BIOL 133 – Ecological Models and Data – TEST #1 – 26 February, 2015

NB: Each subproblem is worth 10 points. There are a total of 160 points.

NB: There is a table of functions and formulas at the end of the test (pg. 6)

NAME: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. According to the National Climate Data Center, US winter temperatures were warmer than average for the 20th century during 11 of the first 15 years (2000-2014) of the 21st century.
   1. If nothing has changed, the probability of being warmer than average would be 0.5. Use the Binomial distribution to calculate the probability of getting 11 “warm” years out of 15 years, if the probability of a warm year is 0.5. Report this probability below.
   2. Use the Binomial distribution to calculate the probability of getting 11 or more warmer than average, out of 15 trials. In other words, what is the probability of getting 11 OR 12 OR 13 OR 14 OR 15 warm years between 2000 and 2014? Report this probability below.
   3. Using only the data from 2000-2014, what is the MLE () of the probability of a warm year? Report your estimate of below.
   4. Use the Binomial distribution to calculate the probability of getting 11 out of 15 “warm” years, given your estimate of for the 21st century. Report this probability below.
   5. Use Bayes’ Theorem and the two models fit to the data in questions 1a and 1d to estimate the probability that the frequency of warm years is different in the 21st and 20th centuries.
   6. How confident would you need to be that climate has not changed, in order to believe we need more data to make conclusions, given these data on winter temperature? In other words, use Bayes’ Theorem to calculate the minimum prior probability that the proportion of warm years is still 0.5, that would allow you to say the two models from questions 1a and 1d are equally likely.

|  |  |  |
| --- | --- | --- |
| Temperature dependent sex ratio in turtles | | |
|  | Number of … | |
| Temperature | males | females |
| Cool (25°C) | 222 | 12 |
| Warm (30.5°C) | 13 | 224 |
| DATA SOURCE: Bull & Vogt 1979 *Science* 1186-1188 | | |

1. One way in which climate affects populations is through changes in reproduction. For example, in some animals, the sex ratio of offspring depends on the temperature during embryo development. The table to the right shows data from a classic study of sex ratio of turtles (*Graptemys pseudogeographica*) eggs incubated at cool and warm temperatures.
   1. Estimate the MLE proportions of male turtles in nests incubated under warm and cool conditions. Report these parameters below.
   2. Calculate likelihood profile confidence limits for these estimates, and show them below.

|  |  |  |
| --- | --- | --- |
| Temperature quartile | # deaths due to heat stroke | # deaths due to other causes |
| Coolest  (lowest 25%) | 3 | 67 |
| Medium cool  (25%-50%) | 1 | 63 |
| Medium warm  (50-75%) | 1 | 68 |
| Warmest  (highest 25%) | 7 | 72 |
| DATA SOURCE: Mumby et al. 2013. Ecology 94:1131–1141. | | |

1. Another way in which climate affects populations is through changes in survival. The data for this problem come from a remarkable study of sources of mortality in Asian elephants throughout most of the 20th and 21st century. Use these data to evaluate three competing models about the effects of temperature on the probability that elephants die from heat stroke during warmer years.
   1. Fit a model to the data in which the probability of heat stroke differs between the warmer than average (50-75% and top 25%) and colder than average (lowest 25% and 25-50%) years. Report the log-likelihood and number of estimated parameters for this model.
   2. Fit a model to the data in which the probability of heat stroke differs between the most extreme (warmest and coldest) years, and the intermediate (middle 25-75%) years. Report the log-likelihood and number of estimated parameters for this model.
   3. Calculate AIC’s for each of the models you have fit to the data. Present the AIC values.
   4. Which model or models are supported by the data? Briefly explain your conclusions.

|  |  |  |
| --- | --- | --- |
|  | Color of hares on first day when snow cover is < 20% | |
| Year | # white | # brown |
| 2010 | 10 | 33 |
| 2011 | 10 | 53 |
| 2012 | 32 | 26 |
| DATA SOURCE: Mills et al. 2013 *PNAS* 110:7360-7365 | | |

1. Snowshoe hares are brown in summer, and white in winter. In the past, this change in coat color helped the hares camouflage with their environment, during snowy and non-snowy seasons. Now, scientists are concerned that the timing of coat color change is mis-matched with the earlier date of snowmelt, leaving white hares conspicuous and susceptible to predation against a brown background in spring. The data for this problem come from a study of the timing of coat color change in relation to snowmelt.
   1. Fit a model to the data in which the probability of being white after snowmelt is the same for the three years of this study. Report the log-likelihood and number of estimated parameters for this model.
   2. Fit a model to the data in which the probability of being white after snowmelt is different for each of the three years of this study. Report the log-likelihood and number of estimated parameters for this model.
   3. Use a likelihood ratio test to compare these two nested models. Report the chi-square statistic, degrees of freedom, and p-value for this pair of models
   4. In words, briefly summarize your conclusions from this statistical test
   5. In the 20th century, the proportion of hares that were mis-matched with the environment in early spring was about 10%. Does the proportion of hares that are the wrong color in these three 21st century years differ from the 20th century proportion? Justify your answer using statistics.
2. [EXTRA CREDIT + 5 points] For the sake of argument, let’s assume the winter of 2015 is colder than the average for the 20th century. How would this one additional data point change your answer to question 1e?

Possibly-useful functions and formulas:

|  |  |
| --- | --- |
|  | dbinom(k,N,p, log = TRUE/FALSE) |
|  | logLik(model.name) |
| glm(Y ~ 1, family = binomial(link = “identity”)) |
|  | glm(Y ~ -1 + treatment, family = binomial(link = “identity”)) |
|  | confint(model.name) |
|  | cbind(successes, failures) |
| AIC(model.name) |
| AICi = -2log(Li) + 2k1 | lrtest(model.name1, model.name2) |
|  | library(lmtest) |