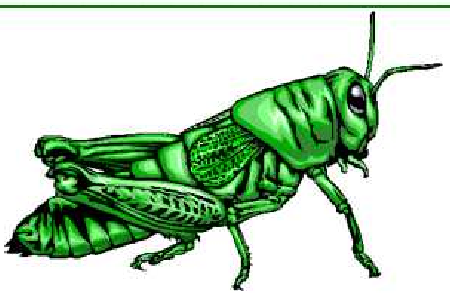
Linear Regression with Biological Data
(or the realities of working with real-life data)

Data: The following data shows the relationship between chirps per second of a ground cricket and the corresponding ground temperature.



Pierce (1949) measured the frequency (the number of wing vibrations per second) of chirps made by a ground cricket, at various ground temperatures. Since crickets are ectotherms (cold-blooded), the rate of their physiological processes and their overall metabolism are influenced by temperature. Consequently, there is reason to believe that temperature would have a profound effect on aspects of their behavior, such as chirp frequency.

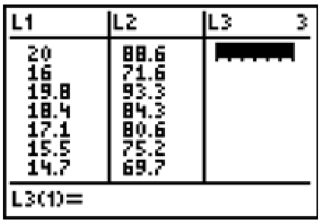
Chirps/Second	Temperature (° F)
20.0	88.6
16.0	71.6
19.8	93.3
18.4	84.3
17.1	80.6
15.5	75.2
14.7	69.7
17.1	82.0
15.4	69.4
16.2	83.3
15.0	78.6
17.2	82.6
16.0	80.6
17.0	83.5
14.1	76.3

Task:
a.) Determine a linear regression model equation to represent this data.
b.) Graph the new equation.
c.) Decide whether the new equation is a "good fit" to represent this data.
d.) Extrapolate data: If the ground temperature reached 95°, then at what approximate rate would you expect the crickets to be chirping?
e.) Interpolate data: With a listening device, you discovered that on a particular morning the crickets were chirping at a rate of 18 chirps per second. What was the approximate ground temperature that morning?
f.) If the ground temperature should drop to freezing (32° F), what happens to the cricket's chirping?

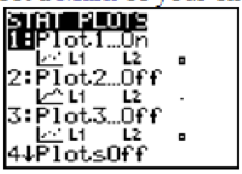
Answers in this problem are to be rounded to the *nearest thousandth.*

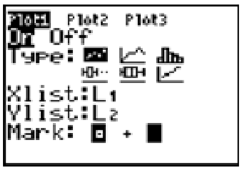
Step 1. Enter the data into the lists.
For basic entry of data, see Basic Commands.

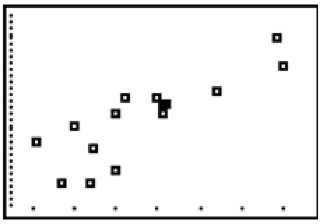
STAT
EDIT
use L1 and L2



Step 2. Create a scatter plot of the data.
Go to STATPLOT (2nd Y=) and choose the first plot. Turn the plot ON, set the icon to Scatter Plot (the first one), set Xlist to L1 and Ylist to L2 (assuming that is where you stored the data), and select a Mark of your choice.



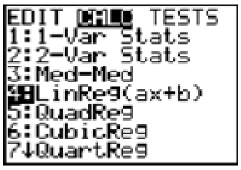


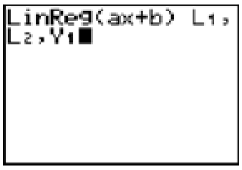


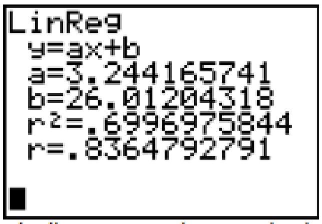
Obviously, there is some scatter to this data. This variability is the norm, rather than the exception, when working with biological data sets. Real life data seldom creates a nice straight line.

Step 3. Choose the Linear Regression Model.
Press STAT, arrow right to CALC, and arrow down to 4: LinReg (ax+b). Hit ENTER. When LinReg appears on the home screen, type the parameters L1, L2, Y1. The Y1 will put the equation in to Y= for you.

(Y_1 comes from **VARS → YVARS, #Function, Y_1**)

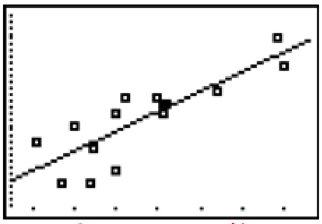






The linear regression equation is
$y = 3.244x + 26.012$
(answer to part a)

Step 4. Graph the Linear Regression Equation from Y1.
ZOOM #9 ZoomStat to see the graph.



(answer to part b)

Step 5. Is this model a "good fit"?

The correlation coefficient, r, is .8364792791 which just barely places the correlation into the "strong" category. (0.8 or greater is a "strong" correlation)

The coefficient of determination, r^2, is .6996975844 which means that 70% of the total variation in y can be explained by the relationship between x and y. The other 30% remains unexplained.

Yes, it is somewhat of a "good fit".

(answer to part c)

Step 6. Extrapolate: *(beyond the data set)*

If the ground temperature reached 95°, then at what approximate rate would you expect the crickets to be chirping?

Go to TBLSET (above WINDOW) and set the TblStart to 20 (since the highest temperature in the data set had 19.8 chirps/second). Set the delta Tbl to a decimal setting of your choice. Go to TABLE (above GRAPH) and arrow up or down to find your desired temperature, 95°, in the Y1 column.

```
TABLE SETUP
 TblStart=20
 ΔTbl=.001
Indpnt: Auto Ask
Depend: Auto Ask
```

X	Y1
21.264	94.996
21.265	94.999
21.266	95.002
21.267	95.006
21.268	95.009
21.269	95.012
21.27	95.015

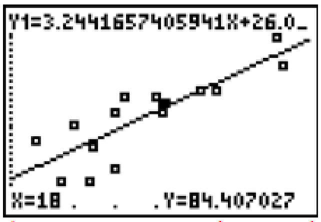
X=21.265

(answer to part d -- approx. 21.265 chirps per second)

Step 7. Interpolate: *(within the data set)*

With a listening device, you discovered that on a particular morning the crickets were chirping at a rate of 18 chirps per second. What was the approximate ground temperature that morning?

From the graph screen, hit TRACE, arrow up to obtain the power equation, type 47, hit ENTER, and the answer will appear at the bottom of the screen.



(answer to part e -- the ground temperature will be approx. 84.407° F)

Step 8. *If the ground temperature should drop to freezing (32° F), what happens to the cricket's chirping?*

X	Y1
1.83	31.949
1.84	31.981
1.85	32.014
1.86	32.046
1.87	32.079
1.88	32.111
1.89	32.144

X=1.85

The TABLE tells us that at 32° F there are 1.85 chirps per second. So, what does this really mean? Are the crickets cold?

These findings are a bit deceiving. At 32° F, the crickets are dead. The lifespan of a cricket in a cold climate is very short. The crickets spend the winter as eggs laid in the soil. These eggs hatch in late spring or early summer, and tiny immature crickets called nymphs emerge. Nymphs develop into adults within approximately 90 days. The adults mate and lay eggs in late summer before succumbing to old age or freezing temperatures in the fall.

Also, remember that the further you extrapolate away from the data set, the less reliable the information will be.

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