# CHAPTER 2
## Description of Samples and Populations

**2.1.1 (a)** i) Molar width
ii) Continuous variable
iii) A molar
iv) 36

**(b)** i) Birthweight, date of birth, and race
ii) Birthweight is continuous, date of birth is discrete (although one might say categorical and ordinal), and race is categorical
iii) A baby
iv) 65

• **2.1.2 (a)** i) Height and weight
ii) Continuous variables
iii) A child
iv) 37

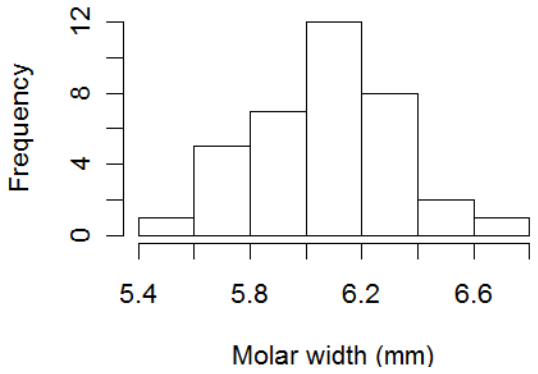
**(b)** i) Blood type and cholesterol level
ii) Blood type is categorical, cholesterol level is continuous
iii) A person
iv) 129

**2.1.3 (a)** i) Number of leaves
ii) Discrete variable
iii) A plant
iv) 25

**(b)** i) Number of seizures
ii) Discrete variable
iii) A patient
iv) 20

• **2.2.1 (a)**There is no single correct answer. One possibility is:

| Molar width | Frequency (no. specimens) |
|---|---|
| [5.4, 5.6) | 1 |
| [5.6, 5.8) | 5 |
| [5.8, 6.0) | 7 |
| [6.0, 6.2) | 12 |
| [6.2, 6.4) | 8 |
| [6.4, 6.6) | 2 |
| [6.6, 6.8) | 1 |
| Total | 36 |

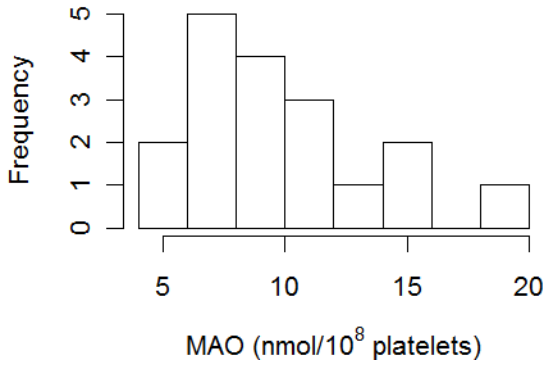



**(b)** The distribution is fairly symmetric.

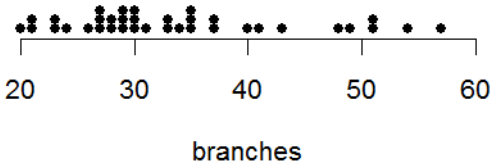
**2.2.2**


**2.2.3** There is no single correct answer. One possibility is

| MAO | Frequency (no. patients) |
|---|---|
| 4.0-5.9 | 2 |
| 6.0-7.9 | 5 |
| 8.0-9.9 | 4 |
| 10.0-11.9 | 3 |
| 12.0-13.9 | 1 |
| 14.0-15.9 | 2 |
| 16.0-17.9 | 0 |
| 18.0-19.9 | 1 |
| Total | 18 |

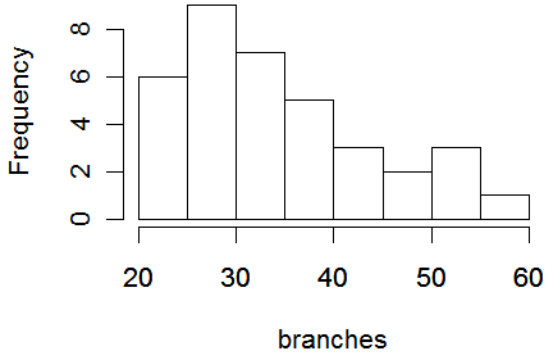


**2.2.4**



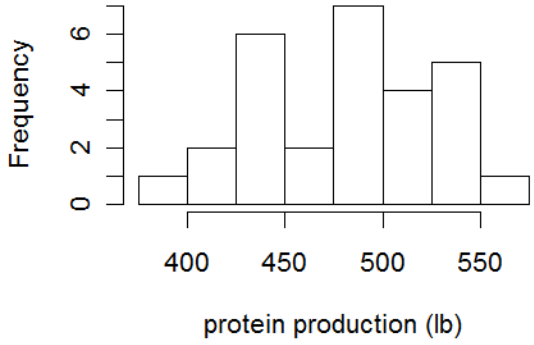

**2.2.5** There is no single correct answer. One possibility is

| Branches | Frequency (no. cells) |
|---|---|
| 20-24 | 6 |
| 25-29 | 9 |
| 39-34 | 7 |
| 35-39 | 5 |
| 40-44 | 3 |
| 45-49 | 2 |
| 50-54 | 3 |
| 55-59 | 1 |
| Total | 36 |



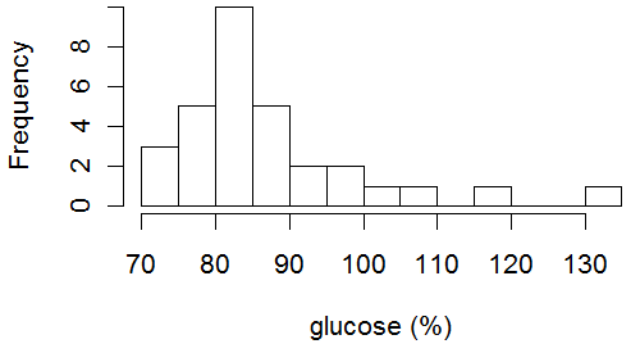

**2.2.6** There is no single correct answer. One possibility is

| Protein production | Frequency (no. cows) |
|---|---|
| 375-399 | 1 |
| 400-424 | 2 |
| 425-449 | 6 |
| 450-474 | 2 |
| 475-499 | 7 |
| 500-524 | 4 |
| 525-549 | 5 |
| 550-574 | 1 |
| Total | 28 |

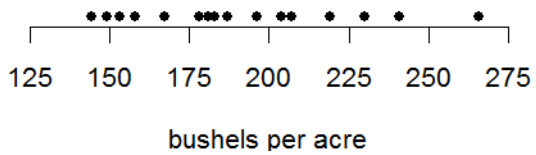



• **2.2.7** There is no single correct answer. One possibility is

| Glucose (%) | Frequency (no. of dogs) |
|---|---|
| 70-74 | 3 |
| 75-79 | 5 |
| 80-84 | 10 |
| 85-89 | 5 |
| 90-94 | 2 |
| 95-99 | 2 |
| 100-104 | 1 |
| 105-109 | 1 |
| 110-114 | 0 |
| 115-119 | 1 |
| 120-124 | 0 |
| 125-129 | 0 |
| 130-134 | 1 |
| Total | 31 |

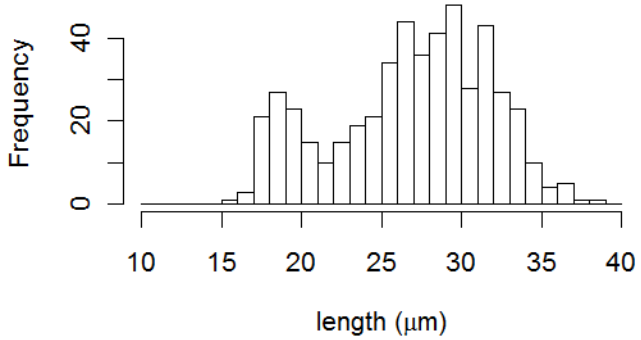


**2.2.8 (a)**



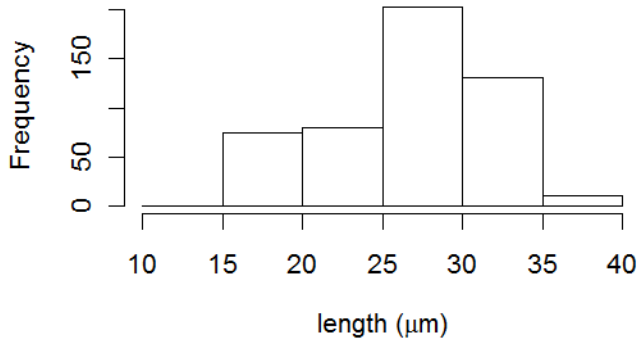

**(b)**
The distribution is very slightly skewed to the right.

**2.2.9 (a)**




**(b)** The distribution is bimodal.

**(c)** The histogram with only 6 classes obscures the bimodal nature of the distribution.




• **2.3.1** Any sample with $\Sigma y_i = 100$ would be a correct answer. For example: 18, 19, 20, 21, 22.

**2.3.2** Any sample with $\Sigma y_i = 100$ and median 15 would be a correct answer. For example: 13, 14, 15, 28, 30.

**2.3.3** $\bar{y} = \Sigma y_i/n = \dfrac{6.3 + 5.9 + 7.06.9 + 5.9}{5} = 6.40$ nmol/gm. The median is the 3rd largest value (i.e., the third observation in the *ordered* array of 5.9 5.9 6.3 6.9 7.0), so the median is 6.3 nmol/gm.

**2.3.4** Yes, the data are consistent with the claim that the typical liver tissue concentration is 6.3 nmol/gm. The value of 6.3 fits comfortably near the center of the sample data.

• **2.3.5** $\bar{y}$ = 293.8 mg/dl; median = 283 mg/dl.

• **2.3.6** $\bar{y}$ = 309 mg/dl; median = 292 mg/dl.

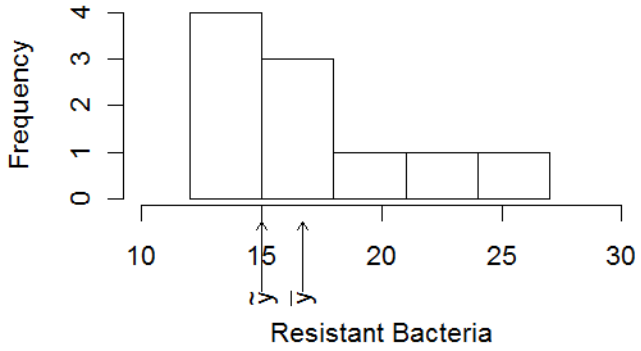
**2.3.7** $\bar{y}$ = 3.492 lb; median = 3.36 lb.

**2.3.8** Yes, the data are consistent with the claim that, in general, steers gain 3.5 lb/day; the value of 3.5 fits comfortably near the center of the sample data. However, the data do not support the claim that 4.0 lb/day is the typical amount that steers gain. Both the mean and the median are less than 4.0; indeed, the maximum in the sample is less than 4.0.

**2.3.9** $\bar{y}$ = 3.389 lb; median = 3.335 lb.

**2.3.10** There is no single correct answer. One possibility is

| Resistant bacteria | Frequency (no. aliquots) |
|---|---|
| 12-14 | 4 |
| 15-17 | 3 |
| 18-20 | 1 |
| 21-23 | 1 |
| 24-26 | 1 |
| Total | 10 |




**(b)** $\bar{y}$ = 16.7, median = $\dfrac{15+15}{2}$ = 15.

• **2.3.11** The median is the average of the 18th and 19th largest values. There are 18 values less than or equal to 10 and 18 values that are greater than or equal to 11. Thus, the median is

$$\frac{10+11}{2} = 10.5 \text{ piglets.}$$

**2.3.12** $\bar{y}$ = 375/36 = 10.4.

• **2.3.13** The distribution is fairly symmetric so the mean and median are roughly equal. It appears that half of the distribution is below 50 and half is above 50. Thus, mean ≈ median ≈ 50.

• **2.3.14** The bars in the histogram that correspond to observations less than 40 represent about one-sixth of the total area. Thus, about 15% of the observations are less than 40.

**2.3.15** Mean ≈ 35, median ≈ 40

**2.3.16** The bars in the histogram that correspond to observations greater than 45 represent about one-fourth of the total area. Thus, about 25% of the observations are greater than 45.

**2.4.1 (a)** Putting the data in order, we have

13 13 14 14 15 15 16 20 21 26

The median is the average of observations 5 and 6 in the ordered list. Thus, the median is $\frac{15+15}{2}$ = 15. The lower half of the distribution is

13 13 14 14 15

The median of this list is the 3rd largest value, which is 14. Thus, the first quartile of the distribution is $Q_1 = 14$. Likewise, the upper half of the distribution is

15 16 20 21 26

The median of this list is the 3rd largest value, which is 20. Thus, the third quartile of the distribution is $Q_3 = 20$.

**(b)** IQR = $Q_3 - Q_1 = 20 - 14 = 6$

**(c)** To be an outlier at the upper end of the distribution, an observation would have to be larger than $Q_3 + 1.5(\text{IQR}) = 20 + 1.5(6) = 20 + 9 = 29$, which is the upper fence.

• **2.4.2 (a)** The median is the average of the 9th and 10th largest observations. The ordered list of the data is

4.1 5.2 6.8 7.3 7.4 7.8 7.8 8.4 8.7 9.7 9.9 10.6 10.7 11.9 12.7 14.2 14.5 18.8

Thus, the median is $\frac{8.7+9.7}{2} = 9.2$.

To find $Q_1$ we consider only the lower half of the data set:

4.1 5.2 6.8 7.3 7.4 7.8 7.8 8.4 8.7 9.7

$Q_1$ is the median of this half (i.e., the 5th largest value), which is 7.4.

To find $Q_3$ we consider only the upper half of the data set:

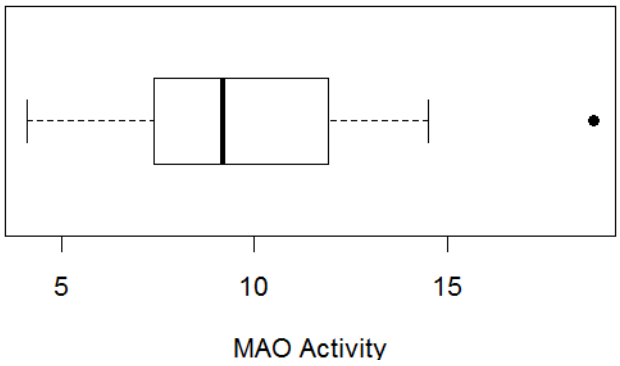
9.7 9.9 10.6 10.7 11.9 12.7 14.2 14.5 18.8.

$Q_3$ is the median of this half (i.e., the 5th largest value in this list), which is 11.9.

**(b)** IQR = $Q_3$ - $Q_1$ = 11.9 - 7.4 = 4.5.

**(c)** Upper fence = $Q_3$ + 1.5 × IQR = 11.9 + 6.75 = 18.65.

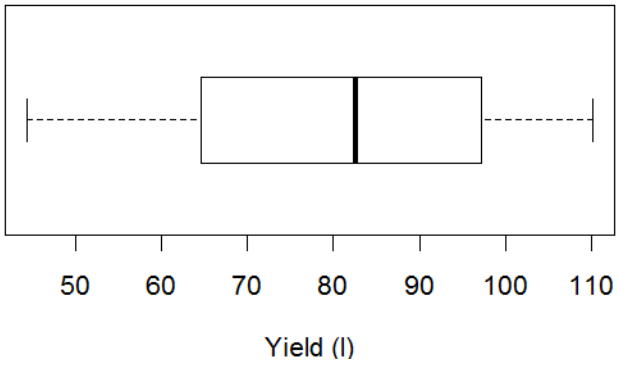
**(d)**



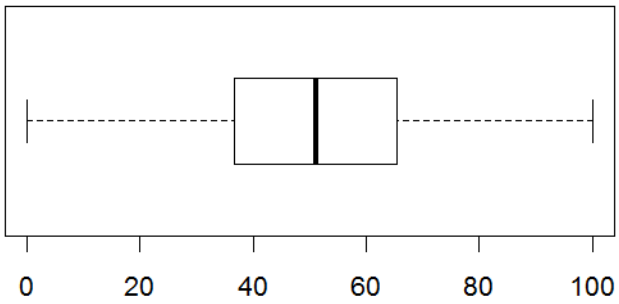

**2.4.3** **(a)** Median = 82.6, $Q_1$ = 63.7, $Q_3$ = 102.9.

**(b)** IQR = 39.2.

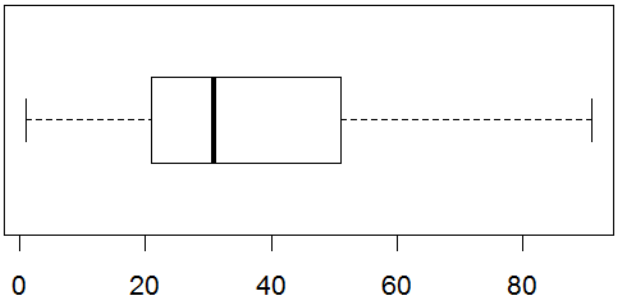
**(c)**



**2.4.4 (a)** $Q_1 = 35$, median = 50, $Q_3 = 65$.




**(b)** $Q_1 = 20$, median = 35, $Q_3 = 50$.



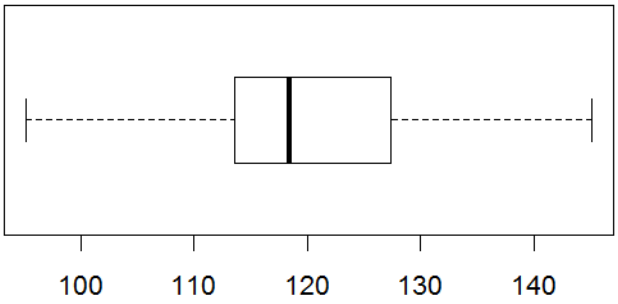

**2.4.5** The histogram is centered at 40. The minimum of the distribution is near 25 and the maximum is near 65. Thus, boxplot (d) is the right choice.

**2.4.6** Yes, it is possible that there is no data value of exactly 42. The first quartile does not need to equal a data value. For example, it could be that the first quartile is the average of two points that have the values 41 and 43.

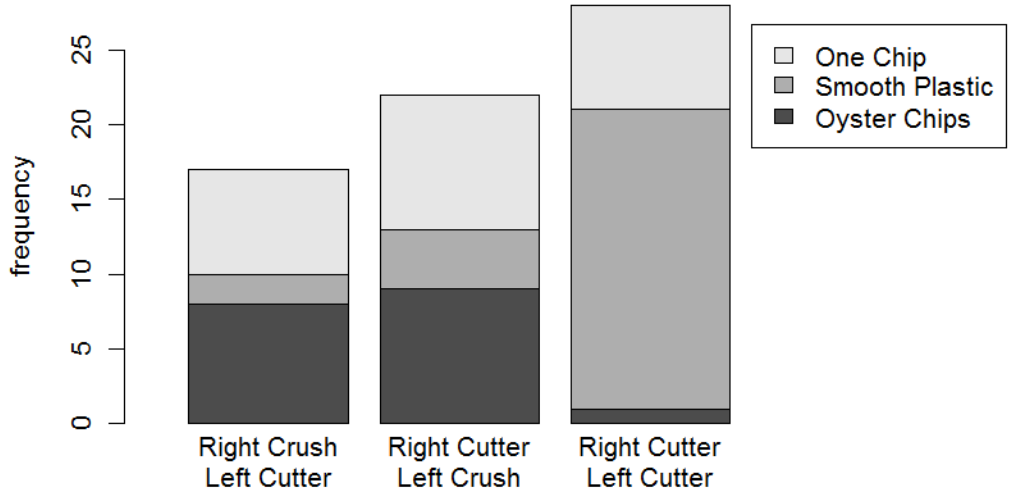
**2.4.7 (a)** The IQR is 127.42 – 113.59 = 13.83.

**(b)** For a point to be an outlier it would have to be less than 113.59 – 1.5*13.83 = 92.845 or else greater than 127.42 + 1.5*13.83 = 148.165. But the minimum is 95.16 and the maximum is 145.11, so there are no outliers present.

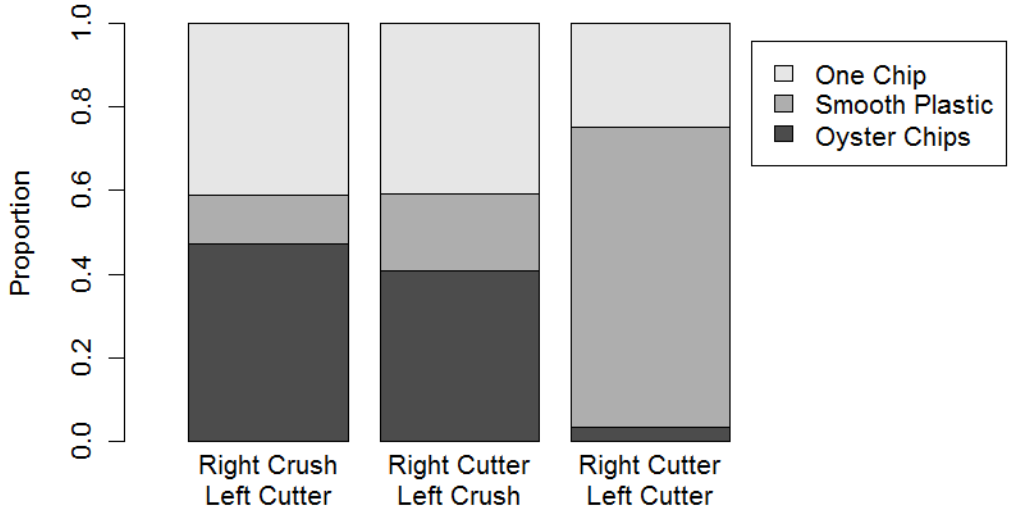
**2.4.8**




**2.5.1 (a)**

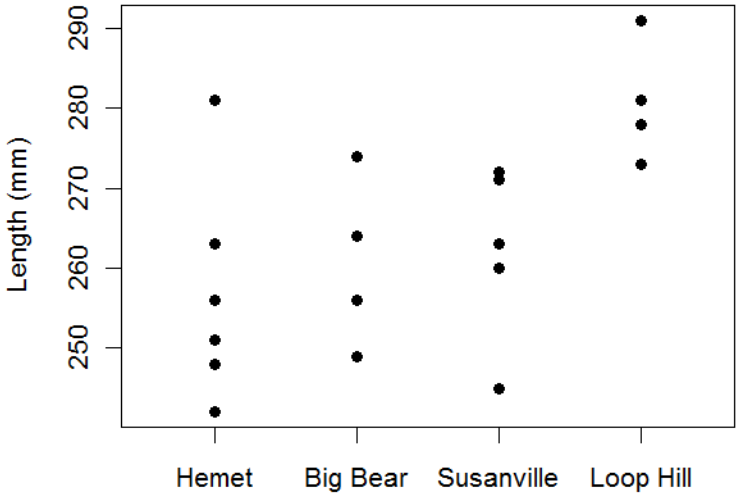



**(b)**

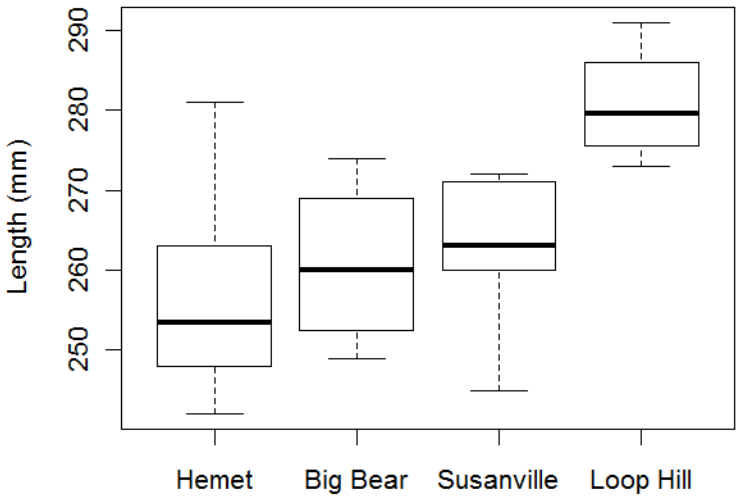


**(c)** The relative frequency chart in part (b) is more useful because it accounts for the different samples sizes for each claw configuration.

**2.5.2 (a)**

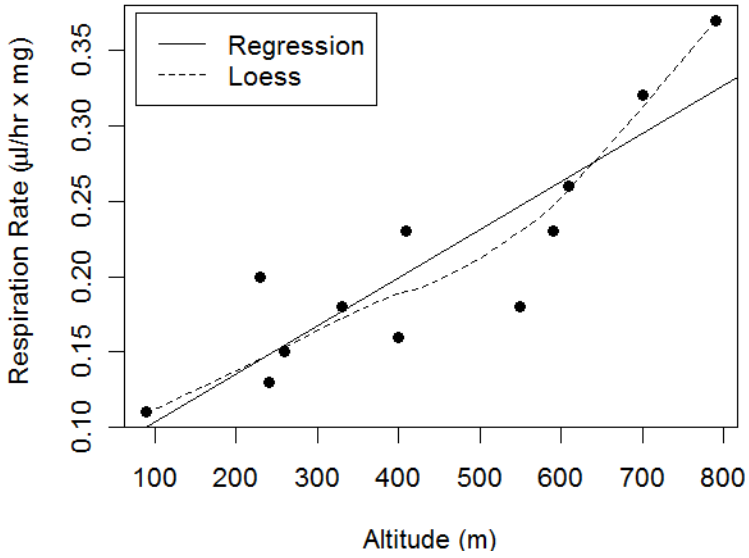



**(b)**




**(c)** Because of the small sample size, the dotplot is a simple and adequate way to represent these data.

**2.5.3**




• **2.6.1 (a)** $\bar{y} = 15$, $\sum (y_i - \bar{y})^2 = 18$, s = $\sqrt{18/3} = 2.45$.

**(b)** $\bar{y} = 35$, $\sum (y_i - \bar{y})^2 = 44$, s = $\sqrt{44/4} = 3.32$.

**(c)** $\bar{y} = 1$, $\sum (y_i - \bar{y})^2 = 24$, s = $\sqrt{24/3} = 2.83$.

**(d)** $\bar{y} = 3$, $\sum (y_i - \bar{y})^2 = 28$, s = $\sqrt{28/4} = 2.65$.

**2.6.2 (a)** $\bar{y} = 7$, $\sum (y_i - \bar{y})^2 = 16$, s = $\sqrt{16/4} = 2$.

**(b)** $\bar{y} = 5$, $\sum (y_i - \bar{y})^2 = 6$, s = $\sqrt{6/3} = 1.4$.

**(c)** $\bar{y} = 6$, $\sum (y_i - \bar{y})^2 = 26$, s = $\sqrt{26/4} = 2.5$.

**2.6.3** Any sample for which the deviations $(y_i - \bar{y})$ are equal to -3, -1, 0, 2, 2 would be a correct answer. Example: 17, 19, 20, 22, 22; in this case $\bar{y} = 20$.

• **2.6.4 (a)** $\bar{y} = 33.10$ lb; s = 3.444 lb.

**(b)** Coefficient of variation = $\frac{s}{\bar{y}} = \frac{3.444}{33.10} = 0.104$ or 10.4%.

**2.6.5 (a)** $\bar{y}$ = 1.190; s = 0.1840.

**(b)** Coefficient of variation = 0.1840/1.190 = 0.155 or 15.5%.

**2.6.6** The data are -13, -29, -7, 2, -10, -43, 4, 15, -13, -30. $\bar{y}$ = -12.4 mm Hg; s = 17.6 mm Hg.

**2.6.7 (a)** $\bar{y}$ = 6.343; s = 0.7020.

**(b)** Median = 6.2; $Q_1$ = 5.9, $Q_3$ = 6.8, IQR = 6.8 - 5.9 = .9.

**(c)** Coefficient of variation = 0.7020/6.343 = 0.111 or 11.1%.

**(d)** New $\bar{y}$ = 6.77; new s = 1.68; new median = 6.2, new IQR = 0.9. The median and interquartile range display resistance in that they do not change. The standard deviation changes greatly, showing its lack of resistance. The mean changes a modest amount.

**2.6.8 (a)** The first quartile is the 4th largest observation, which is 26.4. The third quartile is the 12th largest observation, which is 37.5. The interquartile range is 37.5 - 26.4 = 11.1.

**(b)** The range is 45.5 - 18.4 = 27.1.

• **2.6.9 (a)** $\bar{y} \pm$ s is 32.23 ± 8.07, or 24.16 to 40.30; this interval contains 10/15 or 67% of the observations.

**(b)** $\bar{y} \pm$ 2s is 16.09 to 48.37; this interval contains 15/15 or 100% of the observations.

**2.6.10** According to the Empirical Rule, we expect 68% of the data to be within one SD of the mean; this is quite close to the observed 67%. We expect 95% of the data to be within two SDs of the mean. In fact, 100% of the observations are in this interval.

**2.6.11 (a)** $\bar{y} \pm$ s is 57.9 to 138.7; this interval contains 26/36 or 72% of the observations.

**(b)** $\bar{y} \pm$ 2s is 17.5 to 179.1; this interval contains 34/36 or 94% of the observations.

**(c)** $\bar{y} \pm$ 3s is -22.9 to 219.5; this interval contains 36/36 or 100% of the observations.

**2.6.12** According to the Empirical Rule, we expect 68% of the data to be within one SD of the mean; this is close to the observed 72%. We expect 95% of the data to be within two SDs of the mean; this is quite close to the observed 94%. We expect over 99% of the data to be within three SDs of the mean; in fact, 100% of the observations are in this interval.

**2.6.13** We would expect the coefficient of variation for weight to change more from age 2 to age 9. This is due to the fact that genetic factors tend to influence height more than weight and these genetic factors do not change in the course of life. On the other hand, environmental factors such as food, etc., can vary significantly.

• **2.6.14** Coefficient of variation = $\frac{s}{\bar{y}} = \frac{6.8}{166.3}$ = 0.04 or 4%.

• **2.6.15** The mean is about 45. The length of the interval that covers the middle 95% of the data is approximately equal to 70 - 20 = 50. An estimate of s is (length of interval)/4 = 50/4 ≈ 12.

**2.6.16** The mean is about 100. The length of the interval that covers the middle 95% of the data is approximately equal to 150 - 60 = 90. An estimate of s is (length of interval)/4 = 90/4 ≈ 22.

• **2.7.1** y' = (y - 7)*100. Thus, the mean of y' is ( $\bar{y}$ - 7)*100 = (7.373 - 7)*100 = 37.3. The SD of y' is $s \times 100$ = 0.129*100 = 12.9.

**2.7.2 (a)** Mean = (36.497)(1.8) + 32 = 97.695; SD = (0.172)(1.8) = 0.310

**(b)** Coefficient of variation = .310/97.695 = 0.003 or 0.3%. [Remark: This is not the same as the original coefficient of variation, which is 0.172/36.497 = 0.005 or 0.5%.]

**2.7.3 (a)** Mean = (1.461)(2.20) = 3.214 lb/day; SD = (0.178)(2.20) = 0.392 lb/day.

**(b) (i)** Coefficient of variation = 0.178/1.461 = 0.122 or 12.2%
**(ii)** Coefficient of variation = 0.392/3.214 = 0.122 or 12.2%

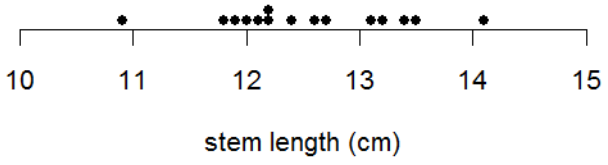
**2.7.4** New mean = (1.461-1)(100) = 46.1; new SD = (.178)(100) = 17.8.

**2.7.5** Both a log transformation and a square root transformation will pull in the right-hand tail and push out the left-hand tail, but a log transformation is more severe than is a square root transformation. Thus, the first histogram, (i) is for the square root transformation and (ii) is the histogram that results from a log transformation.

**2.7.6** Both log(Y) and 1/sqrt(Y) do a good job, with 1/sqrt(Y) being slightly better (but either of these two could be considered acceptable).

**2.S.1** If the mean of five observations is 181, then the sum of the five observations is $5 \times 181$ = 905. The sum of the first four observations is 180 + 182 + 179 + 176 = 717. Thus, the height of the fifth student must be 905 – 717 = 188 cm.

**2.S.2 (a)**

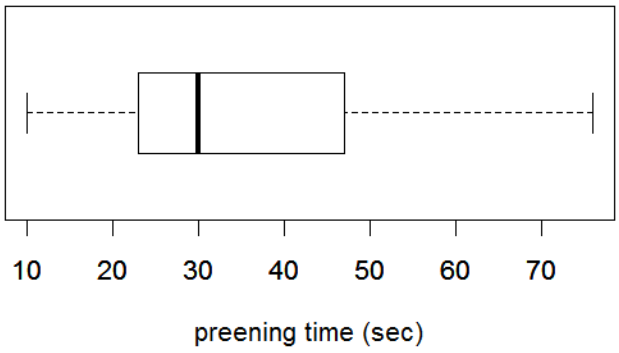



**(b)** IQR = 13.2 - 12 = 1.2

**2.S.3 (a)** The median is (29 + 31)/2 = 30. $Q_1$ = (22 + 24)/2 = 23; $Q_3$ = (46 + 48)/2 = 47.

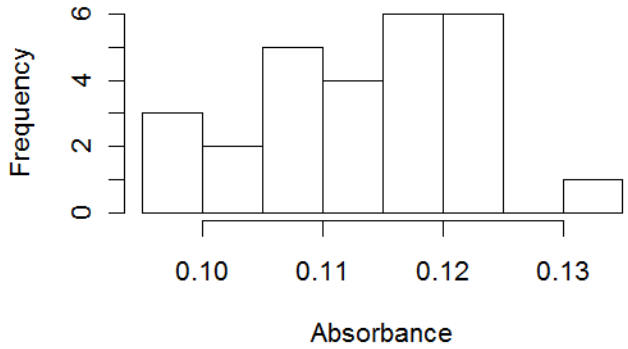
**(b)** IQR = 47 - 23 = 24.

**(c)** Upper fence = 47 + (1.5)(24) = 47 + 36 = 83. Lower fence = 23 - (1.5)(24) = 23 - 36 = -13.




**2.S.4 (a)** There is no single correct answer. One possibility is

| Absorbance | Frequency |
|---|---|
| 0.095-0.099 | 3 |
| 0.100-0.104 | 2 |
| 0.105-0.109 | 5 |
| 0.110-0.114 | 4 |
| 0.115-0.119 | 6 |
| 0.120-0.124 | 6 |
| 0.125-0.129 | 0 |
| 0.130-0.134 | 1 |
| Total | 27 |




**2.S.5 (a)** Median = 0.114; $Q_1 = 0.107$; $Q_3 = 0.120$; IQR = 0.120 - 0.107 = 0.013.

**(b)** To be an outlier on the high end of the distribution, an observation must be greater than the upper fence of 0.120 + (1.5)(0.013) = 0.120 + 0.0195 = 0.1395.

**2.S.6** The midrange is not robust, because changes in the extreme values – the minimum or the maximum – result in changes in the midrange.

**2.S.7 (a)** Median = (0 + 1)/2 = 0.5.

**(b)** Mean = 2.75.

**(c)**


**(d)** The distribution is strongly bimodal, with no data near the mean.

**2.S.8 (a)** $\bar{y} = 8$, $\sum (y_i - \bar{y})^2 = 30$, s = $\sqrt{30/4} = 2.74$.

**(b)** $\bar{y} = 24$, $\sum (y_i - \bar{y})^2 = 36$, s = $\sqrt{36/4} = 3.00$.

**(c)** $\bar{y} = 2$, $\sum (y_i - \bar{y})^2 = 54$, s = $\sqrt{54/4} = 3.67$.

**2.S.9 (a)** (i) $\bar{y} \pm$ s is 0.76 to 3.70; this interval contains 34 + 50 + 18 = 102 of the observations. Thus, 102/144 or 71% of the observations are within 1 SD of the mean.
(ii) $\bar{y} \pm 2$s is -.71 to 5.17; this interval contains 13 + 34 + 50 + 18 + 16 + 10 = 141 of the observations. Thus, 141/144 or 98% of the observations are within 2 SDs of the mean.

**(b)** The total number of larvae is (0)(13) + (1)(34) + (2)(50) + ... + (7)(1) = 321. The mean is $\bar{y}$ = 321/144.

**(c)** The median is the average of the 72nd and 73rd largest observations. Both of these observations are in the class "2", so the median is (2 + 2)/2 = 2.

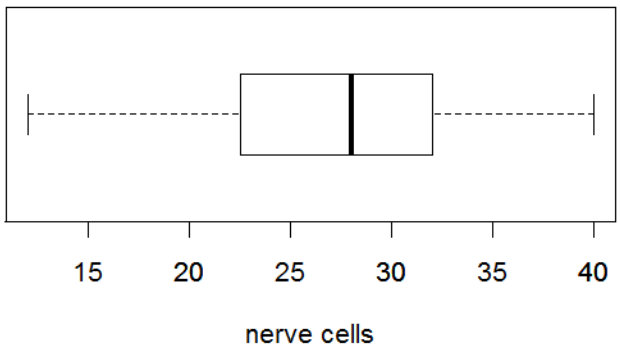
**2.S.10 (a)** $\bar{y} = 0.19$; s = 4.22.

**(b)** Median = 1.0.

**(c)** New mean = 1.44; new SD = 2.08; new median = (1.0 + 1.5)/2 = 1.25. The median displays resistance. The mean and the SD change greatly, showing lack of resistance.

**2.S.11 (a)** Median = 28; $Q_1$ = 22; $Q_3$ = 33; IQR = 33 - 22 = 11.

**(b)** Upper fence = 33 + (1.5)(11) = 49.5; lower fence = 22 - (1.5)(11) = 5.5.

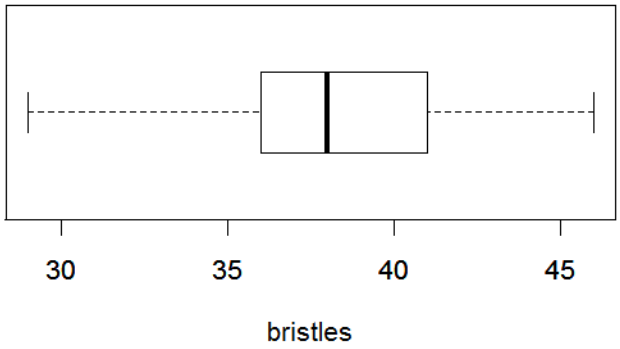



**2.S.12** Yes, the distribution appears to be reasonably symmetric and mound-shaped.

• **2.S.13 (a)** n = 119, so the median is the 60th largest observation. There are 32 observations less than or equal to 37 and 44 observations less than or equal to 38. Thus, the median is 38.

**(b)** The first quartile is the 30th largest observation, which is 36. The third quartile is the 90th largest observation, which is 41.

**(c)**




**(d)** The mean is 38.45 and the SD is 3.20. Thus, the interval $\bar{y} \pm s$ is 38.45 ± 3.20, which is 35.25 to 41.65. This interval includes 36, 27, 28, 29, 40, and 41. The number of flies with 36 to 41 bristles is 11 + 12 + 18 + 13 + 10 + 15 = 79. Thus, the percentage of observations that fall within one standard deviation of the mean is 79/119*100% = 0.664*100% = 66.4%.

**2.S.14 (a)** Mean increase = 3.870; SD of increase = 1.274.

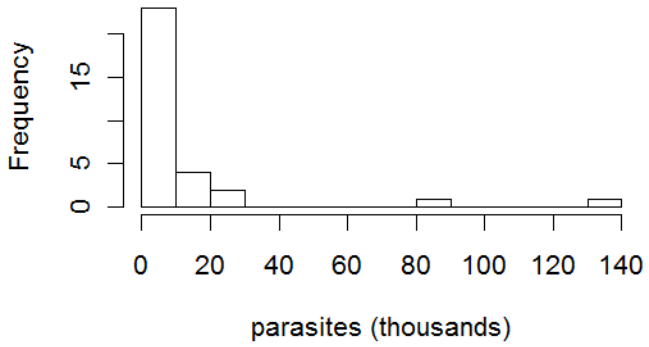
**(b)** Mean before = 1.680, mean after = 5.550. Yes; 5.550 - 1.680 = 3.870.

**(c)** The median increase is (3.5 + 3.5)/2 = 3.5.

**(d)** Before: The median increase is (1.5 + 1.5)/2 = 1.5.
After: The median increase is (5.2 + 5.8)/2 = 5.5.
No; 5.5 - 1.5 ≠ 3.5.

**2.S.15 (a)**

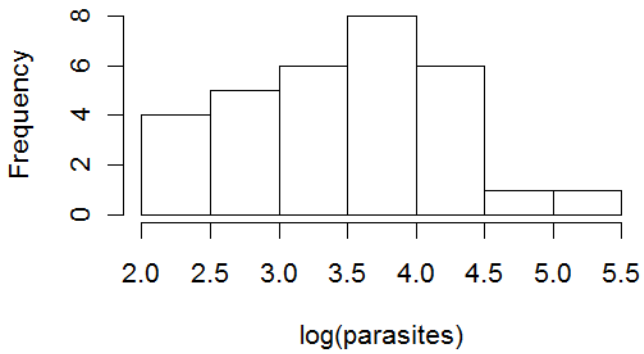
| Number of Parasites | Frequency |
|---|---|
| 0-9,999 | 23 |
| 10,000-19,999 | 4 |
| 20,000-29,999 | 2 |
| 30,000-39,999 | 0 |
| 40,000-49,999 | 0 |
| 50,000-59,999 | 0 |
| 60,000-69,999 | 0 |
| 70,000-79,999 | 0 |
| 80,000-89,999 | 1 |
| 90,000-99,999 | 0 |
| 100,000-109,999 | 0 |
| 110,000-119,999 | 0 |
| 120,000-129,999 | 0 |
| 130,000-139,999 | 1 |
| Total | 31 |




**(b)**

| Log (Number of Parasites) | Frequency |
|---|---|
| 2.000-2.499 | 4 |
| 2.500-2.999 | 5 |
| 3.000-3.499 | 6 |
| 3.500-3.999 | 8 |
| 4.000-4.499 | 6 |
| 4.500-4.999 | 1 |

| | |
|---|---|
| 5.000-5.499 | 1 |
| Total | 31 |




The original distribution is highly skewed; the distribution of the logs is much less skewed.

**(c)** The original mean is 12,889.6; the mean of the logs is 3.4854. The log of the original mean is log(12,889.6) = 4.1102 ≠ 3.4854. No, they are not equal.

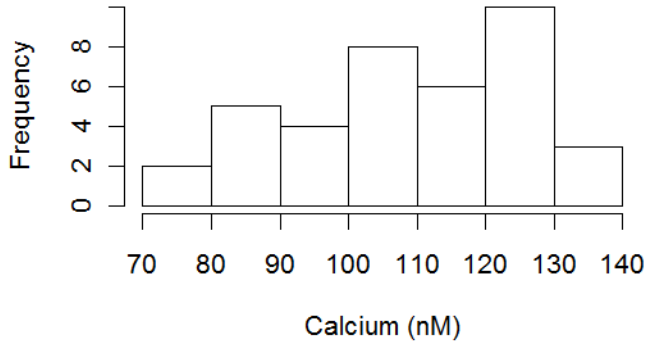
**(d)** The original median is 3672; the median of the logs is 3.5649. The log of the original median is log(3673) = 3.5649. Yes, they are equal.

**2.S.16** The first histogram is a rough histogram for the data, because the data imply that the distribution is skewed to the right. The average is 3.6 and the SD is 1.6. If the distribution were symmetric and mound shaped, like the middle histogram, then there would be data throughout the interval $\bar{y} \pm 2s$, which is 3.6 ± 3.2, or 0.4 to 6.8. However, the minimum is 1.2, which is greater than 0.4. The situation for the third histogram is even worse (i.e., for this histogram there are values much lower than the mean).

**2.S.17** The fourth computer output has the largest SD and has the mean and median nearly equal. This corresponds to histogram (b), which has the most spread. Histogram (c) has a mean which exceeds the mean. It follows that this histogram corresponds to the first computer output. Histogram (a) has the smallest SD and the mean and median are nearly equal, so the second computer output corresponds to histogram (a). The third computer output has a lower mean than median, so it is not used.

**2.S.18** The low volume distribution is symmetric, centered at 20, with a minimum of 0 and a maximum of 40. The high volume distribution is shifted down from the low volume distribution, with a median of about 18 and a maximum of 30, which is the third quartile for the low volume distribution. Thus, one-fourth of the low volume hospitals have mortality rates greater than the highest mortality rate among high volume hospitals.

**2.S.19** The mean is 107.87, the median is 108.5, and the SD is 16.08.




The histogram is fairly symmetric.

**2.S.20** The median is 28, which is consistent with any of the histograms. Likewise the minimum and maximum values agree for all three histograms. However, the boxplot shows that the distribution has a small IQR and is skewed to the right, which means that histogram (a) is correct.