Untitled

September 13, 2021

[14]:
```
import pandas as pd
from pandasql import sqldf
```

1 Methods

This was an investigation to determine the growth (weight gain) of coconut rhinoceros beetle (CRB) larva fed four different diets. Initial set up used CRB eggs placed in small vials, allowed to hatch and monitored the growth of the newly emerged larvae. The results from the study showed that the above two diets were the most ideal for larvae growth (Figs.1, 2). The other two "diets" (1) sphagnum peat moss (SM) and (2) "pure" (PF) frass pellets (obtained by manually separating out some of the frass pellets found in the FCT field sample) and then pulverized to form a powder were both poor diets for CRB larvae. Many of the larvae fed PF only survived from 2-3 weeks with little or no gain in weight, while the SM diet was even less supportive of larva growth dying within a week. Moreover, though both CM and FCT out performed PF and SM, CM showed higher larva mortality near the end of the study than FCT. Larva fed FCT also appeared to gain weight faster than CM but after 9 weeks larva fed CM appeared to have a higher overall increase in mean weight.

2 Data Preparation

2.1 Read Initial Spreadsheet

[15]:
```
df = pd.read_excel('Diet study Means.xlsx')
df
```

[15]:

	Treatment	Larvae ID	Hatch Date	Date	Weight (mg)
0	FCT 5/11/2021	1	5/24/2021 L	2021-05-24 00:00:00	203
1	FCT 5/11/2021	2	5/24/2021 L	2021-05-24 00:00:00	114
2	FCT 5/11/2021	3	5/24/2021 L	2021-05-24 00:00:00	256
3	FCT 5/11/2021	4	5/24/2021 L	2021-05-24 00:00:00	145
4	FCT 5/11/2021	5	5/24/2021 L	2021-05-24 00:00:00	236
..	…	…	…	…	…
168	CM 5/17/2021	4	5/25/2021 L	2021-05-25 00:00:00	85
169	CM 5/17/2021	5	EMPTY	EMPTY	EMPTY
170	CM 5/17/2021	6	5/25/2021 L	2021-05-25 00:00:00	152
171	CM 5/17/2021	7	5/25/2021 L	2021-05-25 00:00:00	192
172	CM 5/17/2021	8	5/25/2021 L	2021-05-25 00:00:00	138

```
    Hatch Date.1              Date.1 Weight (mg).1 Hatch Date.2  \
0     6/2/2021 L  2021-06-02 00:00:00           420   6/9/2021 L
1     6/2/2021 L  2021-06-02 00:00:00           381   6/9/2021 L
2     6/2/2021 L  2021-06-02 00:00:00           385   6/9/2021 L
3     6/2/2021 L  2021-06-02 00:00:00           424   6/9/2021 L
4     6/2/2021 L  2021-06-02 00:00:00           425   6/9/2021 L
..           …                   …           …          …
168   6/1/2021 D  2021-06-01 00:00:00            94        DEAD
169        EMPTY                EMPTY         EMPTY       EMPTY
170   6/1/2021 L  2021-06-01 00:00:00           284   6/8/2021 D
171   6/1/2021 L  2021-06-01 00:00:00           210   6/8/2021 L
172   6/1/2021 D  2021-06-01 00:00:00           211        DEAD

                  Date.2  … Weight (mg).12 Hatch Date.13 Date.13  \
0    2021-06-09 00:00:00  …             NaN           NaN     NaN
1    2021-06-09 00:00:00  …             NaN           NaN     NaN
2    2021-06-09 00:00:00  …             NaN           NaN     NaN
3    2021-06-09 00:00:00  …             NaN           NaN     NaN
4    2021-06-09 00:00:00  …             NaN           NaN     NaN
..                   …  …             …           …     …
168                DEAD  …             NaN           NaN     NaN
169               EMPTY  …             NaN           NaN     NaN
170  2021-06-08 00:00:00  …             NaN           NaN     NaN
171  2021-06-08 00:00:00  …             NaN           NaN     NaN
172                DEAD  …             NaN           NaN     NaN

    Weight (mg).13 Hatch Date.14 Date.14 Weight (mg).14 Hatch Date.15 Date.15  \
0              NaN           NaN     NaN             NaN           NaN     NaN
1              NaN           NaN     NaN             NaN           NaN     NaN
2              NaN           NaN     NaN             NaN           NaN     NaN
3              NaN           NaN     NaN             NaN           NaN     NaN
4              NaN           NaN     NaN             NaN           NaN     NaN
..             …           …     …             …           …     …
168            NaN           NaN     NaN             NaN           NaN     NaN
169            NaN           NaN     NaN             NaN           NaN     NaN
170            NaN           NaN     NaN             NaN           NaN     NaN
171            NaN           NaN     NaN             NaN           NaN     NaN
172            NaN           NaN     NaN             NaN           NaN     NaN

    Weight (mg).15
0              NaN
1              NaN
2              NaN
3              NaN
4              NaN
..             …
168            NaN
```

```
169            NaN
170            NaN
171            NaN
172            NaN

[173 rows x 50 columns]
```

2.2 Delete Unnecessary Columns

[16]:
```
# Remove columns with "Date" heading because the data are redundant

cols = df.columns
for col in cols:
    if col.startswith('Date'):
        df.drop(labels=col, axis='columns', inplace=True)

# Drop all columns which donot contain data

df.dropna(how='all', axis='columns', inplace=True)

df
```

[16]:

	Treatment	Larvae ID	Hatch Date	Weight (mg)	Hatch Date.1	\
0	FCT 5/11/2021	1	5/24/2021 L	203	6/2/2021 L	
1	FCT 5/11/2021	2	5/24/2021 L	114	6/2/2021 L	
2	FCT 5/11/2021	3	5/24/2021 L	256	6/2/2021 L	
3	FCT 5/11/2021	4	5/24/2021 L	145	6/2/2021 L	
4	FCT 5/11/2021	5	5/24/2021 L	236	6/2/2021 L	
..	…	…	…	…	…	
168	CM 5/17/2021	4	5/25/2021 L	85	6/1/2021 D	
169	CM 5/17/2021	5	EMPTY	EMPTY	EMPTY	
170	CM 5/17/2021	6	5/25/2021 L	152	6/1/2021 L	
171	CM 5/17/2021	7	5/25/2021 L	192	6/1/2021 L	
172	CM 5/17/2021	8	5/25/2021 L	138	6/1/2021 D	

	Weight (mg).1	Hatch Date.2	Weight (mg).2	Hatch Date.3	Weight (mg).3	…	\
0	420	6/9/2021 L	686	6/15/2021 L	1494	…	
1	381	6/9/2021 L	390	6/15/2021 L	1102	…	
2	385	6/9/2021 L	768	6/15/2021 L	1460	…	
3	424	6/9/2021 L	548	6/15/2021 L	1210	…	
4	425	6/9/2021 L	778	6/15/2021 L	1442	…	
..	…	…	…	…	…	…	
168	94	DEAD	DEAD	DEAD	DEAD	…	
169	EMPTY	EMPTY	EMPTY	EMPTY	EMPTY	…	
170	284	6/8/2021 D	334	DEAD	DEAD	…	
171	210	6/8/2021 L	188	6/15/2021 D	34	…	
172	211	DEAD	DEAD	DEAD	DEAD	…	

```
    Hatch Date.7 Weight (mg).7 Hatch Date.8 Weight (mg).8 Hatch Date.9  \
0    7/14/2021 L          2834  7/20/2021 L          3084  7/28/2021 L
1    7/14/2021 L          1969  7/20/2021 L          1924  7/28/2021 L
2    7/14/2021 L          3006  7/20/2021 L          3458  7/28/2021 L
3    7/14/2021 L          3163  7/20/2021 L          3467  7/28/2021 L
4    7/14/2021 L          2401  7/20/2021 L          2702  7/28/2021 L
..           …             …           …            …           …
168        DEAD          DEAD        DEAD          DEAD        DEAD
169       EMPTY         EMPTY       EMPTY         EMPTY       EMPTY
170        DEAD          DEAD        DEAD          DEAD        DEAD
171        DEAD          DEAD        DEAD          DEAD        DEAD
172        DEAD          DEAD        DEAD          DEAD        DEAD

    Weight (mg).9 Hatch Date.10 Weight (mg).10 Hatch Date.11 Weight (mg).11
0            3454    8/4/2021 L           5260   8/10/2021 L           5613
1            1715    8/4/2021 L           2594   8/10/2021 L           3463
2            3820    8/4/2021 L           5077   8/10/2021 L           5943
3            3347    8/4/2021 L           5320   8/10/2021 L           6045
4            2688    8/4/2021 L           4542   8/10/2021 L           5572
..            …            …             …            …             …
168         DEAD         DEAD          DEAD         DEAD          DEAD
169        EMPTY        EMPTY         EMPTY        EMPTY         EMPTY
170         DEAD         DEAD          DEAD         DEAD          DEAD
171         DEAD         DEAD          DEAD         DEAD          DEAD
172         DEAD         DEAD          DEAD         DEAD          DEAD

[173 rows x 26 columns]
```

2.3 Normalize Data

[17]:
```
df.columns
```

[17]:
```
Index(['Treatment', 'Larvae ID', 'Hatch Date', 'Weight (mg)', 'Hatch Date.1',
       'Weight (mg).1', 'Hatch Date.2', 'Weight (mg).2', 'Hatch Date.3',
       'Weight (mg).3', 'Hatch Date.4', 'Weight (mg).4', 'Hatch Date.5',
       'Weight (mg).5', 'Hatch Date.6', 'Weight (mg).6', 'Hatch Date.7',
       'Weight (mg).7', 'Hatch Date.8', 'Weight (mg).8', 'Hatch Date.9',
       'Weight (mg).9', 'Hatch Date.10', 'Weight (mg).10', 'Hatch Date.11',
       'Weight (mg).11'],
      dtype='object')
```

[18]:
```
# Create a new dataframe "data" for first "Hatch Date", "Weight (mg)" columns

mylist = ['Treatment', 'Larvae ID', 'Hatch Date', 'Weight (mg)']
data = df[mylist]
data.columns = ['treatment', 'larva_id', 'hatch_date', 'mass']
```

```
# Append rows containing values from subsequent "Hatch Date.*", "Weight (mg).*"␣
↪columns

for i in range(1,12):
    mylist = ['Treatment', 'Larvae ID', f'Hatch Date.{i}', f'Weight (mg).{i}']
    df_temp = df[mylist]
    df_temp.columns = ['treatment', 'larva_id', 'hatch_date', 'mass']
    data = data.append(df_temp, ignore_index=True)

data
```

[18]:

	treatment	larva_id	hatch_date	mass
0	FCT 5/11/2021	1	5/24/2021 L	203
1	FCT 5/11/2021	2	5/24/2021 L	114
2	FCT 5/11/2021	3	5/24/2021 L	256
3	FCT 5/11/2021	4	5/24/2021 L	145
4	FCT 5/11/2021	5	5/24/2021 L	236
…	…	…	…	…
2071	CM 5/17/2021	4	DEAD	DEAD
2072	CM 5/17/2021	5	EMPTY	EMPTY
2073	CM 5/17/2021	6	DEAD	DEAD
2074	CM 5/17/2021	7	DEAD	DEAD
2075	CM 5/17/2021	8	DEAD	DEAD

[2076 rows x 4 columns]

[19]:
```
# Split hatch_date column

data['observation_date'] = data.apply(lambda x : x['hatch_date'].split(" ")[0],␣
↪axis='columns')
data['status'] = data.apply(lambda x : x['hatch_date'][-1], axis='columns')
data.drop('hatch_date', axis='columns', inplace=True)
data['status'].replace({'L':'larva', 'D':'dead', 'Y':'empty', 'G':'egg'},␣
↪inplace=True)

# Recode 'status'

data['unique_larva_id'] = data.apply(lambda x: f"{x['treatment']}␣
↪{x['larva_id']}", axis='columns')
#data['unique_larva_id'] = data.apply(lambda x: x['treatment'].replace('  ','␣
↪'), axis='columns')
data.drop('larva_id', axis='columns', inplace=True)

# Recode 'treatment'
```

```
data['treatment'] = data.apply(lambda x: x['treatment'].split(' ')[0],␣
↪axis='columns')
data['treatment'].replace({'FCT':'frass', 'CM':'manure', 'SM':'peat moss', 'PF':
↪'fecal pellets'}, inplace=True)


# Add a new record for setup date of each insect

new_rows = []
for unique_larva_id in data.unique_larva_id.unique():
    new_rows.append({'unique_larva_id':unique_larva_id,
                     'observation_date': unique_larva_id.split(' ')[1],
                     'treatment': unique_larva_id.split(' ')[0],
                     'status':'egg', 'mass':10})
data = data.append(new_rows, ignore_index=True, sort=False)
data['treatment'].replace({'FCT':'frass', 'CM':'manure', 'SM':'peat moss', 'PF':
↪'fecal pellets'}, inplace=True)

# Delete rows where mass equals EMPTY or DEAD

data = data[data['mass'] != 'EMPTY']
data = data[data['mass'] != 'DEAD']

# sort

data = data.sort_values(by=['unique_larva_id', 'observation_date'])
data = data[['unique_larva_id','treatment','observation_date','status','mass']]

# write CSV filr

data.to_csv('data.csv', index=False)

data
```

[19]:

	unique_larva_id	treatment	observation_date	status	mass
2203	CM 5/11/2021 1	manure	5/11/2021	egg	10
127	CM 5/11/2021 1	manure	5/25/2021	larva	186
300	CM 5/11/2021 1	manure	6/1/2021	larva	381
646	CM 5/11/2021 1	manure	6/15/2021	larva	1307
819	CM 5/11/2021 1	manure	6/22/2021	larva	1548
…	…	…	…	…	…
84	SM 5/17/2021 8	peat moss	5/25/2021	larva	32
257	SM 5/17/2021 8	peat moss	6/2/2021	dead	37
2161	SM 5/17/2021 9	peat moss	5/17/2021	egg	10
85	SM 5/17/2021 9	peat moss	5/25/2021	larva	45
258	SM 5/17/2021 9	peat moss	6/2/2021	dead	21

[1200 rows x 5 columns]

3 Analysis

[20]:
```
# get the last observation record for each larva

df_endpoint = data.groupby('unique_larva_id').tail(1)
df_endpoint.sort_values(['status', 'unique_larva_id'])
```

[20]:

	unique_larva_id	treatment	observation_date	status	mass
1166	CM 5/11/2021 2	manure	7/6/2021	dead	43
480	CM 5/11/2021 8	manure	6/8/2021	dead	165
481	CM 5/12/2021 1	manure	6/8/2021	dead	341
317	CM 5/12/2021 10	manure	6/1/2021	dead	172
311	CM 5/12/2021 4	manure	6/1/2021	dead	191
…	…	…	…	…	…
1766	FCT 5/17/2021 5	frass	8/4/2021	larva	4443
1767	FCT 5/17/2021 6	frass	8/4/2021	larva	4800
1769	FCT 5/17/2021 8	frass	8/4/2021	larva	5142
469	PF 5/17/2021 4	fecal pellets	6/9/2021	larva	141
470	PF 5/17/2021 5	fecal pellets	6/9/2021	larva	201

[173 rows x 5 columns]

[21]:
```
# Summarize the status variable values for each treatment

# egg: egg did not hatch
# dead: larva died before end of experiment
# larva: larva was alive at end of experimant

q = """
SELECT treatment, status, COUNT(*) AS N
FROM df_endpoint
GROUP BY treatment, status
ORDER BY treatment, status;
"""
sqldf(q, globals())
```

[21]:

	treatment	status	N
0	fecal pellets	dead	30
1	fecal pellets	egg	9
2	fecal pellets	larva	2
3	frass	egg	10
4	frass	larva	31
5	manure	dead	10
6	manure	egg	11

```
7         manure  larva  25
8      peat moss   dead  23
9      peat moss    egg  22
```

[22]:
```
# Calculate mean weight for surviving larvae

q = """
SELECT treatment, COUNT(*) AS N, AVG(mass) AS mean, MIN(mass) as min, MAX(mass)␣
 ↪AS max
FROM df_endpoint
WHERE status == 'larva'
GROUP BY treatment;
"""
sqldf(q, globals())
```

[22]:

	treatment	N	mean	min	max
0	fecal pellets	2	171.000000	141	201
1	frass	31	4832.612903	1965	7592
2	manure	25	2549.040000	108	7335

3.1 Treatment effect on egg hatch

treatment	hatched	unhatched	proportion hatched
frass	31	10	0.76
manure	35	11	0.76
fecal pellets	32	9	0.78
peat moss	23	22	0.51

3.2 Treatment effect on larval survival

treatment	alive	dead	proportion surviving
frass	31	0	1.00
manure	25	10	0.71
fecal pellets	2	30	0.06
peat moss	0	23	0.00

3.3 Treatment effect on larval mass at end of experiment

treatment	N	mean {mg)	range (mg)
frass	31	4833	1965-7592
manure	25	2549	108-7335
fecal pellets	2	171	141-201
peat moss	0	-	-