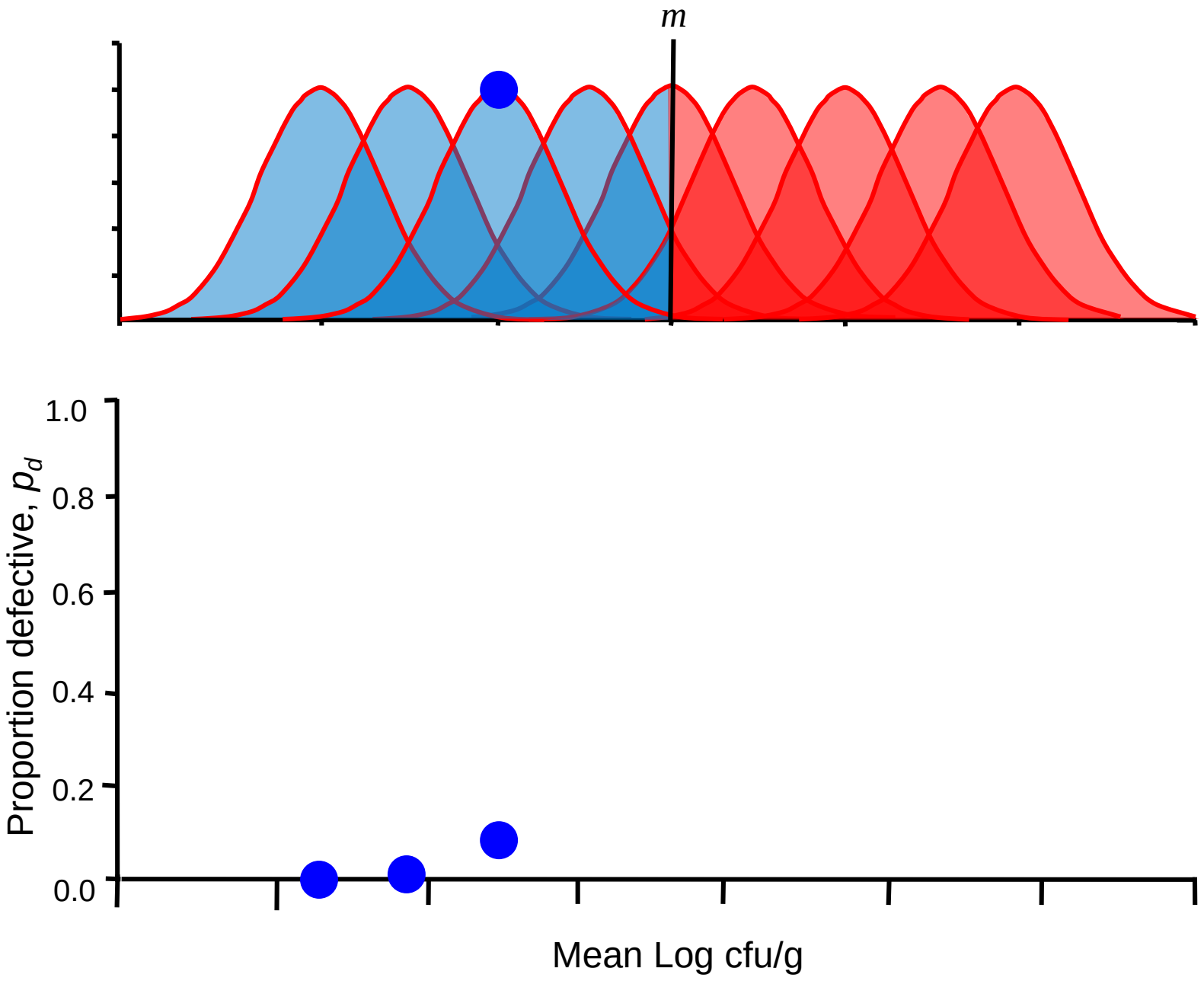
Proportion defective, p_d
Mean Log cfu/g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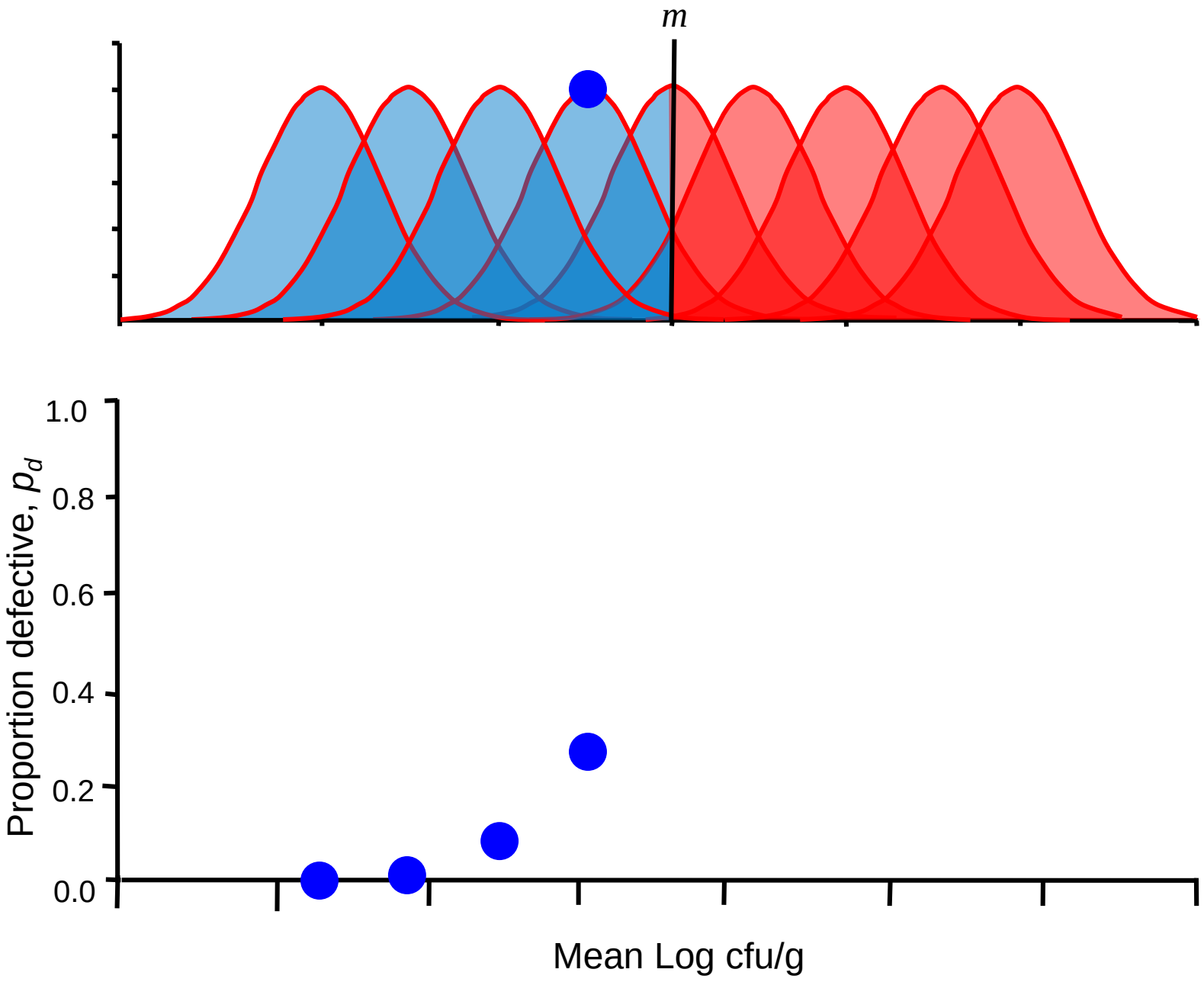
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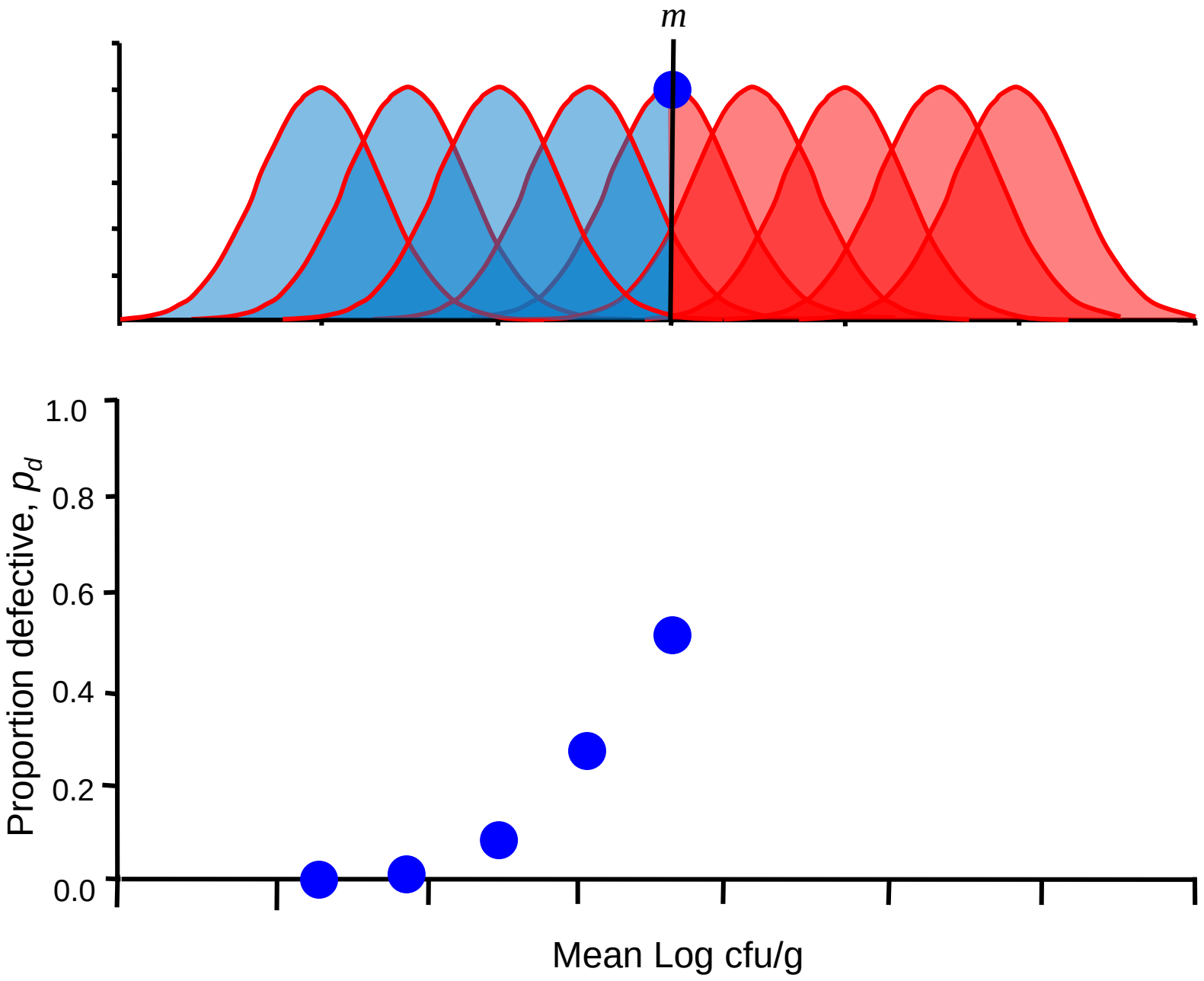
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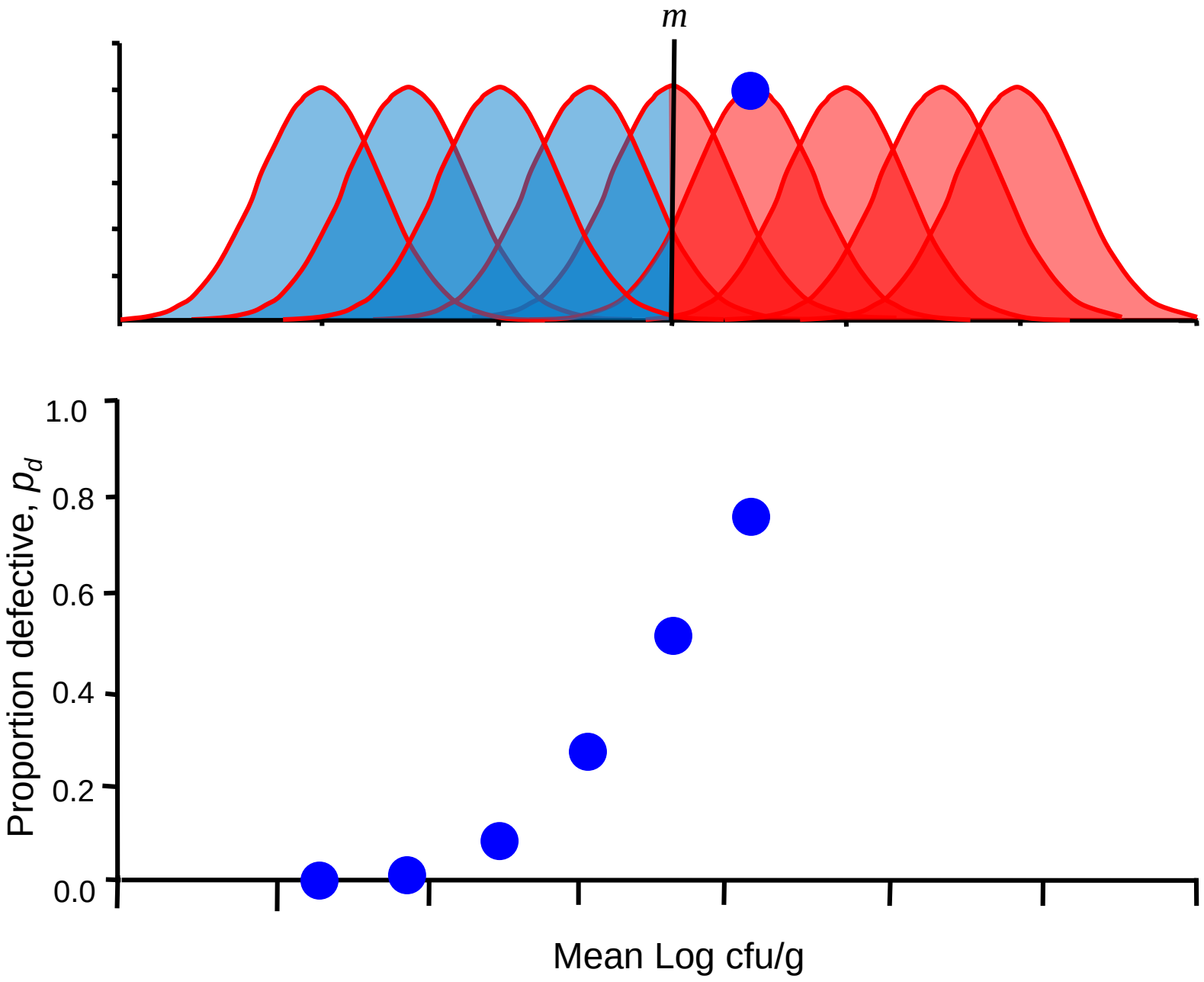
1.0
0.8
0.6
0.4
0.2
0.0
Proportion defective, p_d
Mean Log cfu/g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0.8
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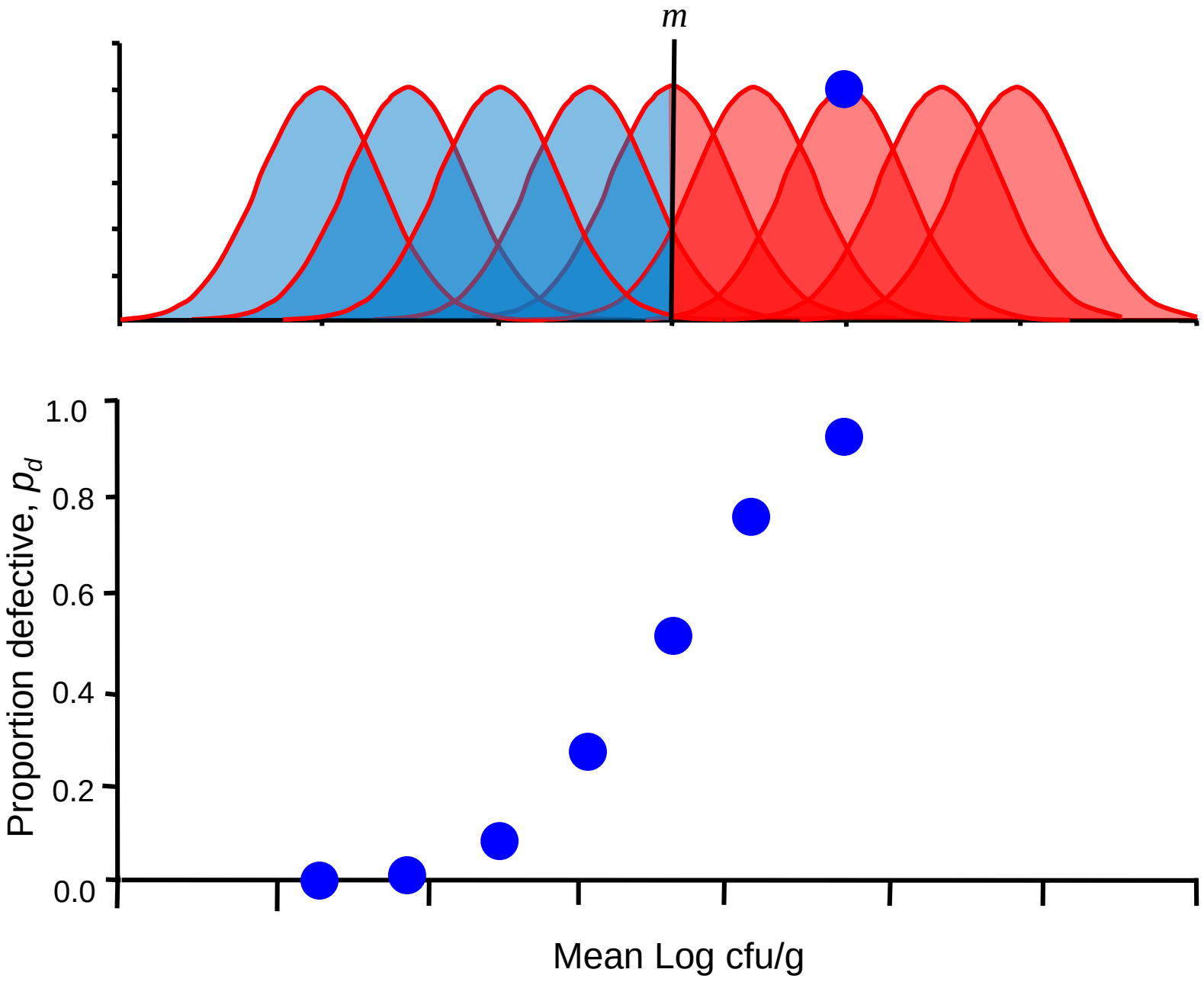
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0.8
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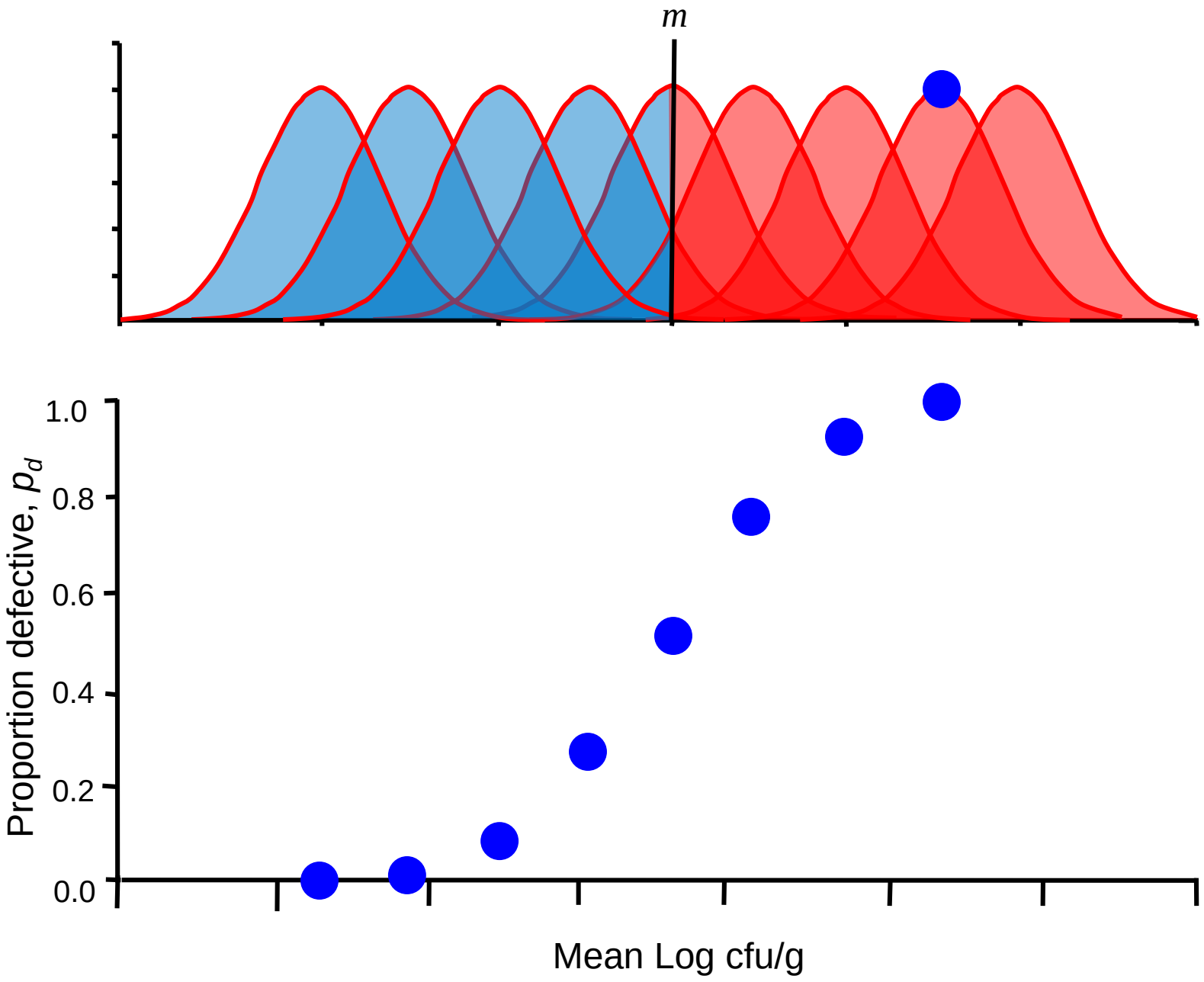
Mean Log cfu/g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0.8
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0.0
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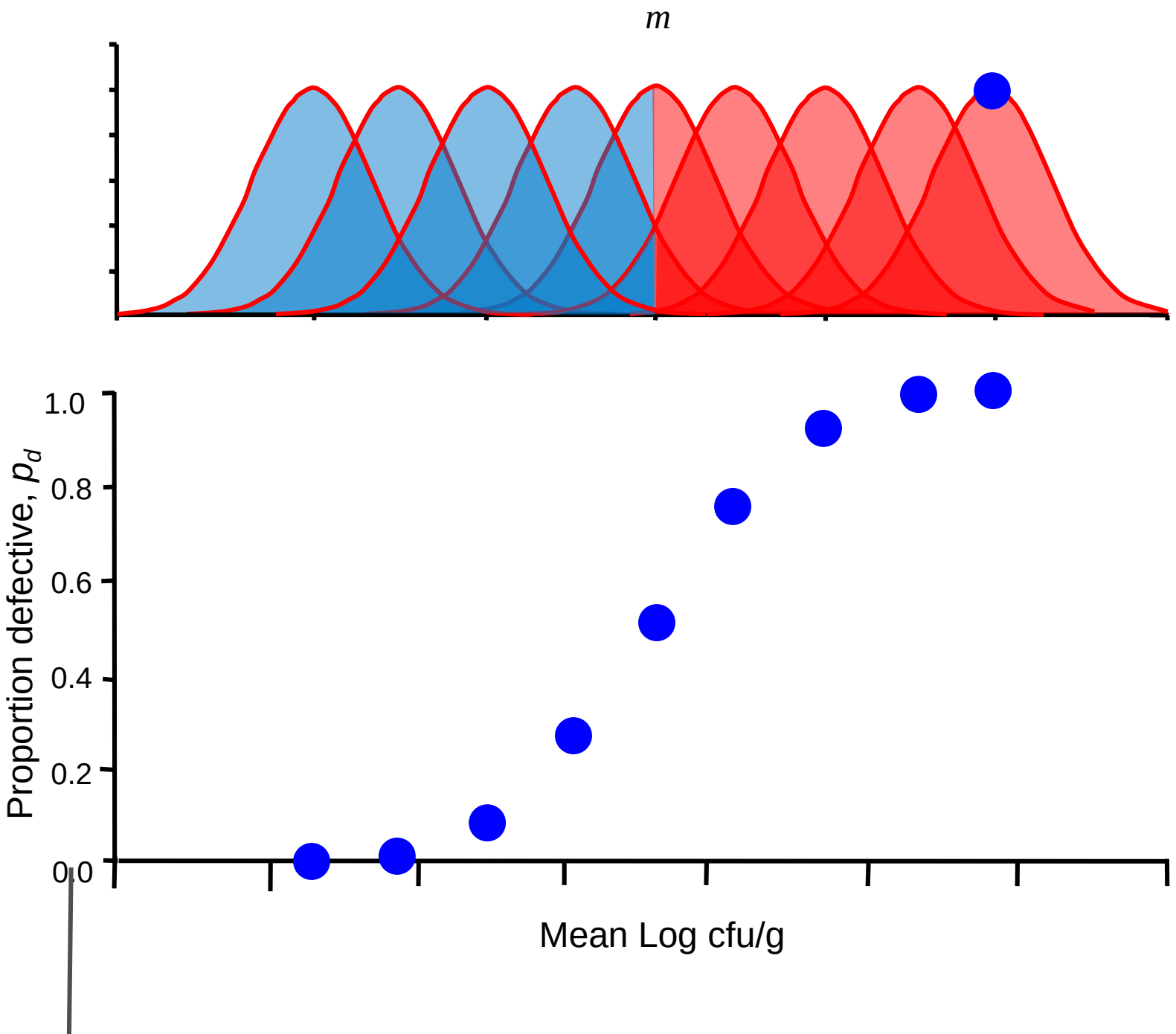
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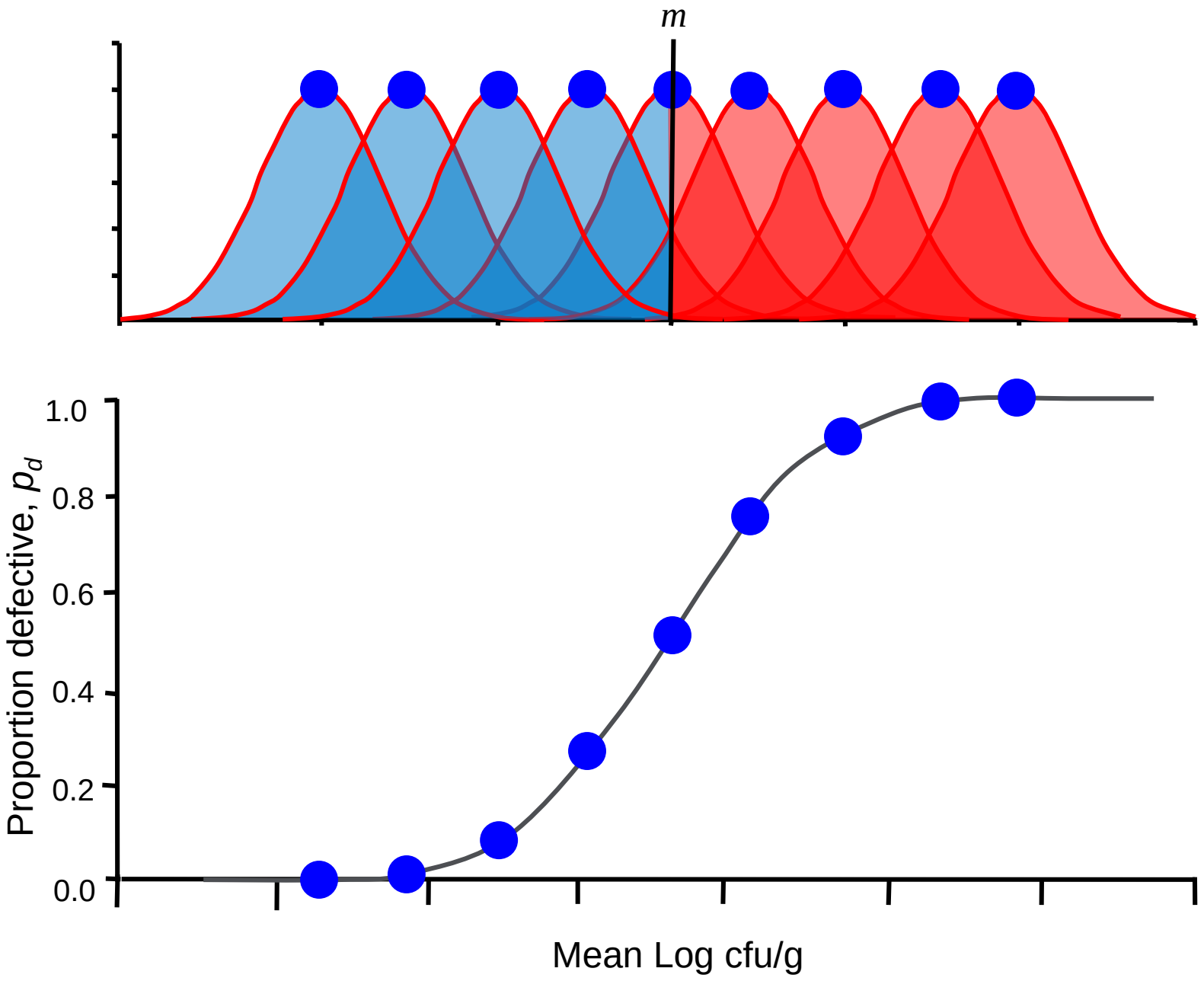
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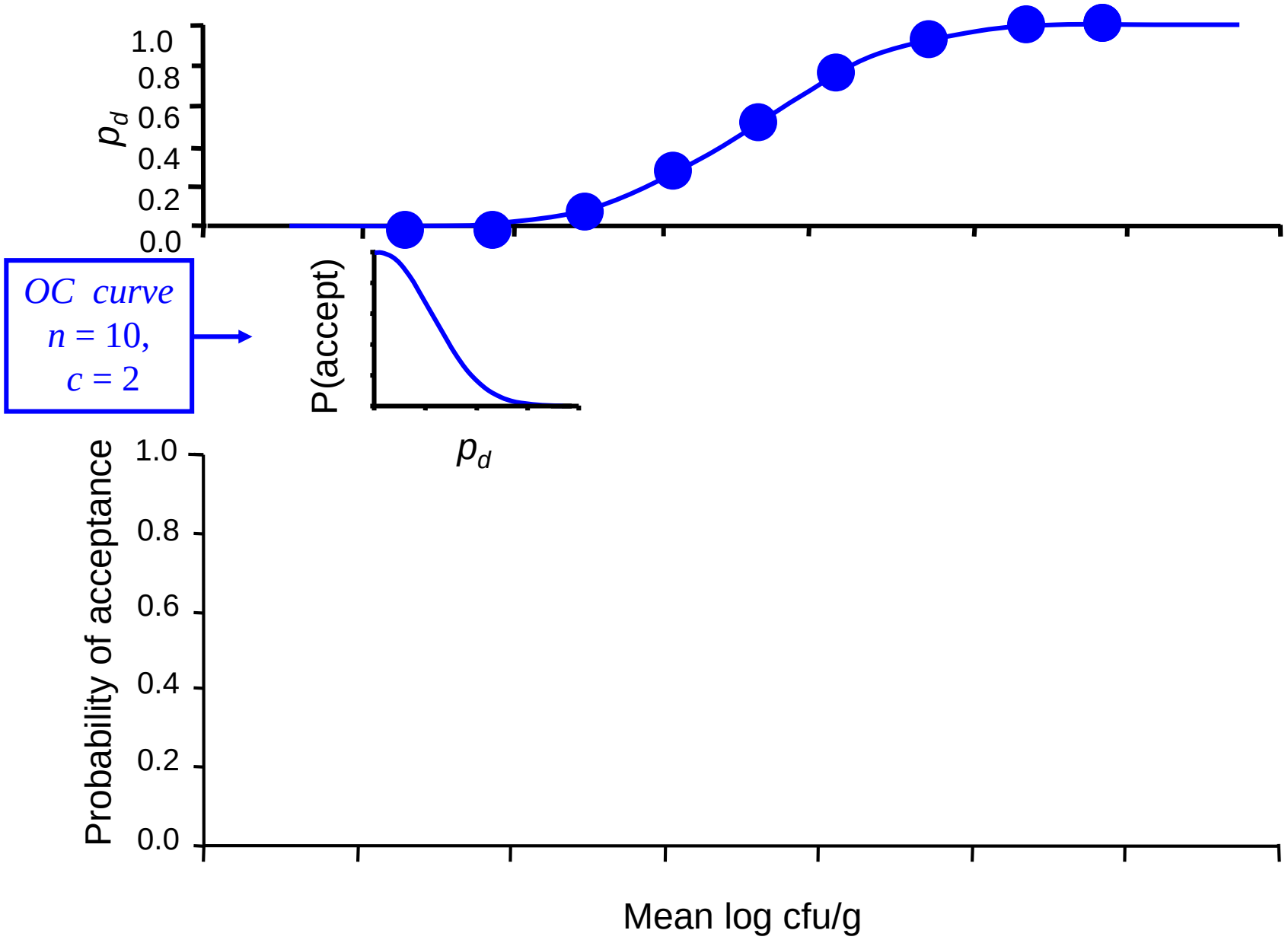
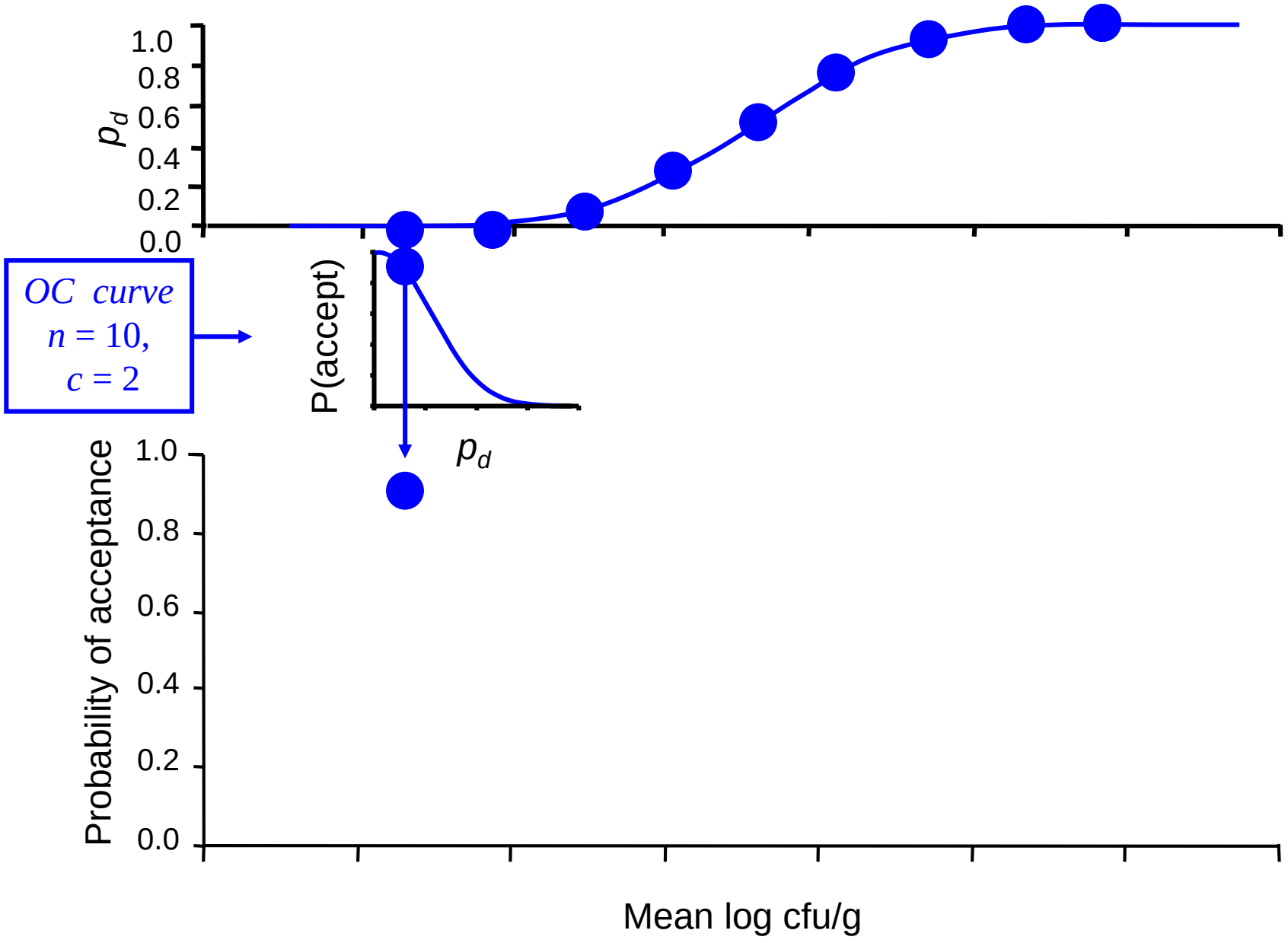

1.0
0.8
0.6
0.4
0.2
0.0
p_d
OC curve
n = 10,
c = 2
P(accept)
p_d
Probability of acceptance
1.0
0.8
0.6
0.4
0.2
0.0
Mean log cfu/g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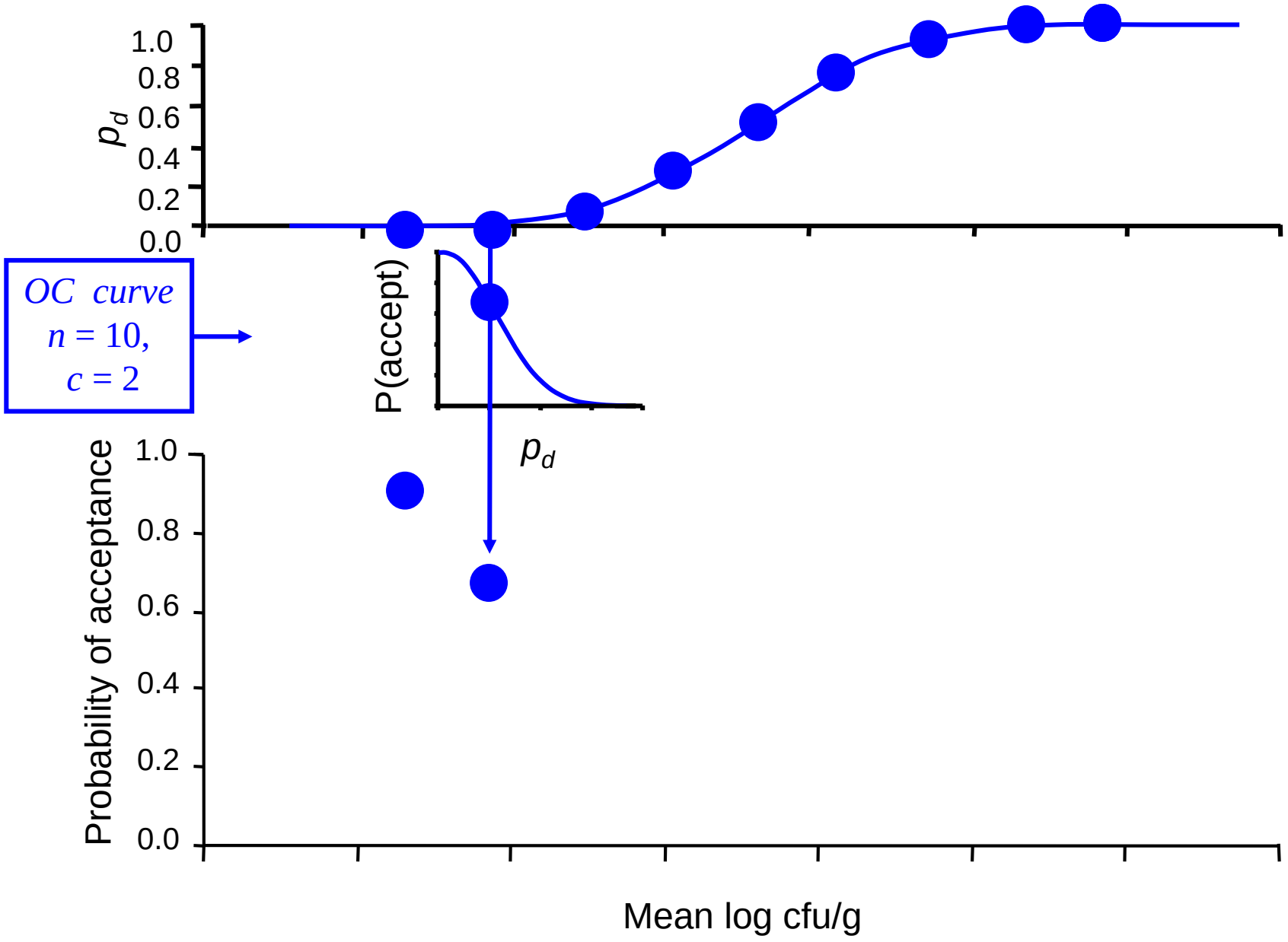
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0.2
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p_d
OC curve
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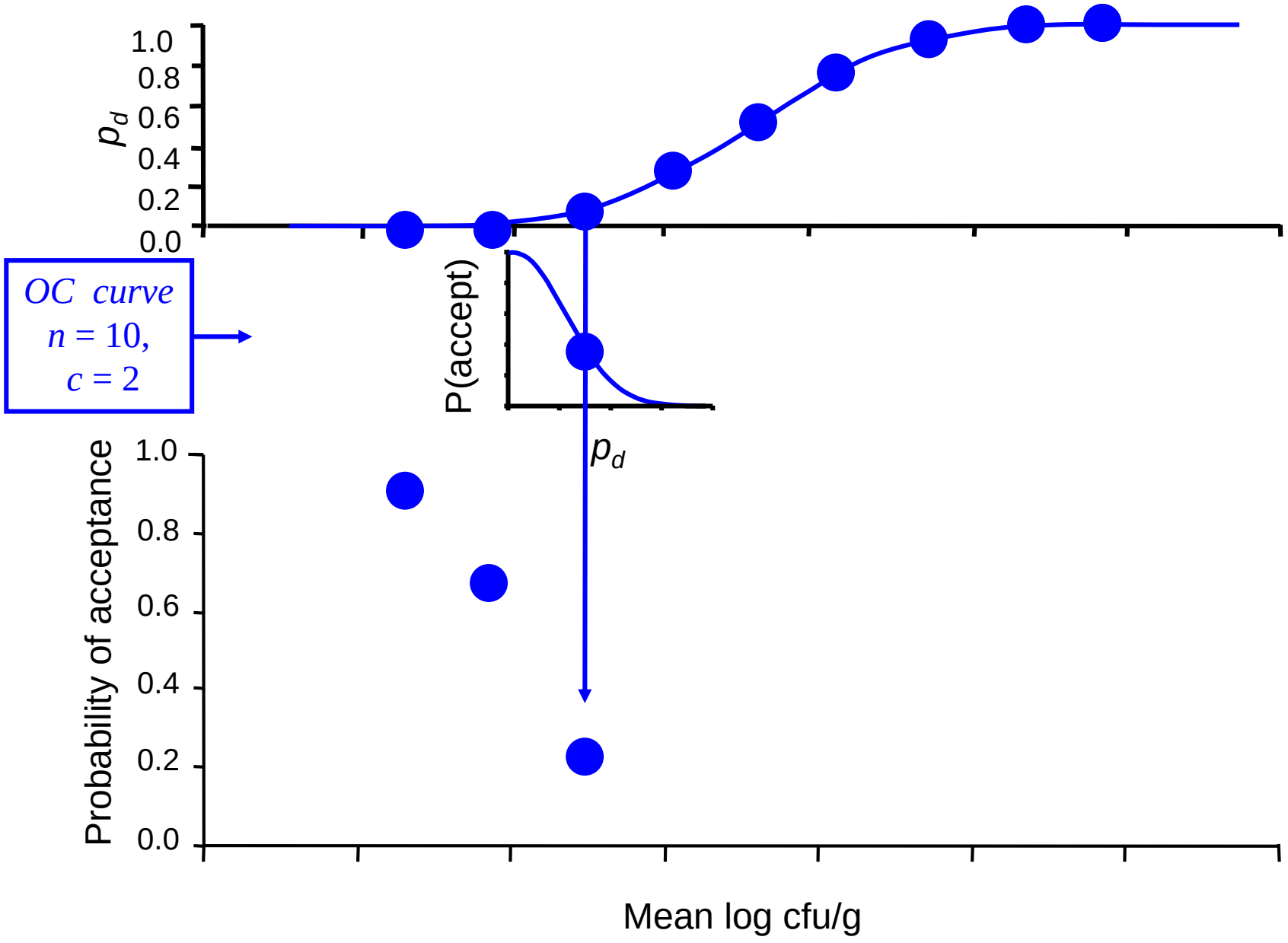
P(accept)
p_d
Probability of acceptance
1.0
0.8
0.6
0.4
0.2
0.0
Mean log cfu/g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0.8
0.6
0.4
0.2
0.0
p_d
OC curve
n = 10,
c = 2
P(accept)
p_d
Probability of acceptance
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0.8
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0.0
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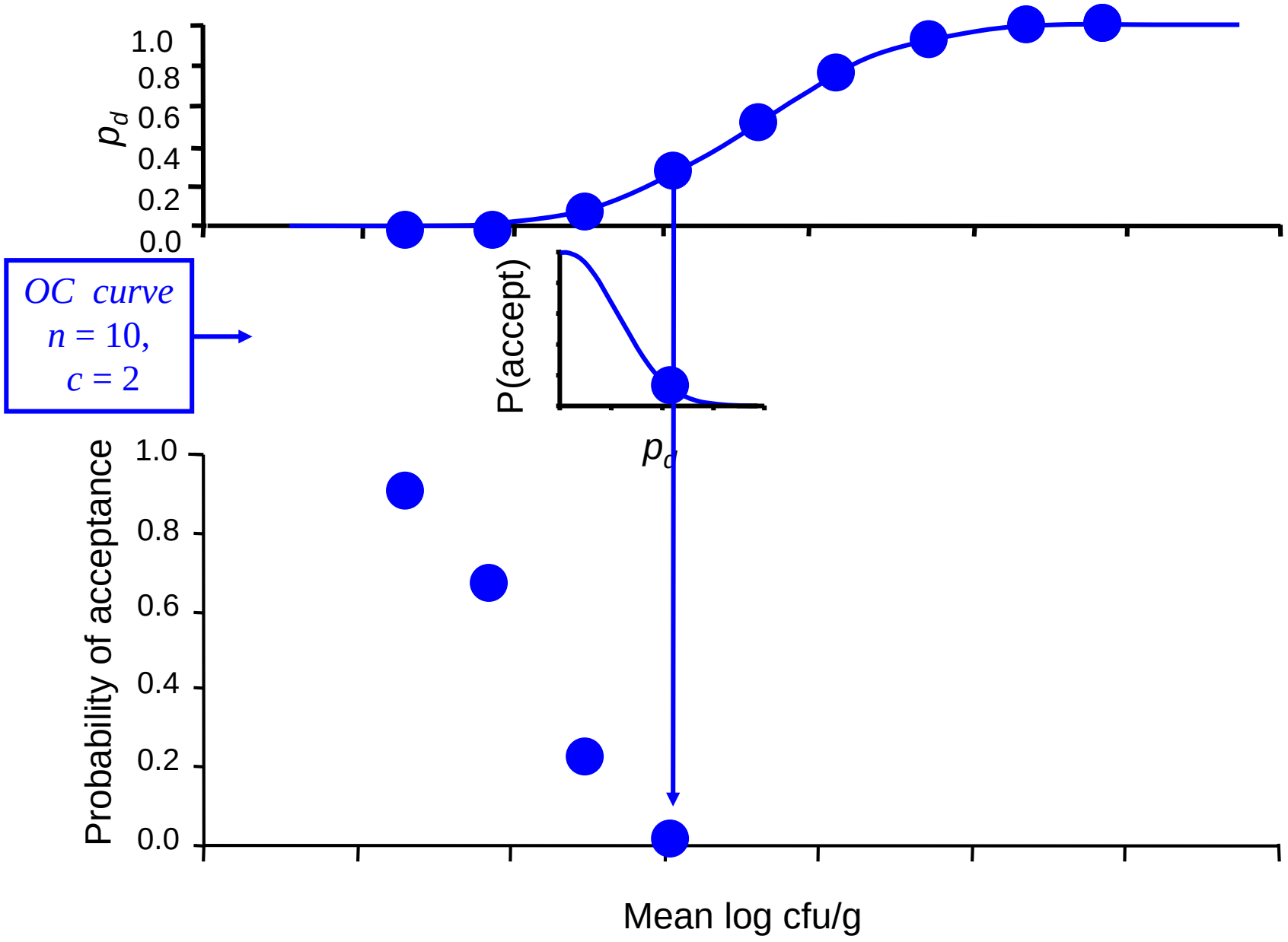
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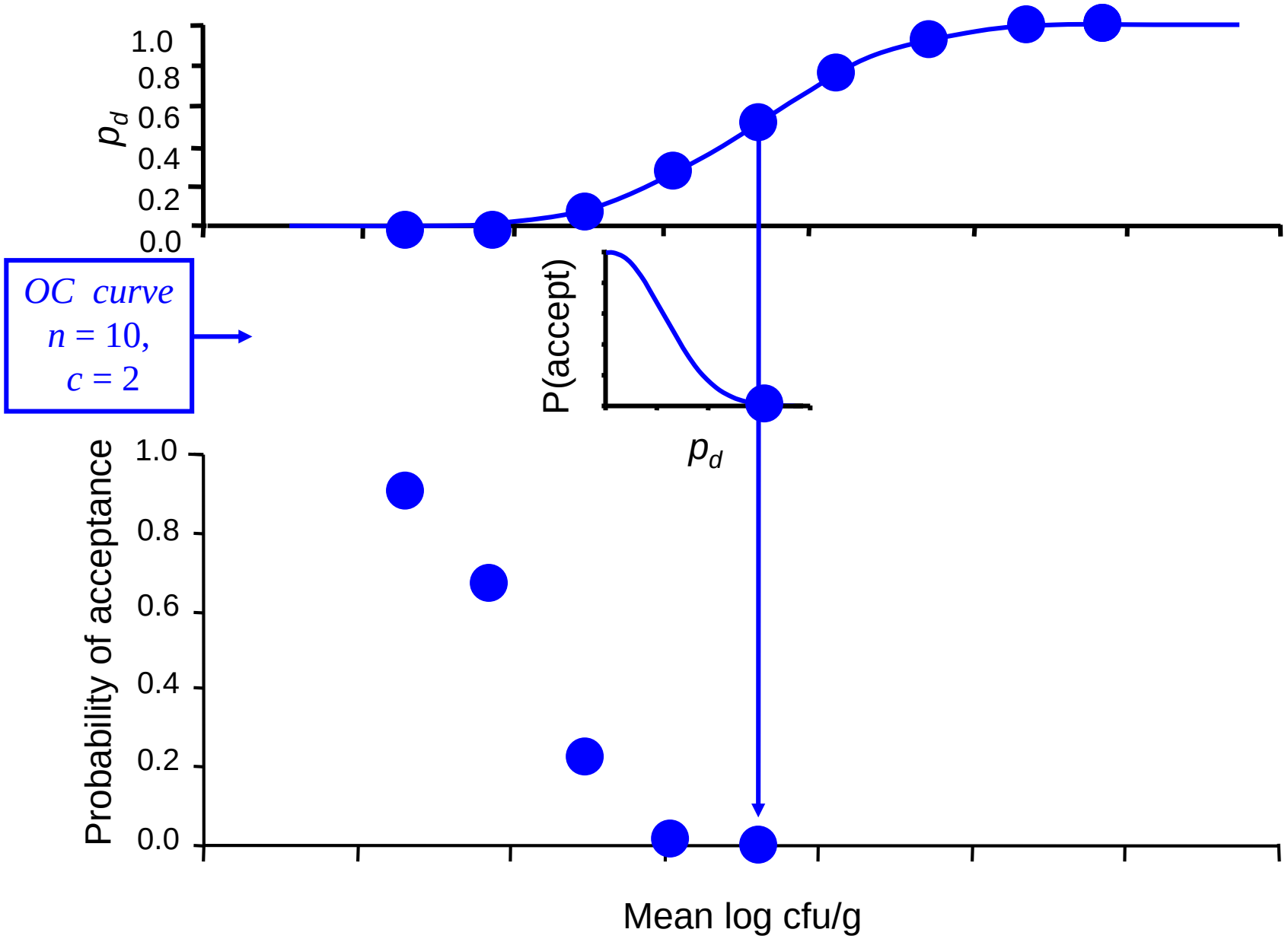
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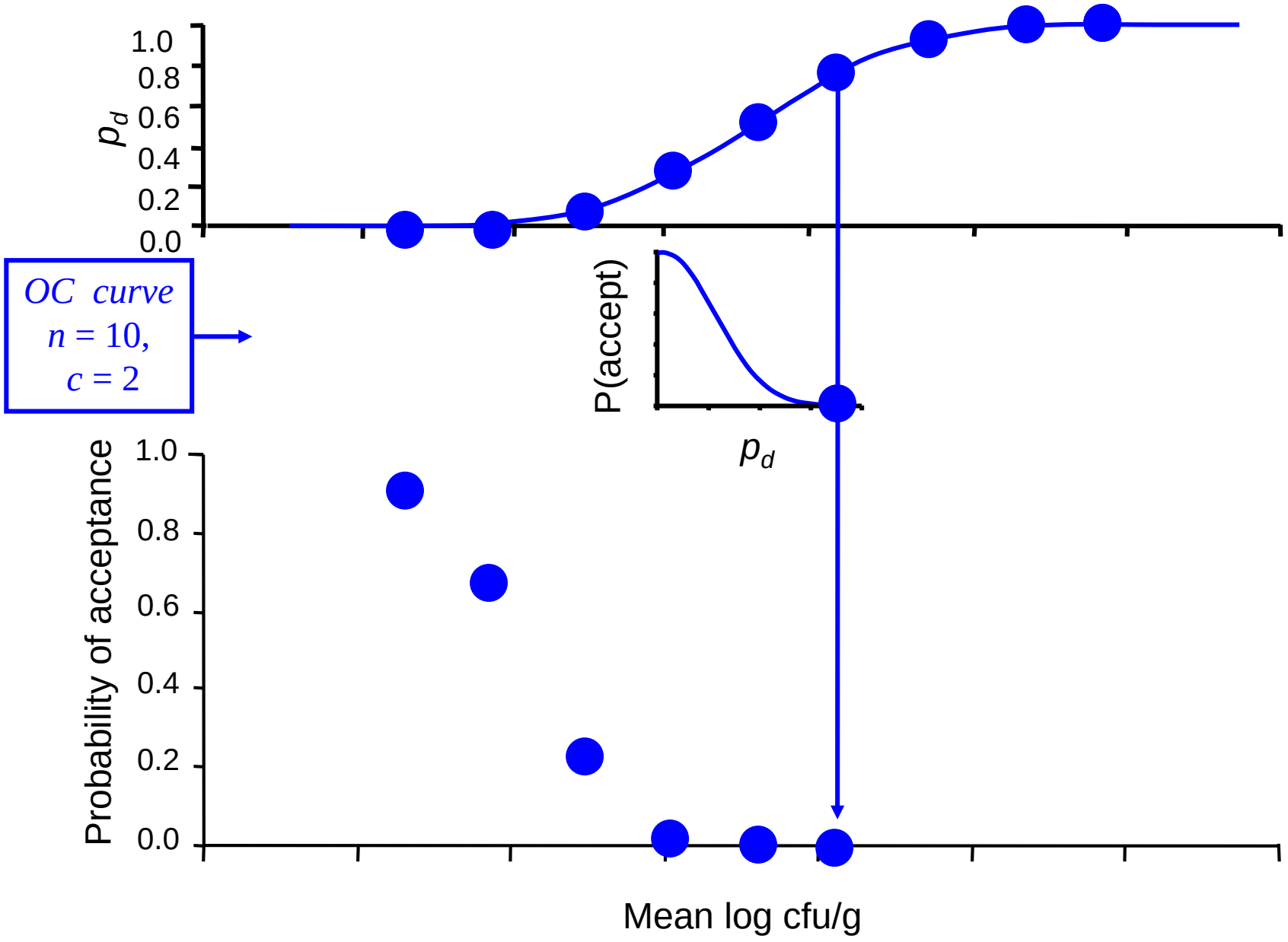
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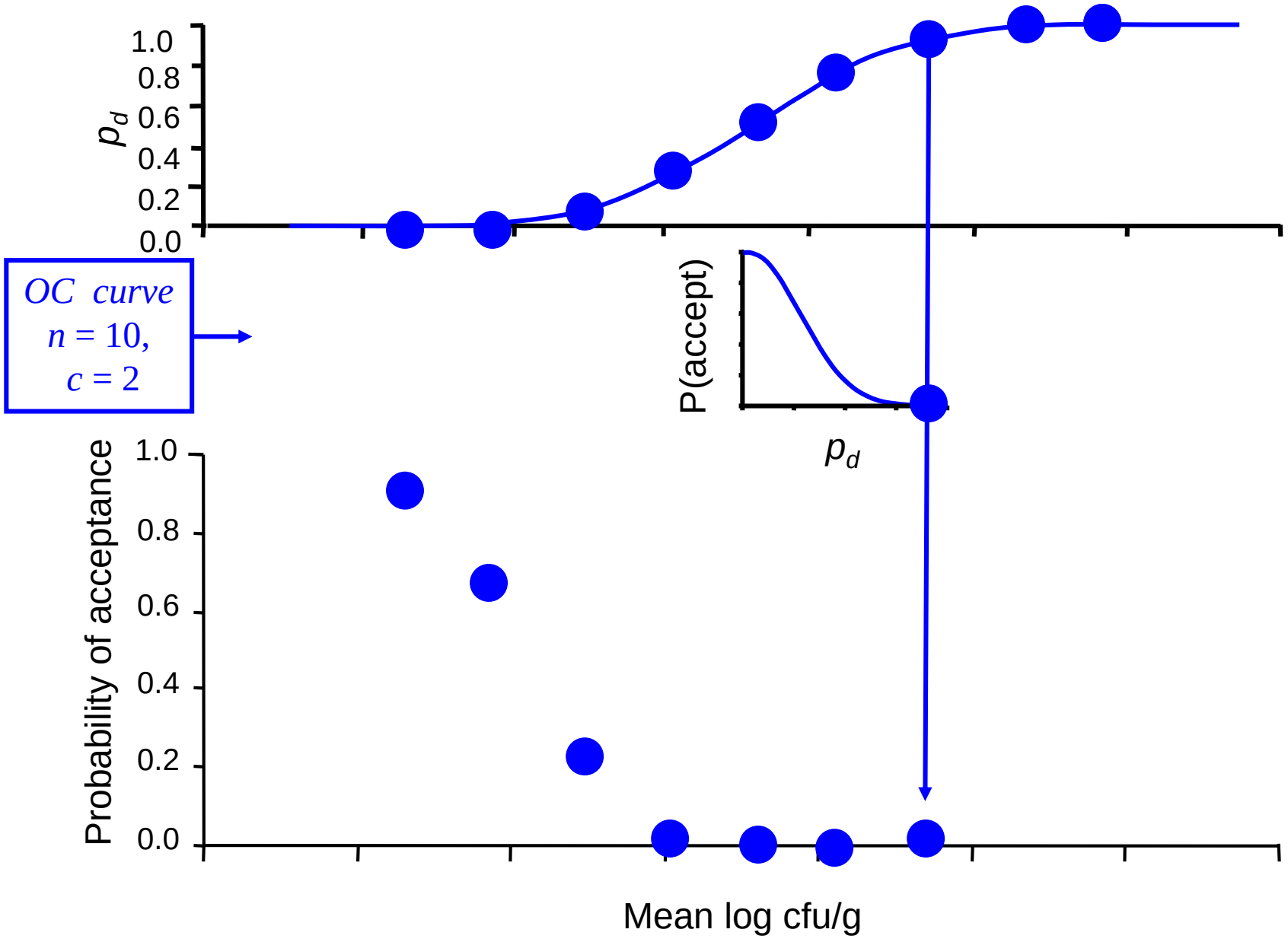
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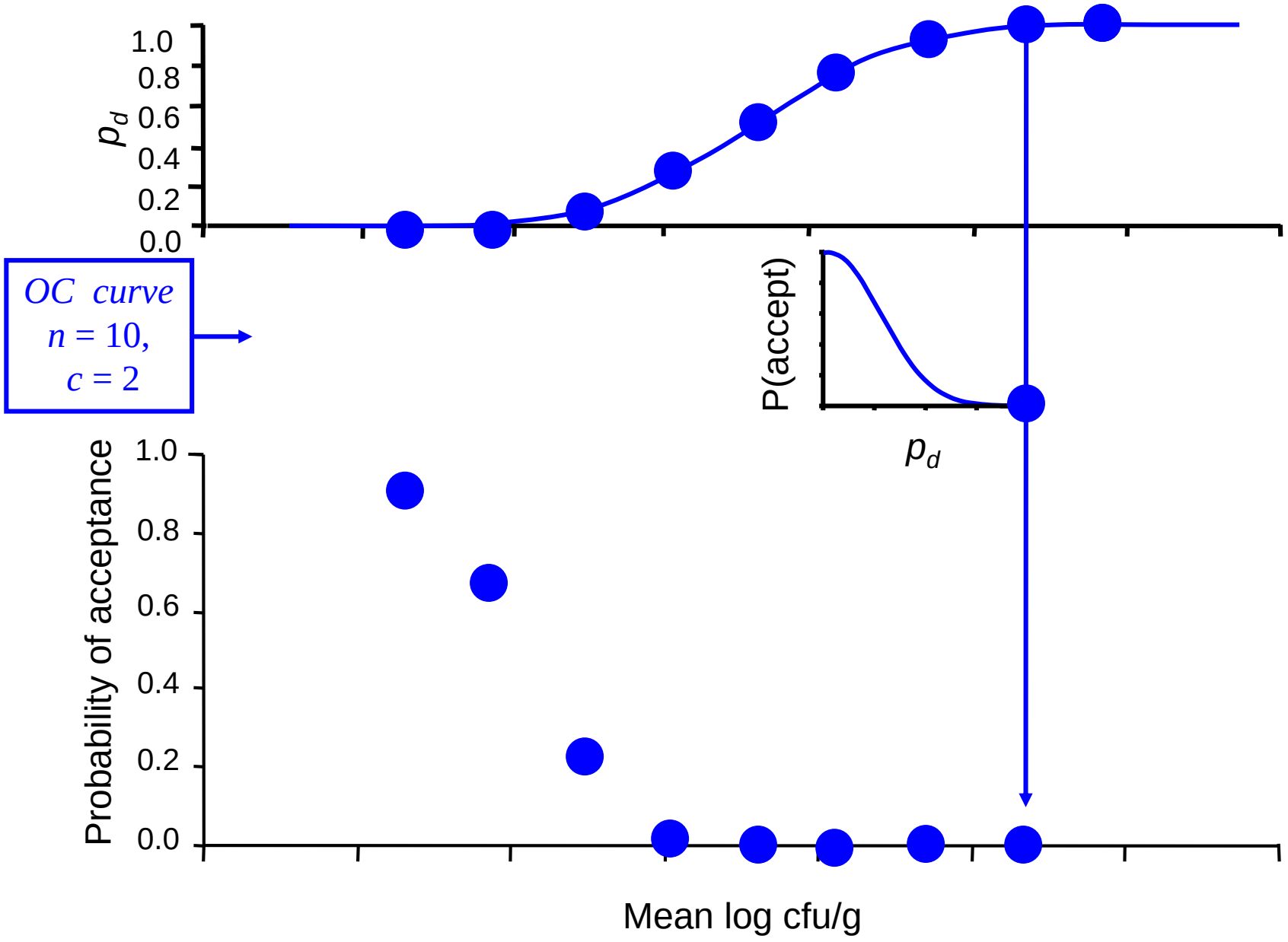
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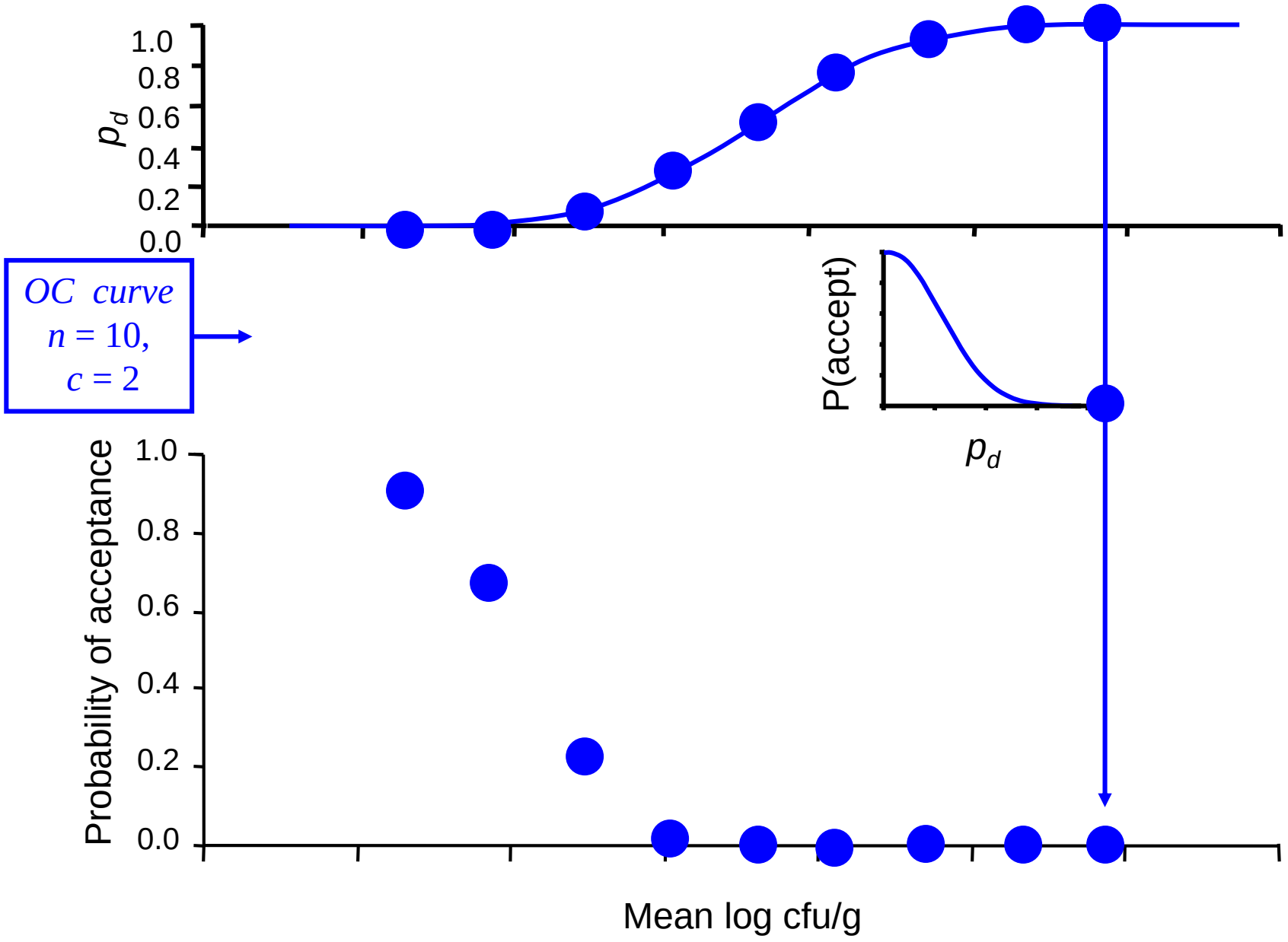
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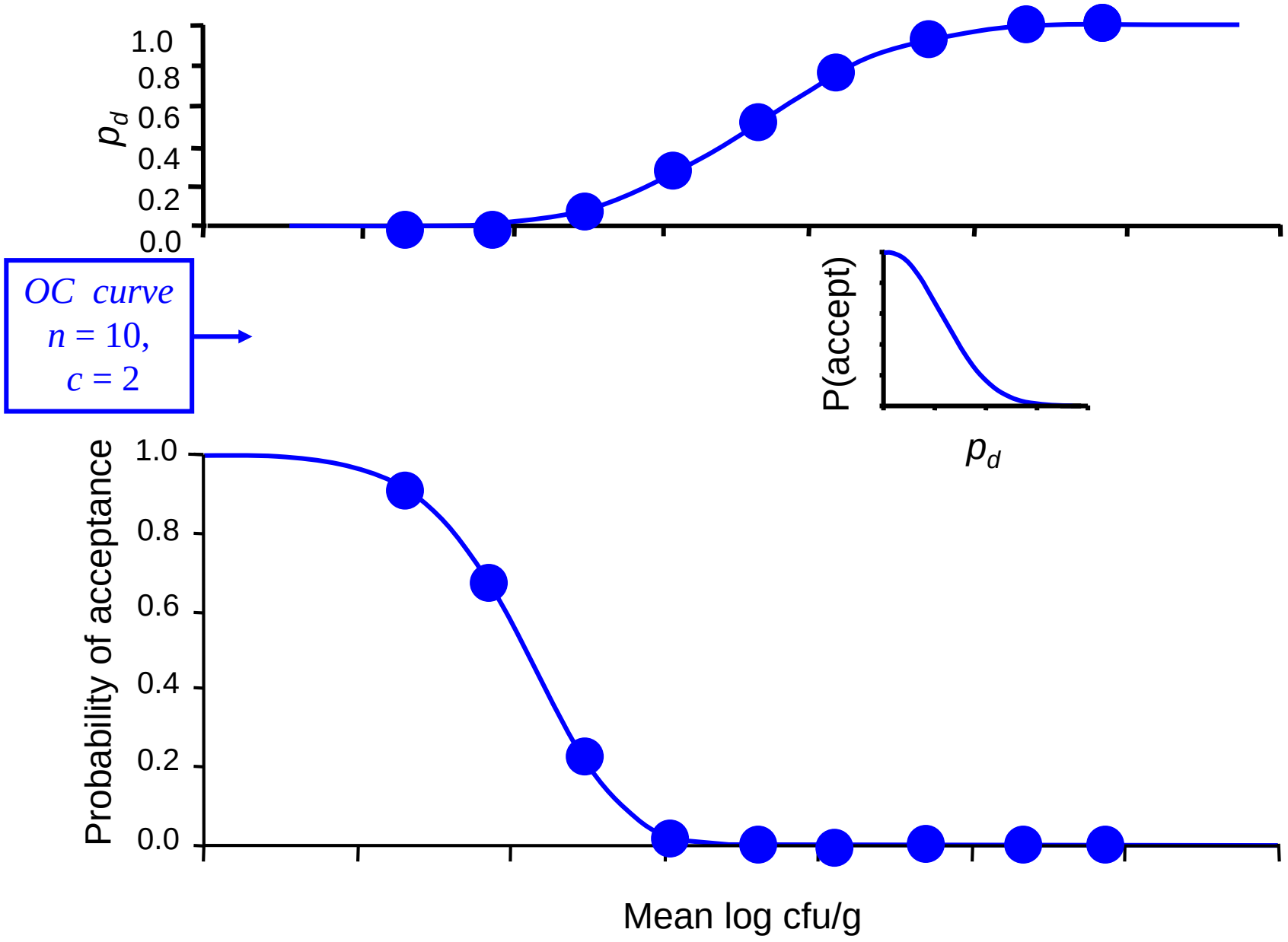
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Mean log cfu/g

ICMSF Cases

Type and likely change to level of hazard	Reduce	No change	May increase
Indicators ***e.g.*** ***Enterobacteriaceae***	Case 4 **(3-class, *n*=5, *c*=3)** **e.g. *m*=1000/g, *M*=10000/g** **5100cfu/g**	Case 5 **(3-class, *n*=5, *c*=2)** **e.g. *m*=1000/g, *M*=10000/g** **3300cfu/g**	Case 6 **(3-class, *n*=5, *c*=1)** **e.g. *m*=1000/g, *M*=10000/g** **1800cfu/g**
Moderate ***e.g.*** ***S.aureus***	Case 7 **(3-class, *n*=5, *c*=2)** **e.g. *m*=100/g, *M*=10000/g** **2600cfu/g**	Case 8 **(3-class, *n*=5, *c*=1)** **e.g. *m*=100/g, *M*=10000/g** **1100cfu/g**	Case 9 **(3-class, *n*=10, *c*=1)** **e.g. *m*=100/g, *M*=10000/g** **330cfu/g**
Serious ***e.g.*** ***Salmonella sp***	Case 10 **(2-class, *n*=5, *c*=0)** **e.g. *m*=0/25g** **1 cfu/55g**	Case 11 **(2-class, *n*=10, *c*=0)** **e.g. *m*=0/25g** **1 cfu/100g**	Case 12 **(2-class, *n*=20, *c*=0)** **e.g. *m*=0/25g** **1 cfu/490g**
Severe ***e.g.*** ***E.coli 0157:H7***	Case 13 **(2-class, *n*=15, *c*=0)** **e.g. *m*=0/25g** **1 cfu/330g**	Case 14 **(2-class, *n*=30, *c*=0)** **e.g. *m*=0/25g** **1 cfu/850g**	Case 15 **(2-class, *n*=60, *c*=0)** **e.g. *m*=0/25g** **1 cfu/2000g**

Relating Criteria to other risk management metrics

Determining the concentration of microorganisms controlled by attributes sampling plans

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Relating microbiological criteria to food safety objectives and performance objectives

M. van Schothorst [a], M.H. Zwietering [b,*], T. Ross [c], R.L. Buchanan [d], M.B. Cole [e], International Commission on Microbiological Specifications for Foods (ICMSF)

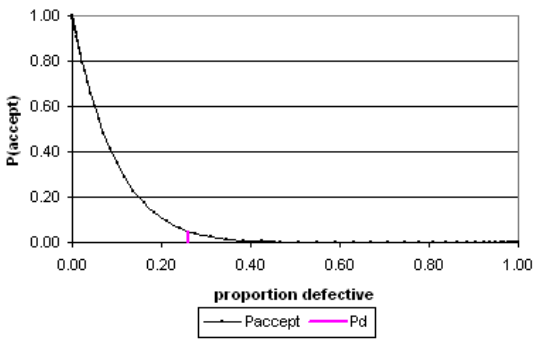
ICMSF Sampling Plan Spreadsheet

Microsoft Excel - sampleplans2_05

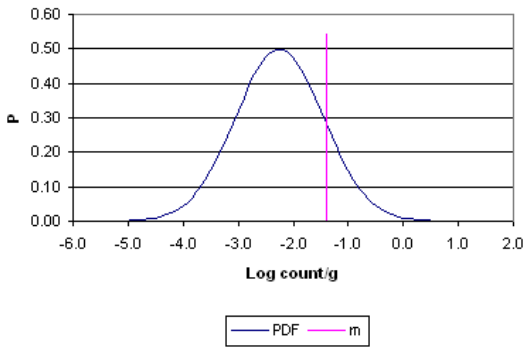
File Edit View Insert Format Tools Data Window Help Adobe PDF

meanlog -2.24971974774393

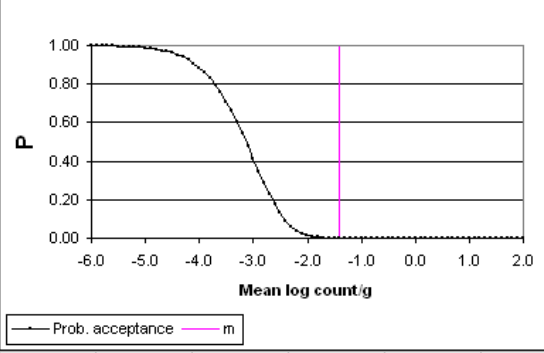
Operating characteristic curve for proportion defective, with n=10 and c=0



Probability density function (PDF) for log counts. Distribution mean = -2.25 and sigma = 0.80



Operating characteristic curve scaled to relate mean log count to m



Batch acceptance for Pd			P(accept)	
Pd	20	%	10.7	%
actualPd	25.9	%	5.00	%

Sandbox: for your own calculations

INPUTS			P(accept)		
mean	-2.25		Computed	5.00	%
sigma	0.80		Desired	5	%
m	-1.40				
n	10		Find mean that gives desired P(accept)		
c	0				
amount	25	g	Find n that gives desired P(accept) or better (less)		

ALTERNATIVE n AND c			P(accept)		
mean	-2.25		Computed	0.91	%
sigma	0.80		Target, left	5.00	%
m	-0.98				
n	30		For any value of n and c imputed find the m that gives the same P(accept) as the model on the left		
c	0				
amount	9.6	g			

Means and median					
	Arithmetic			Geometric=median	
	0.0307	cfu/g		0.0056	cfu/g
one cfu in	32.6	grams	one cfu in	177.7	grams

Implied Acceptance level		
Percentile	z-score	Concentration at this percentile
99.9	3.10	0.23

Conclusions

For more information, see www.icmsf.org

- Operating characteristic curves are based on the principles of probability.
- New approach relates the performance of a given sampling plan to detect a certain level of a hazard.
- Supports the use of micro criteria to verify that a food safety objective has been achieved.