Power Analysis

Confidence in BSR Estimates

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Question 1: How many hatchlings should be sampled from a nest to robustly estimate the number of males that contributed to it?

Methods:

For each number of males females could mate with,

And for each number of hatchlings sampled from each nest (100 total),

100,000 simulations were run.

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Assumption: mating is random (any male can mate with any female)

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For each nest, males could fertilize eggs in different ways:

1. Random fertilization: each egg could be fertilized by any male
2. Exponential fertilization: the first male fertilizes 1/2 the eggs, the next male 1/4, the next 1/8, etc.
3. Dominant fertilization: the first male fertilizes 90%, 70%, or 50% of the eggs, and the rest of the males fertilize fewer eggs
4. Flexible dominant fertilization: based on green turtle data from Tortuguero National Park in Costa Rica (Alfaro-Nunez et al. 2015), the proportion contributed by each sire depends on the total number of sires, and is overall dominated by 1-2 males in each case.

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For each simulation:

. For each number of males:

. . For each sample size of hatchlings:

. . . For each of 100 eggs in the nest:

. . . . Assign sires with probabilities based on the fertilization mode

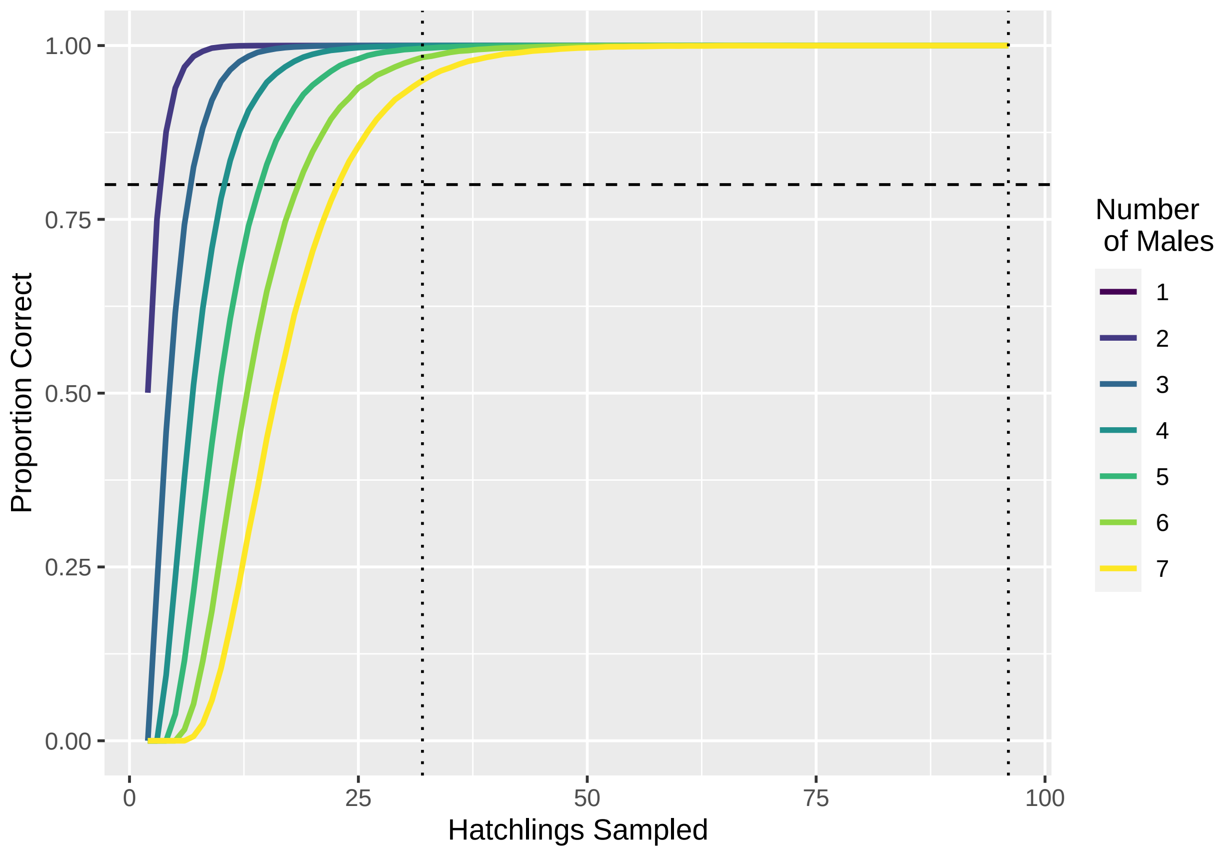
. . Sample the nest and determine if all the sires have been identified

Assuming random fertilization

```r
source('hatchlings_to_sample.R')

hatchlings_to_sample(n_hatchlings = 100,
                     max_hatchlings = 96,
                     max_males = 7,
                     breeding = 'random',
                     n_sims = n_sims,
                     dom = NULL,
                     n_sizes = c(32, 96))
```

```
## [[1]]
```



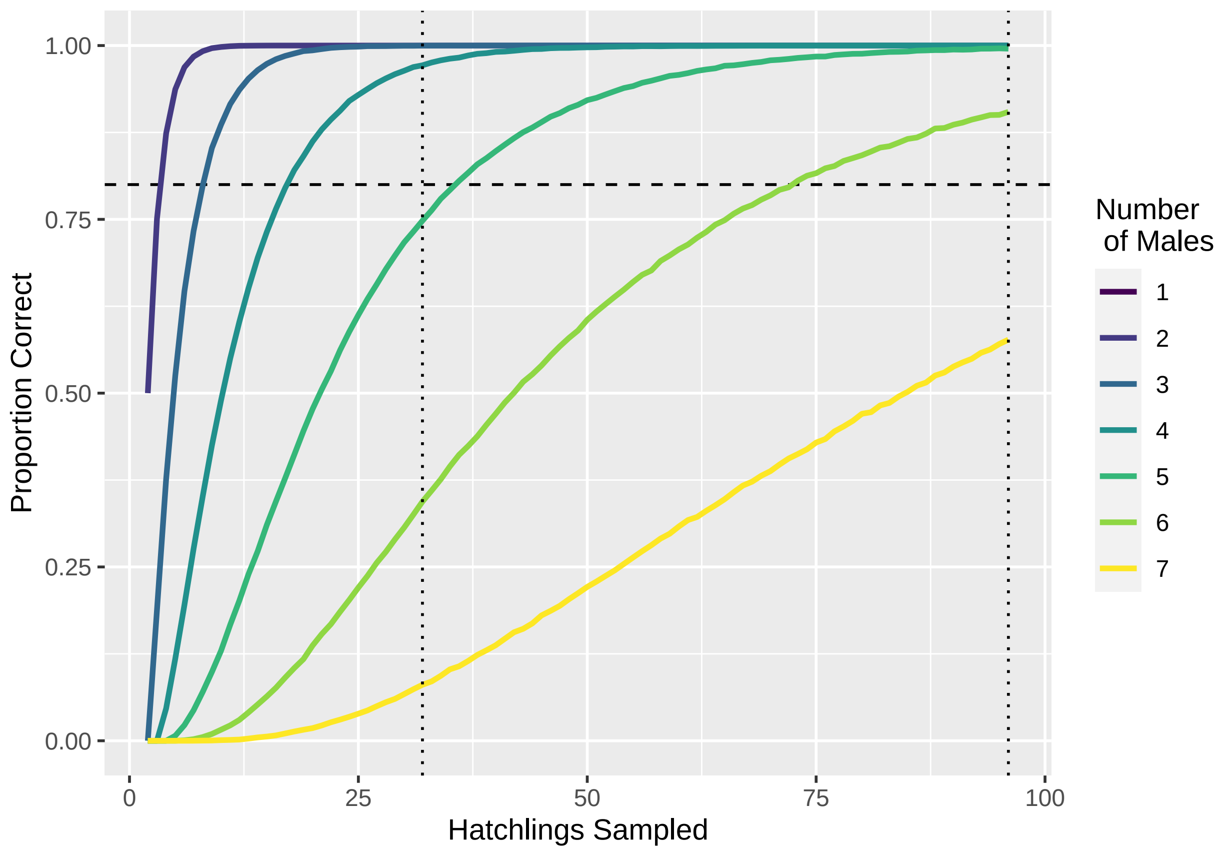

```
##
## [[2]]
##   Males      32 96
## 1     1      NA NA
## 2     2 1.00000  1
## 3     3 0.99999  1
## 4     4 0.99956  1
## 5     5 0.99599  1
## 6     6 0.98302  1
## 7     7 0.94973  1
```

Assuming exponential decay in fertilization (1/2, 1/4, 1/8, etc.)

```
source('hatchlings_to_sample.R')

hatchlings_to_sample(n_hatchlings = 100,
                     max_hatchlings = 96,
                     max_males = 7,
                     breeding = 'exponential',
                     n_sims = n_sims,
                     dom = NULL,
                     n_sizes = c(32, 96))
```

```
## [[1]]
```



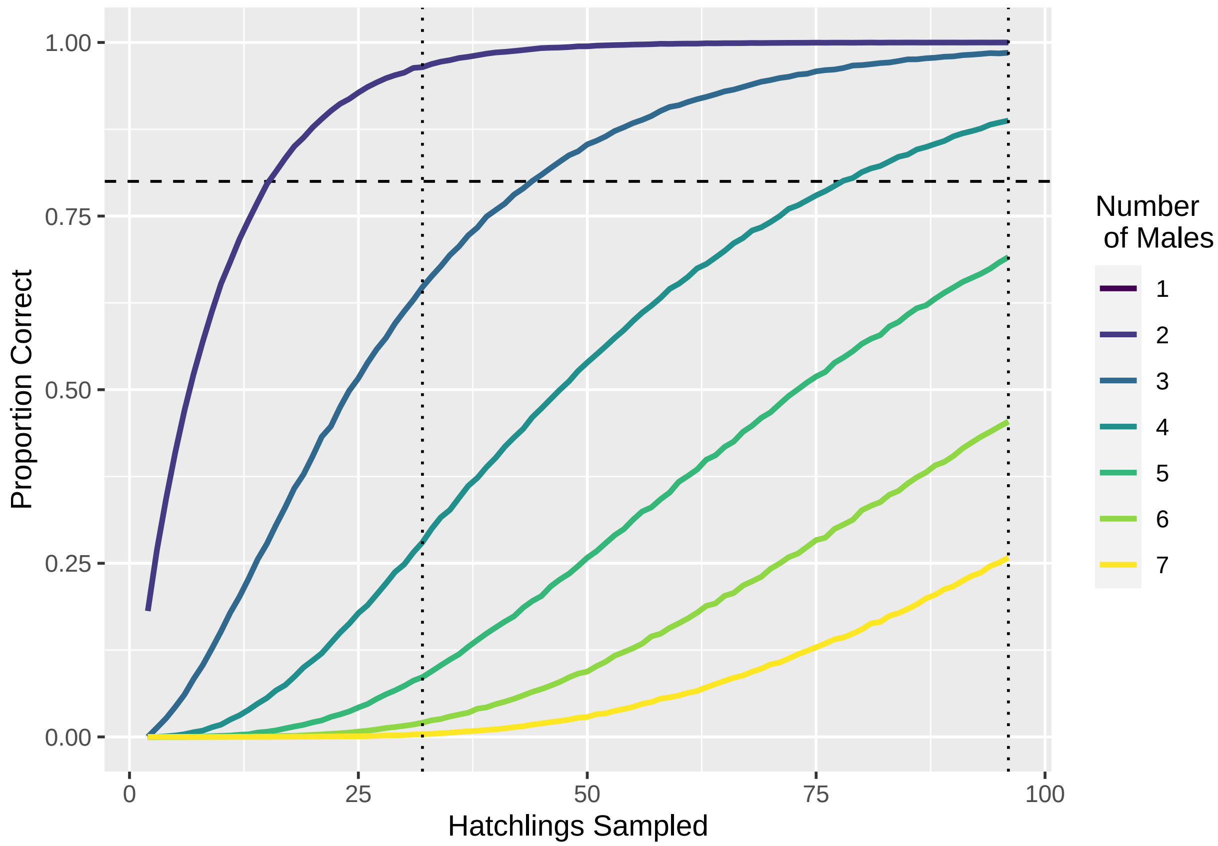

```
##
## [[2]]
##   Males       32      96
## 1     1       NA      NA
## 2     2 1.00000 1.00000
## 3     3 0.99987 1.00000
## 4     4 0.97160 0.99998
## 5     5 0.74804 0.99554
## 6     6 0.34402 0.90458
## 7     7 0.08052 0.57693
```

Assuming one dominant sire that fertilizes 90% of eggs

```r
source('hatchlings_to_sample.R')

hatchlings_to_sample(n_hatchlings = 100,
                     max_hatchlings = 96,
                     max_males = 7,
                     breeding = 'dominant',
                     n_sims = n_sims,
                     dom = 0.9,
                     n_sizes = c(32, 96))
```

```
## [[1]]
```



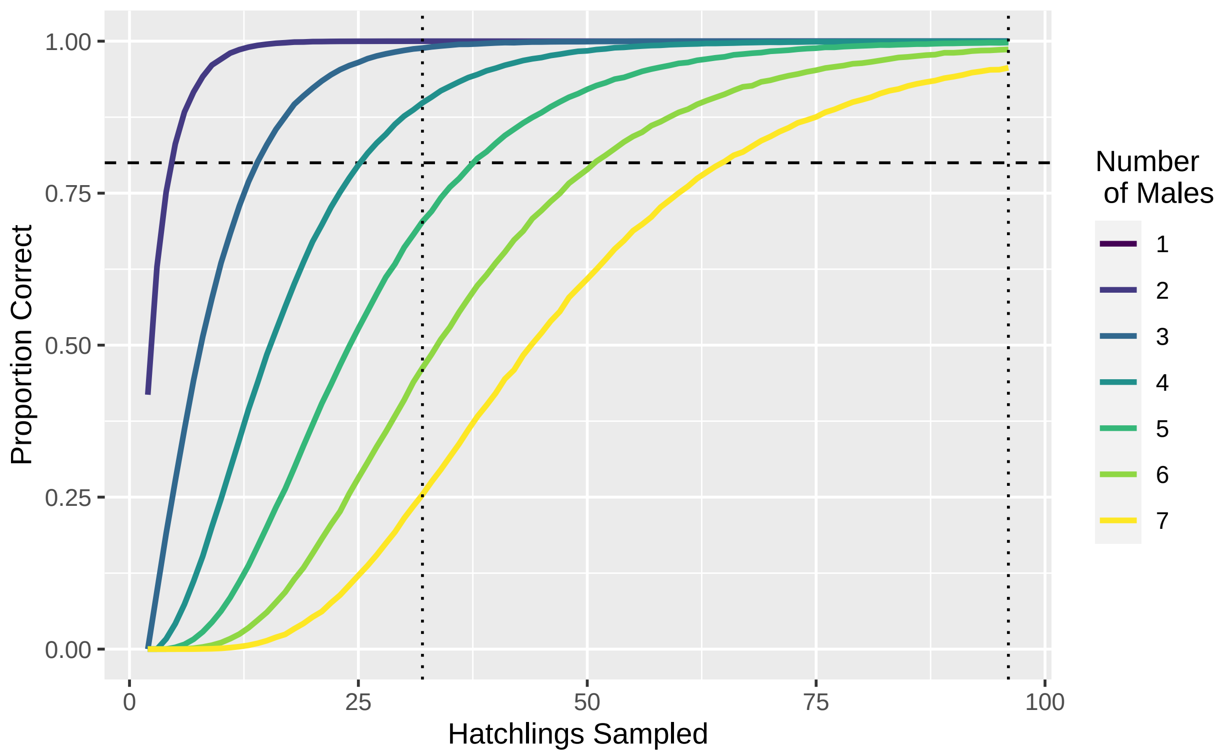

```
##
## [[2]]
##   Males       32      96
## 1     1       NA      NA
## 2     2  0.96443 0.99997
## 3     3  0.64765 0.98520
## 4     4  0.28018 0.88754
## 5     5  0.08602 0.69098
## 6     6  0.02045 0.45401
## 7     7  0.00390 0.25798
```

Assuming one dominant sire that fertilizes 70% of eggs

```
source('hatchlings_to_sample.R')

hatchlings_to_sample(n_hatchlings = 100,
                     max_hatchlings = 96,
                     max_males = 7,
                     breeding = 'dominant',
                     n_sims = n_sims,
                     dom = 0.7,
                     n_sizes = c(32, 96))
```

```
## [[1]]
```



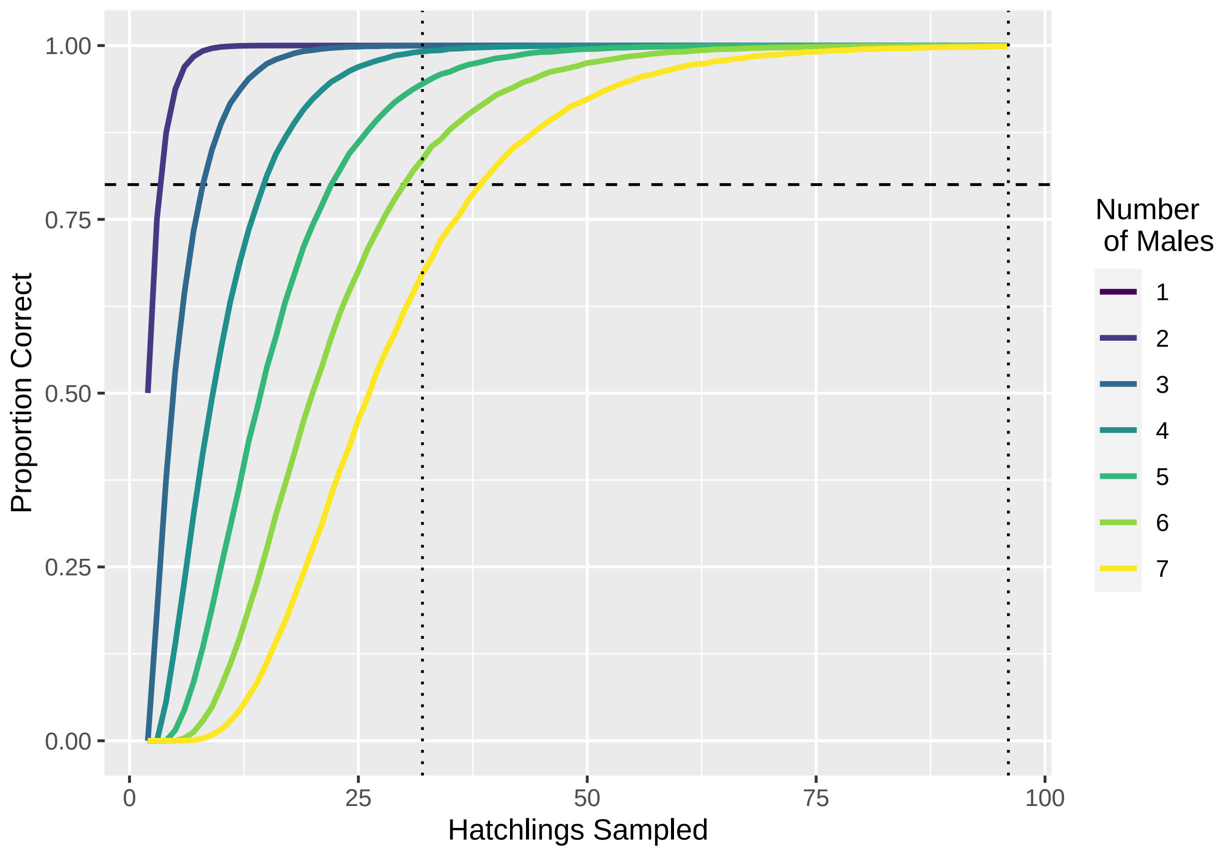

```
##
## [[2]]
##   Males       32      96
## 1     1       NA      NA
## 2     2 0.99999 1.00000
## 3     3 0.98869 0.99999
## 4     4 0.89855 0.99985
## 5     5 0.70335 0.99773
## 6     6 0.46263 0.98648
## 7     7 0.25411 0.95629
```

Assuming one dominant sire that fertilizes 50% of eggs

```
source('hatchlings_to_sample.R')

hatchlings_to_sample(n_hatchlings = 100,
                     max_hatchlings = 96,
                     max_males = 7,
                     breeding = 'dominant',
                     n_sims = n_sims,
                     dom = 0.5,
                     n_sizes = c(32, 96))
```

```
## [[1]]
```




```
##
## [[2]]
##   Males      32      96
## 1     1      NA      NA
## 2     2 1.00000 1.00000
## 3     3 0.99971 1.00000
## 4     4 0.99144 1.00000
## 5     5 0.94486 1.00000
## 6     6 0.83615 0.99976
## 7     7 0.67213 0.99850
```

Assuming one dominant sire where fertilization is flexible, and dependent on the total number of sires

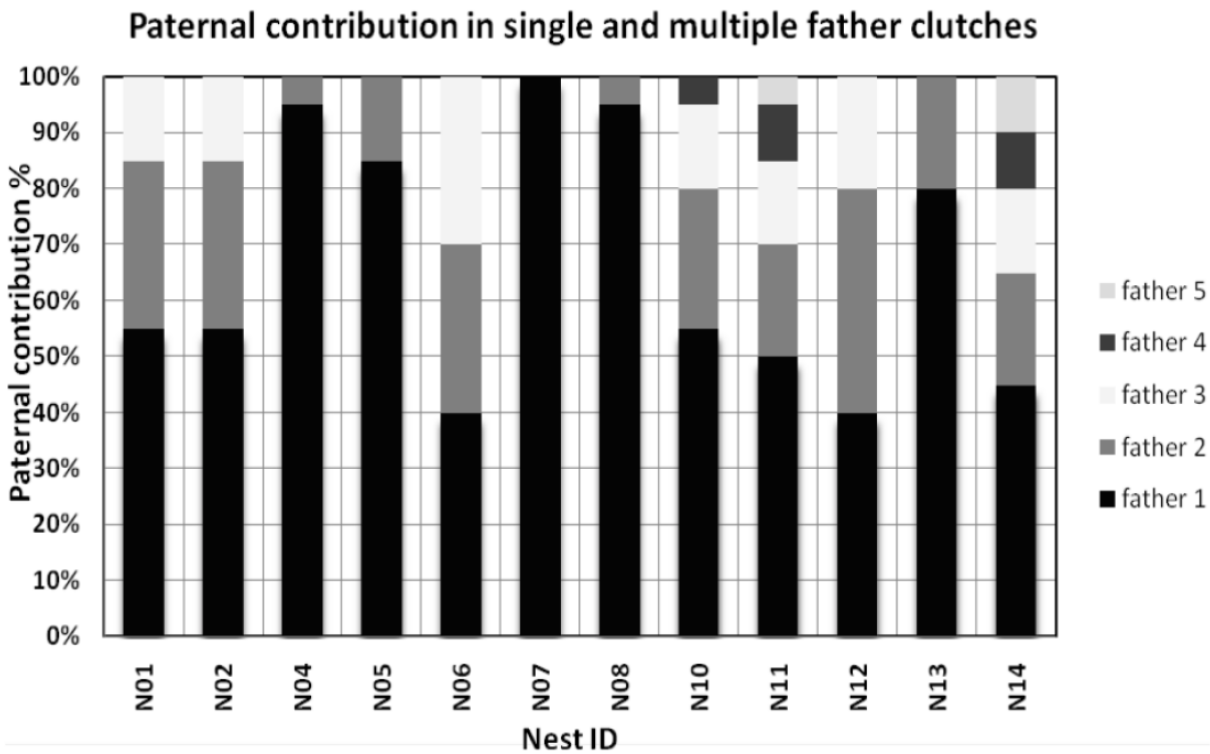


Figure 1 Paternal contribution for all nests having multiple paternity (MP) and single paternity. The different colours represent the proportion of offspring that each father has contributed per nest. The first colour in the bottom of each column represents the primary father or the father that contributed to most offspring until the last colour in the top representing the father with the small offspring contribution.

Figure 1: Figure 1 (Alfaro-Nunez et al. 2015)

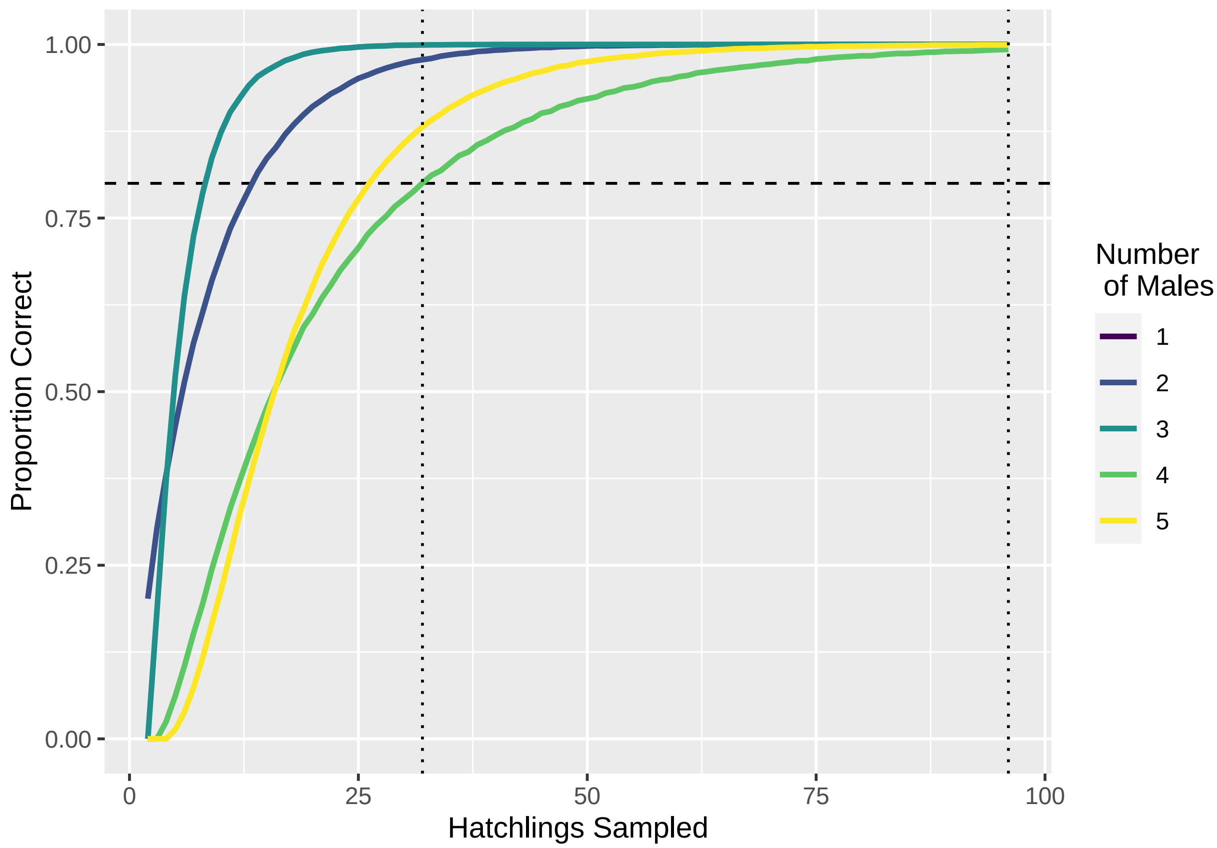
Proportion fertilized by each sire is calculated as the average contribution for each sire based on Alfaro-Nunez et al. 2015:

```
##          Sire1  Sire2  Sire3  Sire4  Sire5
## 1 Sire  1.0000 0.0000 0.0000 0.0000 0.0000
## 2 Sires 0.8868 0.1132 0.0000 0.0000 0.0000
## 3 Sires 0.4744 0.3241 0.2015 0.0000 0.0000
## 4 Sires 0.5485 0.2508 0.1509 0.0499 0.0000
## 5 Sires 0.4744 0.1982 0.1523 0.0997 0.0755
```

```r
source('hatchlings_to_sample.R')

hatchlings_to_sample(n_hatchlings = 100,
                     max_hatchlings = 96,
                     max_males = 5,
                     breeding = 'flexible_dominant',
                     n_sims = n_sims,
                     dom = NULL,
                     n_sizes = c(32, 96))
```

```
## [[1]]
```




```
##
## [[2]]
##   Males       32      96
## 1     1       NA      NA
## 2     2 0.97803 0.99999
## 3     3 0.99925 1.00000
## 4     4 0.80048 0.99292
## 5     5 0.88141 0.99932
```