

Guam Coconut Rhinoceros Beetle Project

Technical Report CRB-2014-08-01



Test of Netting as a Physical Barrier for CRB Adults

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We measured containment rates for four types of netting. Only one type of fish net (14 mesh 0.25 mm nylon monofilament), with a containment rate of 67% (an escape rate of 33%), proved useful as a barrier for adult CRB. This fish net is more than a physical barrier because beetles become permanently entangled. Most of the beetles escaping from the fish net were small. A higher mesh (smaller hole size) may reduce the high escape rate for smaller beetles.

1 Introduction

Use of netting as a physical barrier has been suggested as a tactic to prevent adult CRB from entering or leaving active and potential breeding sites. We previously tested plastic bird netting and found a high escape rate (ref). In this experiment, we tested bird netting plus three types of fish netting.

2 Materials and Methods

2.1 Beetles

We used field collected beetles. Prior to being used in the experiment, beetles were flight tested in the lab. Beetles which passed the flight test were marked with a unique number, measured, and weighed. Equal numbers of beetles were randomly selected and placed in plastic containers filled with moist peat moss.

2.2 Netting

Four types of netting were tested in this experiment.

2.2.1 Bird Net

Easy Gardner birdBlock STI-602. (Figure 1, 6)

2.2.2 Green Net 1

Half-inch mesh netting, PA206, ordered from www.leevalley.com.(Figure 2)

2.2.3 Green Net 2

Procured from Mari Marutani, Triton Farm(Figure 3)

2.2.4 Fish Net

Nylon, high tenacity, 14 mesh. Manufactured by Fortune Net and Twine, Quezon City, Philippines. (Figure 4, 5)

2.3 Experimental Setup

The experiment was performed during the nights of August 20, 22, and 28, 2014. Containers were placed inside inside bags constructed from netting and these were put on the ground at the center of a field at the Yigo Ag Expt Stn. At 7:00 PM, lids were removed from the containers. At 7:00 AM the following morning, the containers were picked up and the number of beetles remaining or entangled were counted (Figure 7). A trail cam equipped with an IR flash and mounted on a post was used to make time lapse videos of the experiment between 7:00 and 10:00 PM each evening (Figure 8).

2.4 Analysis

Analysis was performed using an iPython notebook (Program listing 2). ImageJ was used to make time lapse videos (AVI format; JPEG compression; 20 FPS; 5 s between frames).

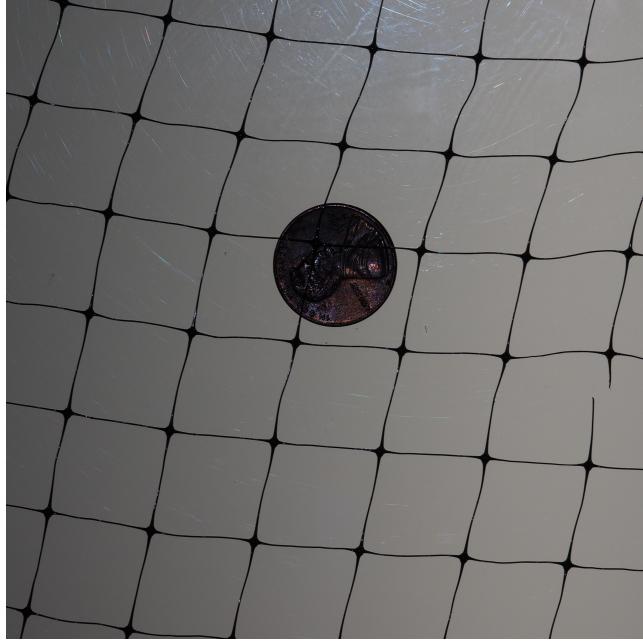


Figure 1: Bird net. Circular object is a U.S. penny (diameter = 19.05 mm). Distance between notes = 16.2 mm.

3 Results and Discussion

The escape rate observed for the fish net is a function of beetle size (Figure 10). The escape rate for beetles with an elytral width of less than 18 mm was 76% (16 of 21 escaped), whereas the escape rate for beetles with an elytral width of greater than 18 mm was only 4% (1 out of 28).

Time lapse videos for escape tests performed on 2014-08-22 and 2014-08-28 are published on YouTube at <http://youtu.be/C5C0Q-txYow> and http://youtu.be/mnxAf-7K_dU. These videos clearly show that beetles become permanently entangled in the fish net, but are able to pass through other net types after a few minutes. The beetles become entangled in much the same way fish are caught in a gill net. When trying to escape, the 0.25 mm nylon monofilament from which the net is made gets lodged in the crack between the beetle's head and thorax, preventing escape (Figure 11). We expect that a fish net with a slightly higher mesh (smaller holes) will prevent the high escape rate observed for smaller beetles. However, if the mesh becomes too high we expect that beetles will be able to escape by bringing their powerful front legs into play to stretch and break the monofilament. We have seen this behavior with the very heavy nylon screening from which our large field cages are made. Beetles are able to use their legs to bore holes through this.

Use of fish netting may become an important tactic for preventing adult CRB from entering or leaving piles of potential breeding material. Note that fish net is more than a physical barrier because beetles become permanently entangled.



Figure 2: Green net 1. Circular object is a U.S. penny (diameter = 19.05 mm). Distance between nots = 14.2 mm.



Figure 3: Green net 2. Circular object is a U.S. penny (diameter = 19.05 mm). Distance between nots = 9.9 mm.

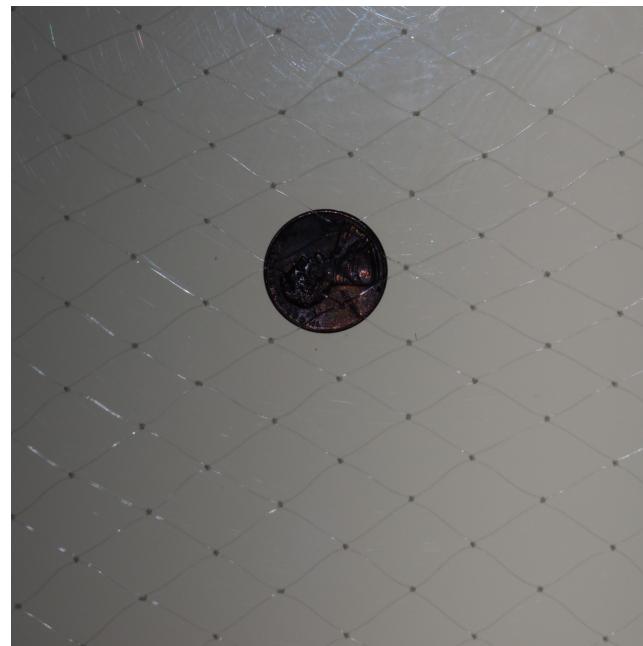


Figure 4: Fish net. Circular object is a U.S. penny (diameter = 19.05 mm). Distance between notes = 13.0 mm.

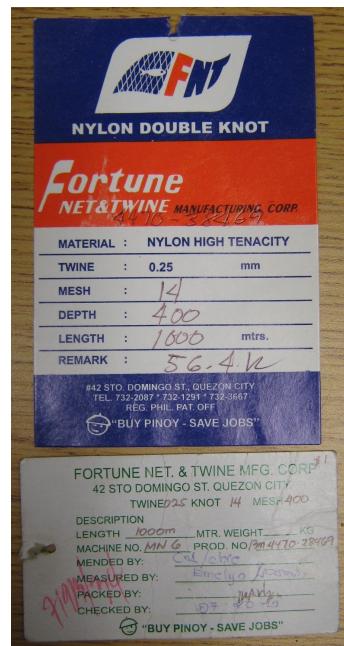


Figure 5: Fish net label.



Figure 6: Bird net label.



Figure 7: Test containers when picked up on the morning following the 2014-08-28 escape test.



Figure 8: Tripod holding the trail cam used for time lapse video.

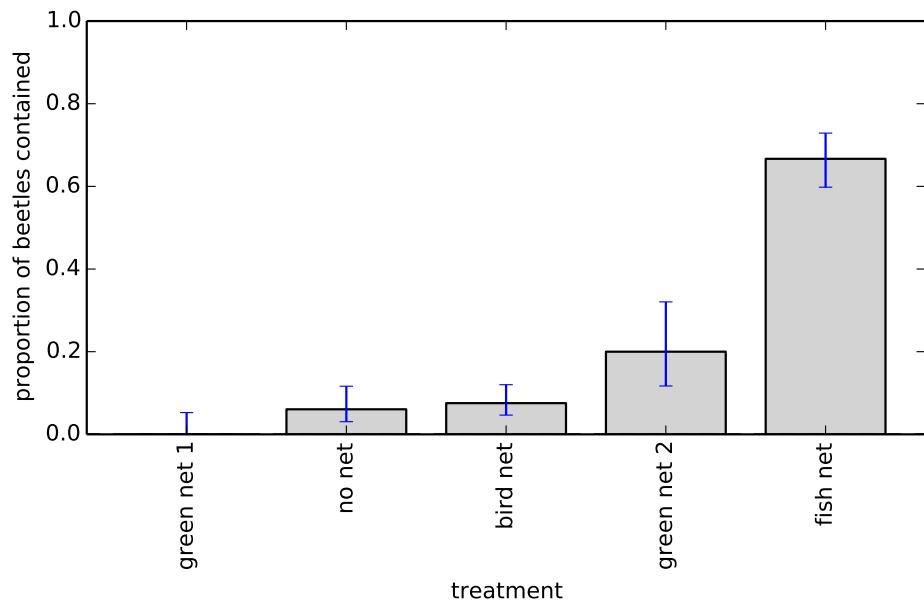


Figure 9: Proportion of adult coconut rhinoceros beetles remaining in containers or entangled.
Error bars are 95% confidence intervals.

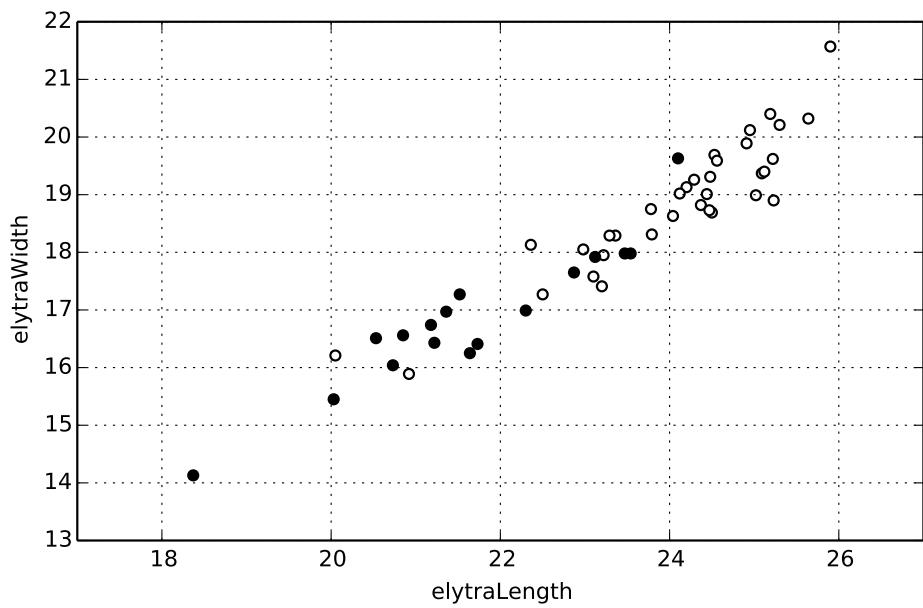


Figure 10: Sizes of beetles escaping from the fish net. Black circles indicate beetles which escaped. White circles are those which remained.



Figure 11: Entangled beetles cut out of fish net.

Listing 1: dataFile

```
beetleID ,dateMarked ,dateEscapeTest ,sex ,elytraLength ,elytraWidth ,mass ,source ,note ,  
treatment ,result  
2222,08/20/14 12:00 AM,08/20/14 12:00 AM,f ,25.19 ,20.4 ,4.163 ,Yigo barrel trap ,NULL,  
fish net ,entangled  
2223,08/20/14 12:00 AM,08/20/14 12:00 AM,f ,24.2 ,19.4 ,3.691 ,Yigo barrel trap ,NULL,  
bird net ,escaped  
2224,08/20/14 12:00 AM,08/20/14 12:00 AM,f ,23.47 ,17.98 ,3.421 ,Yigo barrel trap ,NULL,  
fish net ,escaped  
2225,08/20/14 12:00 AM,08/20/14 12:00 AM,f ,22.32 ,17.16 ,3.084 ,Yigo barrel trap ,NULL,  
bird net ,escaped  
2226,08/20/14 12:00 AM,08/20/14 12:00 AM,f ,22.87 ,17.65 ,2.935 ,Yigo barrel trap ,NULL,  
fish net ,escaped  
2227,08/20/14 12:00 AM,08/20/14 12:00 AM,m,26.65 ,21.3 ,5.225 ,Yigo barrel trap ,NULL,  
bird net ,escaped  
2228,08/20/14 12:00 AM,08/20/14 12:00 AM,m,24.5 ,18.69 ,3.502 ,Yigo barrel trap ,NULL,  
fish net ,peat  
2229,08/20/14 12:00 AM,08/20/14 12:00 AM,m,24.77 ,19.83 ,4.277 ,Yigo barrel trap ,NULL,  
bird net ,escaped  
2230,08/20/14 12:00 AM,08/20/14 12:00 AM,m,24.1 ,19.63 ,4.62 ,Yigo barrel trap ,NULL,  
fish net ,escaped  
2231,08/20/14 12:00 AM,08/20/14 12:00 AM,f ,23.02 ,18.36 ,3.714 ,Yigo barrel trap ,NULL,  
bird net ,entangled  
2232,08/20/14 12:00 AM,08/20/14 12:00 AM,f ,20.92 ,15.89 ,1.857 ,Yigo barrel trap ,NULL,  
fish net ,peat  
2233,08/20/14 12:00 AM,08/20/14 12:00 AM,m,21.79 ,16.54 ,2.795 ,Yigo barrel trap ,NULL,  
bird net ,escaped  
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fish net ,entangled  
2235,08/20/14 12:00 AM,08/20/14 12:00 AM,f ,25.24 ,19.77 ,5.696 ,Yigo barrel trap ,NULL,  
bird net ,escaped  
2236,08/20/14 12:00 AM,08/20/14 12:00 AM,f ,23.78 ,18.75 ,3.966 ,Yigo barrel trap ,NULL,  
fish net ,entangled  
2237,08/20/14 12:00 AM,08/20/14 12:00 AM,m,24.77 ,18.27 ,3.471 ,Yigo barrel trap ,NULL,  
bird net ,peat  
2238,08/20/14 12:00 AM,08/20/14 12:00 AM,f ,21.52 ,17.27 ,3.473 ,Yigo barrel trap ,NULL,  
fish net ,escaped  
2239,08/20/14 12:00 AM,08/20/14 12:00 AM,m,25.16 ,19.55 ,4.027 ,Yigo barrel trap ,NULL,  
bird net ,escaped  
2240,08/20/14 12:00 AM,08/20/14 12:00 AM,m,23.22 ,17.95 ,3.555 ,Yigo barrel trap ,NULL,  
fish net ,entangled  
2241,08/20/14 12:00 AM,08/20/14 12:00 AM,f ,27.66 ,22.06 ,6.761 ,Yigo barrel trap ,NULL,  
bird net ,escaped  
2242,08/20/14 12:00 AM,08/20/14 12:00 AM,f ,24.37 ,18.82 ,3.773 ,Yigo barrel trap ,NULL,  
fish net ,entangled  
2243,08/20/14 12:00 AM,08/20/14 12:00 AM,m,23.2 ,18.02 ,3.085 ,Yigo barrel trap ,NULL,  
bird net ,escaped  
2244,08/20/14 12:00 AM,08/20/14 12:00 AM,m,23.12 ,17.92 ,3.439 ,Yigo barrel trap ,NULL,  
fish net ,escaped  
2245,08/20/14 12:00 AM,08/20/14 12:00 AM,m,21.88 ,16.85 ,2.923 ,Yigo barrel trap ,NULL,  
bird net ,escaped  
2246,08/20/14 12:00 AM,08/20/14 12:00 AM,f ,25.22 ,19.62 ,5.142 ,Yigo barrel trap ,NULL,  
fish net ,entangled  
2247,08/20/14 12:00 AM,08/20/14 12:00 AM,f ,23.96 ,18.45 ,2.941 ,Yigo barrel trap ,NULL,
```

bird net , peat
2248,08/20/14 12:00 AM,08/20/14 12:00 AM,f ,24.44 ,19.01 ,3.497 ,Yigo barrel trap ,NULL,
fish net ,entangled
2249,08/20/14 12:00 AM,08/20/14 12:00 AM,f ,24.95 ,20.07 ,5.282 ,Yigo barrel trap ,NULL,
bird net ,escaped
2250,08/20/14 12:00 AM,08/20/14 12:00 AM,m,25.09 ,19.37 ,4.09 ,Yigo barrel trap ,NULL,
fish net ,entangled
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bird net ,escaped
2252,08/20/14 12:00 AM,08/20/14 12:00 AM,m,20.53 ,16.51 ,2.42 ,Yigo barrel trap ,NULL,
fish net ,escaped
2253,08/20/14 12:00 AM,08/20/14 12:00 AM,f ,23.93 ,17.97 ,2.907 ,Yigo barrel trap ,NULL,
bird net ,escaped
2254,08/20/14 12:00 AM,08/20/14 12:00 AM,f ,22.98 ,18.05 ,3.362 ,Yigo barrel trap ,NULL,
fish net ,peat
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net ,escaped
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net ,escaped
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net 1,escaped
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net 1,escaped
2313,08/22/14 12:00 AM,08/22/14 12:00 AM,m,20.64 ,15.71 ,2.097 ,Field , Container B, green
net 1,escaped
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net 1,escaped
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net 1,escaped
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net , escaped
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net , escaped
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net , escaped
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net , escaped
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net , escaped
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net , entangled
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net , entangled
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net , entangled
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net , peat
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net , entangled
2302,08/22/14 12:00 AM,08/22/14 12:00 AM,m,20.03 ,15.45 ,2.039 ,Field , Container C, fish
net , escaped
2306,08/22/14 12:00 AM,08/22/14 12:00 AM,f ,25.64 ,20.32 ,5.961 ,Field , Container C, fish
net , peat
2310,08/22/14 12:00 AM,08/22/14 12:00 AM,f ,24.48 ,19.31 ,5.072 ,Field , Container C, fish
net , entangled
2314,08/22/14 12:00 AM,08/22/14 12:00 AM,f ,25.02 ,18.99 ,4.706 ,Field , Container C, fish
net , entangled
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net , entangled
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net , entangled
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net , entangled
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, peat
2267,08/22/14 12:00 AM,08/22/14 12:00 AM,f ,23.28 ,18.3 ,4.722 ,Field , Container D, no net
, escaped
2271,08/22/14 12:00 AM,08/22/14 12:00 AM,f ,21.65 ,16.03 ,2.314 ,Field , Container D, no
net , escaped
2275,08/22/14 12:00 AM,08/22/14 12:00 AM,m,24.83 ,19.73 ,3.816 ,Field , Container D, no
net , escaped

, escaped
2327,08/22/14 12:00 AM,08/22/14 12:00 AM,f ,23.73 ,18.95 ,4.536 ,Field ,Container D,no net , escaped
2331,08/22/14 12:00 AM,08/22/14 12:00 AM,f ,22.04 ,16.52 ,3.07 ,Field ,Container D,no net , escaped
2334,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,22.91 ,17.98 ,3.317 ,Field ,Container A,bird net , escaped
2338,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,23.85 ,19.08 ,4.103 ,Field ,Container A,bird net , escaped
2342,08/27/14 12:00 AM,08/28/14 12:00 AM,m,23.54 ,18.49 ,3.783 ,Field ,Container A,bird net , escaped
2346,08/27/14 12:00 AM,08/28/14 12:00 AM,m,23.61 ,18.89 ,4.485 ,Field ,Container A,bird net , escaped
2350,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,24.73 ,19.55 ,4.785 ,Field ,Container A,bird net , escaped
2354,08/27/14 12:00 AM,08/28/14 12:00 AM,m,24.79 ,19.87 ,5.017 ,Field ,Container A,bird net , escaped
2358,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,20.87 ,16.6 ,2.866 ,Field ,Container A,bird net , escaped
2362,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,24.43 ,19.42 ,4.296 ,Field ,Container A,bird net , escaped
2366,08/27/14 12:00 AM,08/28/14 12:00 AM,m,23.58 ,18.32 ,2.989 ,Field ,Container A,bird net , escaped
2370,08/27/14 12:00 AM,08/28/14 12:00 AM,m,26.17 ,20.65 ,5.478 ,Field ,Container A,bird net , peat
2374,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,23.7 ,18.28 ,3.439 ,Field ,Container A,bird net , escaped
2378,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,19.98 ,15.42 ,2.471 ,Field ,Container A,bird net , escaped
2382,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,23.51 ,18.72 ,4.218 ,Field ,Container A,bird net , escaped
2386,08/27/14 12:00 AM,08/28/14 12:00 AM,m,22.41 ,17.41 ,3.469 ,Field ,Container A,bird net , escaped
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2394,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,22.33 ,17.35 ,3.168 ,Field ,Container A,bird net , escaped
2335,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,21.15 ,16.37 ,3.149 ,Field ,Container B,green net 2,escaped
2339,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,25.79 ,20.5 ,4.715 ,Field ,Container B,green net 2,escaped
2343,08/27/14 12:00 AM,08/28/14 12:00 AM,m,25.23 ,20.08 ,5.422 ,Field ,Container B,green net 2,escaped
2347,08/27/14 12:00 AM,08/28/14 12:00 AM,m,20.62 ,16.01 ,2.749 ,Field ,Container B,green net 2,escaped
2351,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,22.15 ,17.27 ,3.995 ,Field ,Container B,green net 2,escaped
2355,08/27/14 12:00 AM,08/28/14 12:00 AM,m,23.17 ,18.46 ,4.74 ,Field ,Container B,green net 2,escaped
2359,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,21.06 ,16.13 ,2.479 ,Field ,Container B,green net 2,entangled
2363,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,25.97 ,20.54 ,5.568 ,Field ,Container B,green net 2,escaped
2367,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,23.78 ,16.61 ,4.241 ,Field ,Container B,green

net 2,escaped
2371,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,22.88 ,17.99 ,3.738 ,Field ,Container B,green
net 2,escaped
2375,08/27/14 12:00 AM,08/28/14 12:00 AM,m,25.78 ,20.67 ,4.655 ,Field ,Container B,green
net 2,peat
2379,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,20.36 ,15.81 ,2.676 ,Field ,Container B,green
net 2,escaped
2383,08/27/14 12:00 AM,08/28/14 12:00 AM,m,25.19 ,19.93 ,4.006 ,Field ,Container B,green
net 2,peat
2387,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,21.9 ,17.18 ,2.739 ,Field ,Container B,green
net 2,escaped
2391,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,23.74 ,18.52 ,3.418 ,Field ,Container B,green
net 2,escaped
2336,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,23.79 ,18.31 ,3.489 ,Field ,Container C,fish
net ,entangled
2340,08/27/14 12:00 AM,08/28/14 12:00 AM,m,24.56 ,19.59 ,4.485 ,Field ,Container C,fish
net ,entangled
2344,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,20.73 ,16.04 ,2.405 ,Field ,Container C,fish
net ,escaped
2348,08/27/14 12:00 AM,08/28/14 12:00 AM,m,23.54 ,17.98 ,3.345 ,Field ,Container C,fish
net ,escaped
2352,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,23.2 ,17.41 ,3.44 ,Field ,Container C,fish
net ,entangled
2356,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,24.04 ,18.63 ,3.991 ,Field ,Container C,fish
net ,entangled
2360,08/27/14 12:00 AM,08/28/14 12:00 AM,m,24.95 ,20.12 ,4.442 ,Field ,Container C,fish
net ,entangled
2364,08/27/14 12:00 AM,08/28/14 12:00 AM,m,20.85 ,16.56 ,3.122 ,Field ,Container C,fish
net ,escaped
2368,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,21.36 ,16.97 ,3.298 ,Field ,Container C,fish
net ,escaped
2372,08/27/14 12:00 AM,08/28/14 12:00 AM,m,24.47 ,18.73 ,4.051 ,Field ,Container C,fish
net ,entangled
2376,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,23.36 ,18.29 ,3.677 ,Field ,Container C,fish
net ,entangled
2380,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,22.3 ,16.99 ,3.373 ,Field ,Container C,fish
net ,escaped
2384,08/27/14 12:00 AM,08/28/14 12:00 AM,m,23.1 ,17.58 ,3.741 ,Field ,Container C,fish
net ,entangled
2388,08/27/14 12:00 AM,08/28/14 12:00 AM,m,25.3 ,20.21 ,4.811 ,Field ,Container C,fish
net ,entangled
2392,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,23.29 ,18.29 ,4.533 ,Field ,Container C,fish
net ,entangled
2337,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,24.51 ,18.81 ,3.64 ,Field ,Container D,no net
,escaped
2341,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,24.37 ,19.13 ,4.4 ,Field ,Container D,no net
,escaped
2345,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,19.65 ,15.24 ,1.968 ,Field ,Container D,no
net ,escaped
2349,08/27/14 12:00 AM,08/28/14 12:00 AM,m,23.23 ,17.99 ,3.37 ,Field ,Container D,no net
,escaped
2353,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,26.51 ,21.04 ,4.493 ,Field ,Container D,no
net ,escaped
2357,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,24.52 ,19.53 ,4.248 ,Field ,Container D,no

```

    net , escaped
2361,08/27/14 12:00 AM,08/28/14 12:00 AM,m,21.28 ,16.65 ,2.679 ,Field ,Container D,no
    net , escaped
2365,08/27/14 12:00 AM,08/28/14 12:00 AM,m,20.91 ,16.67 ,2.599 ,Field ,Container D,no
    net , peat
2369,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,26.86 ,21.24 ,5.288 ,Field ,Container D,no
    net , escaped
2373,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,25.21 ,20.16 ,5.526 ,Field ,Container D,no
    net , escaped
2377,08/27/14 12:00 AM,08/28/14 12:00 AM,m,21.3 ,16.89 ,3.073 ,Field ,Container D,no net
    , escaped
2381,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,25.59 ,19.82 ,4.571 ,Field ,Container D,no
    net , escaped
2385,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,23.57 ,18.36 ,4.369 ,Field ,Container D,no
    net , escaped
2389,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,19.76 ,15.39 ,2.23 ,Field ,Container D,no net
    , escaped
2393,08/27/14 12:00 AM,08/28/14 12:00 AM,f ,23.81 ,18.87 ,4.193 ,Field ,Container D,no
    net , escaped

```

Listing 2: IPython notebook

```

# coding: utf-8

# In [1]:
# General syntax to import specific functions in a library:
##from (library) import (specific library function)
from pandas import DataFrame, read_csv

# General syntax to import a library but no functions:
##import (library) as (give the library a nickname/alias)
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd #only needed to determine version number
import sys #only needed to determine Python version number

# Enable inline plotting
get_ipython().magic(u'matplotlib inline')

# Enable rmagic
get_ipython().magic(u'load_ext rmagic')

# A good reference for pandas dataframe manipulation is
# http://pandas.pydata.org/pandas-docs/stable/comparison_with_sql.html

# In [2]:
data = read_csv('escapeTest2.csv')
data.head()

# In [3]:

```

```

n = data.groupby('treatment').size()
n

# In [4]:
escaped = data[data['result'] == 'escaped'].groupby('treatment').size()
escaped

# In [5]:
df = DataFrame({'n':n, 'escaped':escaped})
df['contained'] = df['n'] - df['escaped']
df['pcontained'] = df['contained']/df['n']
df = df.sort('pcontained')
df

# In [6]:
import astropy.stats
ciContained = astropy.stats.binom_conf_interval(df['contained'], df['n'])
ciContained

# In [7]:
df['lcl'] = ciContained[0]
df['ucl'] = ciContained[1]
df['lbar'] = df['pcontained'] - df['lcl']
df['ubar'] = df['ucl'] - df['pcontained']
df

# In [8]:
# The following 2 lines fix a problem with labels being clipped at bottom of figure.
from matplotlib import rcParams
rcParams.update({'figure.autolayout': True})

df.plot(y='pcontained', kind='bar', grid=False, color='lightgray', ylim=(0,1), yerr=[df['lbar'], df['ubar']])
plt.ylabel('proportion of beetles contained')
plt.savefig('containedBars2.pdf')

# In [9]:
d = data[data['treatment']=='fish net']
c = []
for result in d['result']:
    if result == 'escaped':

```

```
c.append('black')
else:
    c.append('white')
d.plot(x='elytraLength', y='elytraWidth', kind='scatter', c=c)
plt.savefig('escapeSizes.pdf')
```

```
# In [9]:
```