

# Generalized Linear Models Case Studies

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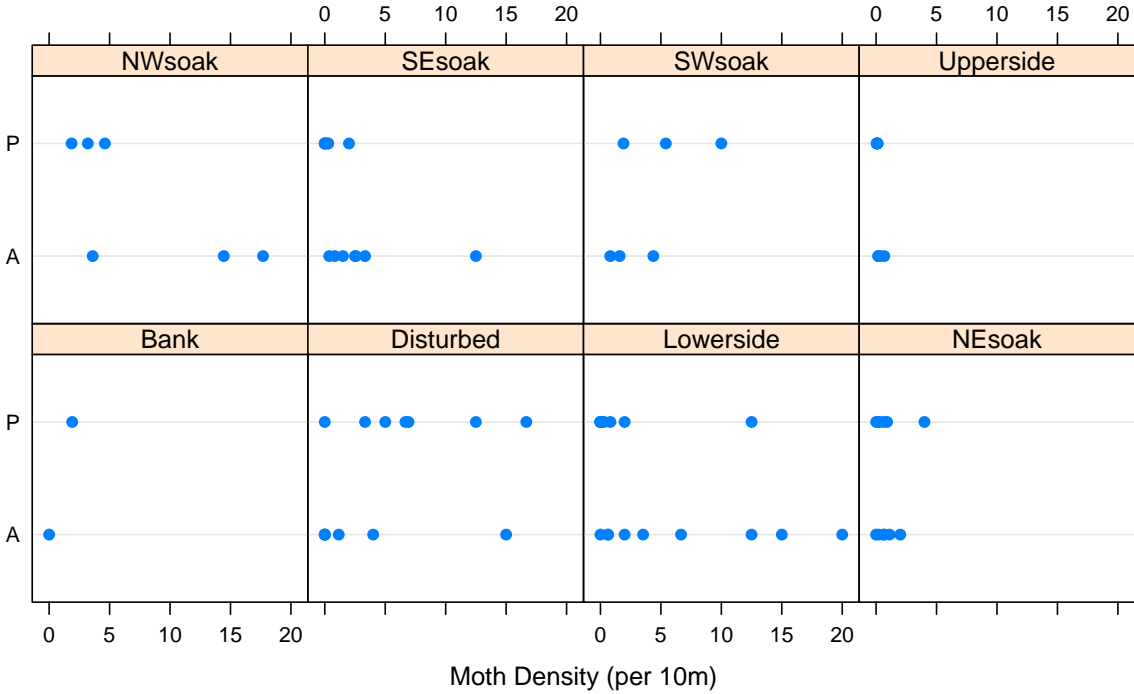
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1 / 13

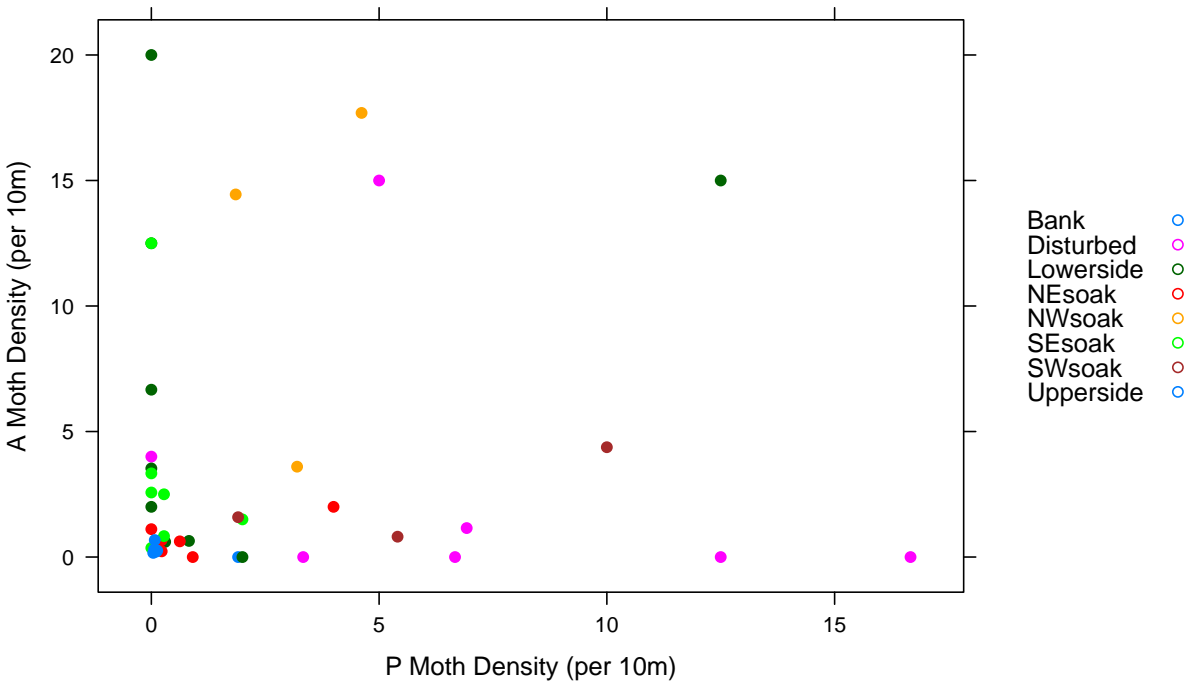
## Poisson Regression Moth Example

- Researchers studied the effect of habitat on density of two different moth species.
- Researchers looked for moths along transects.
- Each transect was partitioned into different sections depending on the habitat type.
- There are 8 different types of habitat.
- Counts of two moth species (labeled A and P) were obtained for each part of each transect.
- Under a Poisson model, we expect the counts to be proportional to the length of the transect within each habitat.

# Dotplot of Data



# Scatterplot of Data



## Model with an Offset

- The count data for species A comes from transects of different lengths.
- Poisson process assumptions suggest that the expected count for a single transect *should be proportional to the length* of the transect.
- We need to modify our typical Poisson regression model to accomodate an *exposure* variable.

## Model Derivation

- For transect  $i$ :
  - ▶  $u_i$  is the length in meters;
  - ▶  $h_i$  is the habitat;
  - ▶  $\theta_i = \theta(h_i)$  is the rate;
  - ▶  $y_i$  be the count of species A;
- The expected count for the  $i$ th habitat is then:

$$E[y_i] = \mu_i = u_i\theta_i$$

## Derivation (cont.)

- We model  $\theta_i = \exp(X_i\beta)$  where  $X_i$  includes all predictors *except for length*.
- In this case:
  - ▶  $\theta_i = \exp(\beta_1)$  if  $h_i$  is the first habitat;
  - ▶  $\theta_i = \exp(\beta_1 + \beta_k)$  if  $h_i$  is the  $k$ th habitat,  $k > 1$ .
- We need  $E[y_i] = \mu_i = u_i\theta_i$ .
- With the exponential inverse link function, this is:

$$\begin{aligned}\mu_i &= \exp(\log u_i + \log(\theta_i)) \\ &= \begin{cases} \exp(\log u_i + \beta_1) & \text{if } k = 1 \\ \exp(\log u_i + \beta_1 + \beta_k) & \text{if } k > 1 \end{cases}\end{aligned}$$

- This is like regular Poisson regression with  $\log u$  as a predictor, *except we want to force the estimated coefficient to be equal to one*.

## Fitting the Model

```
> fitA = with(moths, glm(A ~ habitat, data = moths, family = poisson,
+   offset = log(length)))
> fitAq = with(moths, glm(A ~ habitat, data = moths, family = quasipoisson,
+   offset = log(length)))
> fitP = with(moths, glm(P ~ habitat, data = moths, family = poisson,
+   offset = log(length)))
> fitPq = with(moths, glm(P ~ habitat, data = moths, family = quasipoisson,
+   offset = log(length)))
```

## Poisson Regression for A

```
> display(fitA)
glm(formula = A ~ habitat, family = poisson, data = moths, offset = log(length))
      coef.est coef.se
(Intercept)   -18.35  1275.75
habitatDisturbed  16.53  1275.75
habitatLowerside  16.81  1275.75
habitatNEsoak    15.45  1275.75
habitatNWsoak    18.44  1275.75
habitatSEsoak    16.70  1275.75
habitatSWsoak    16.59  1275.75
habitatUpperside  14.82  1275.75
---
n = 41, k = 8
residual deviance = 180.3, null deviance = 499.0 (difference = 318.7)
```

## QuasiPoisson Regression for A

```
> display(fitAq)
glm(formula = A ~ habitat, family = quasipoisson, data = moths,
     offset = log(length))
      coef.est coef.se
(Intercept)   -18.35  3793.81
habitatDisturbed  16.53  3793.81
habitatLowerside  16.81  3793.81
habitatNEsoak    15.45  3793.81
habitatNWsoak    18.44  3793.81
habitatSEsoak    16.70  3793.81
habitatSWsoak    16.59  3793.81
habitatUpperside  14.82  3793.81
---
n = 41, k = 8
residual deviance = 180.3, null deviance = 499.0 (difference = 318.7)
overdispersion parameter = 8.8
```

## Poisson Regression for P

```
> display(fitP)

glm(formula = P ~ habitat, family = poisson, data = moths, offset = log(length))
      coef.est coef.se
(Intercept)   -1.66    0.50
habitatDisturbed  1.26    0.53
habitatLowerside -0.76    0.56
habitatNEsoak   -1.24    0.57
habitatNWsoak    0.43    0.55
habitatSEsoak   -1.81    0.65
habitatSWsoak    0.78    0.52
habitatUpperside -3.12    0.61
---
n = 41, k = 8
residual deviance = 92.6, null deviance = 389.5 (difference = 296.9)
```

## QuasiPoisson Regression for P

```
> display(fitPq)

glm(formula = P ~ habitat, family = quasipoisson, data = moths,
     offset = log(length))
      coef.est coef.se
(Intercept)   -1.66    1.07
habitatDisturbed  1.26    1.13
habitatLowerside -0.76    1.19
habitatNEsoak   -1.24    1.21
habitatNWsoak    0.43    1.18
habitatSEsoak   -1.81    1.38
habitatSWsoak    0.78    1.11
habitatUpperside -3.12    1.31
---
n = 41, k = 8
residual deviance = 92.6, null deviance = 389.5 (difference = 296.9)
overdispersion parameter = 4.6
```

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