Describing data

Samples and populations are often made of lots of individual (observational) units and their associated information (observations, variables).

We need to be able to describe samples by summary statistics (mean, median, variance, etc) so that these summaries can serve as an estimate of the same summaries for their statistical populations.

1

How do measures of location (mean versus median) and spread (standard deviation versus interquartile range) compare?

Disarming fish (protection against predation)

Threespine stickleback (*Gasterosteus aculeatus*)

Plate Genotypes Ectodysplasin (Eda) locus (3rd generation)

MM (marine)

Mm (hybrid)

mm (freshwater)

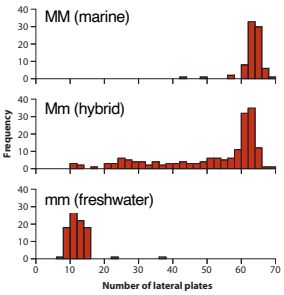
Variation is at the heart of biology! The diversity among individuals and species forms the foundation of biological science

2

How do measures of location (mean versus median) and spread (standard deviation versus interquartile range) compare?

Disarming fish (protection against predation)

Variation is at the heart of biology! The diversity among individuals and species forms the foundation of biological science

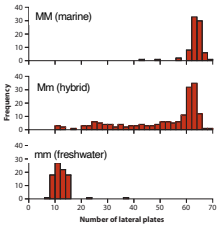


Which distribution is more asymmetric?

Whitlock & Schluter, *The Analysis of Biological Data*, 3e © 2020 W. H. Freeman and Company

3

How do measures of location (mean versus median) and spread (standard deviation versus interquartile range) compare?

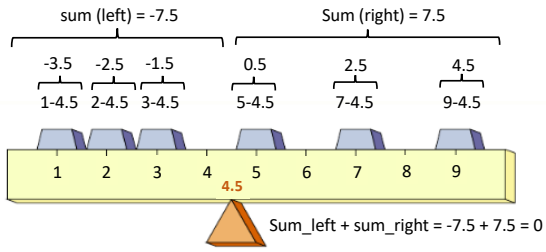


Which distribution is more asymmetric?

Genotype	*n*	Mean	Median	Standard deviation	Interquartile range
MM	82	62.8	63	3.4	2
Mm	174	50.4	59	15.1	21
mm	88	11.7	11	3.6	3

4

The mean can be understood as the center of gravity of a distribution – the sum of values on the left and right of the mean.



$\overline{X}$=4.5

Assume the scale has no weight. Values in the sample are represented by "weights"

5

Recall from lecture 5: the sum of deviations from the mean is always zero, making the mean the 'center of gravity' of a distribution.

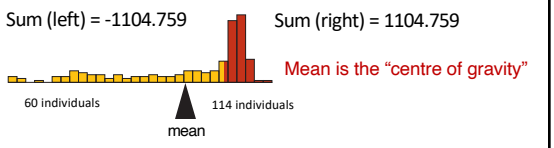
Quantities needed to calculate the standard deviation and variance of snake undulation rate ($\overline{Y} = 1.375\ Hz$).

Observations (Y_i)	Deviations ($Y_i - \overline{Y}$)	Squared deviations ($Y_i - \overline{Y}$)^2
0.9	−0.475	0.225625
1.2	−0.175	0.030625
1.2	−0.175	0.030625
1.3	−0.075	0.005625
1.4	0.025	0.000625
1.4	0.025	0.000625
1.6	0.225	0.050625
2.0	0.625	0.390625
Sum	0.000	0.735

6

Mean (Y) versus Median (referred as to Q_2)

Mm (hybrid) - most asymmetric distribution



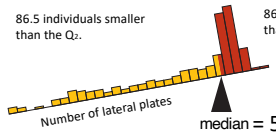
Mean is the "centre of gravity"

$\overline{Y}$=50.4

7

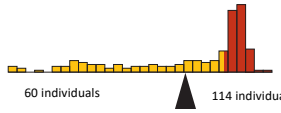
Mean (Y) versus Median (referred as to Q_2)

Mm (hybrid) - most asymmetric distribution



Median is the middle of the distribution

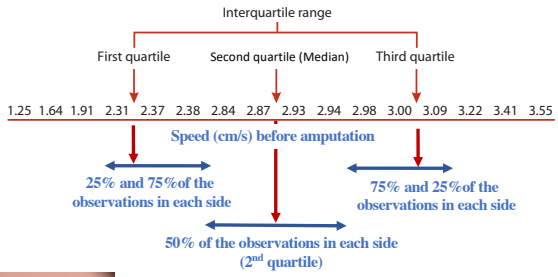
50% of observations (here individual fish) to the left of the median and 50% to the right.

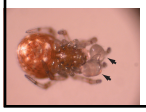


Mean is the "centre of gravity"

8

Interquartile range: the corresponding measure of spread for the median

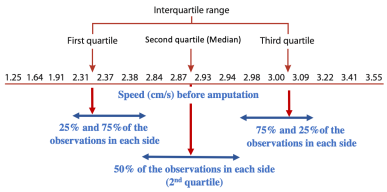




Remember: The corresponding metric of ***spread*** for the mean is the ***standard deviation***

9

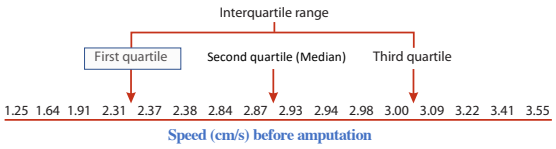
Interquartile range: the corresponding measure of spread for the median



It's crucial to understand what the first, second (median), and third quartiles represent, and how the median differs from the mean. However, I don't expect you to calculate them by hand. Still, it's important to show some of these calculations, as it helps improve numeracy.

10

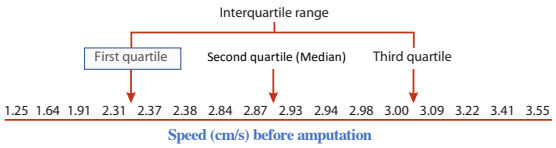
Interquartile range: the corresponding measure of spread for the median



While the calculation of the median (2nd quartile or Q2) differs depending on whether the number of observations is odd or even, the calculations for the 1st (Q1) and 3rd (Q3) quartiles remain the same.

11

Interquartile range: the corresponding measure of spread for the median



Positioning Q_1: $j = 0.25n = (0.25)(16) = 4$

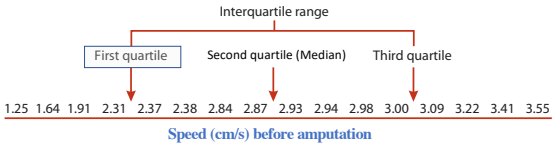
where n is the number of observations in the data (i.e., 16 male spiders.

Because here j is an integer (i.e., whole number, not a fraction), then the 1st quartile is the average of
$Y_{(j)}$ and $Y_{(j+1)}$ = $Y_{(4)}$ and $Y_{(4+1)}$ =(2.31 + 2.37) / 2 = 2.340 cm/s

First quartile (Q_1) = 2.340 cm/s

12

Interquartile range: the corresponding measure of spread for the median

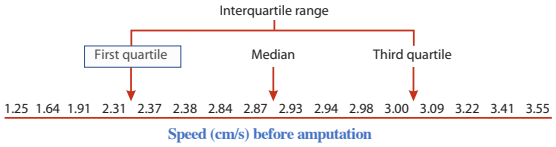


This is not exactly the default rule in R, but the values are very similar. There are several different rules for calculating quartiles.

First quartile (Q_1) = 2.340 cm/s

13

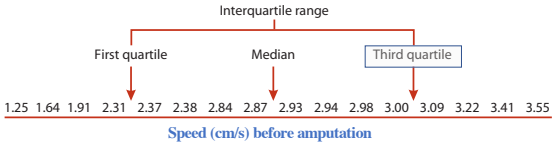
Interquartile range: the corresponding measure of spread for the median



If *j* was not an integer, round *j* (e.g., say *j* was 4.32 then round *j* = 4). We would then have picked the 4th value in the ranked distribution (i.e., 2.31 cm/s)

14

Interquartile range: the corresponding measure of spread for the median



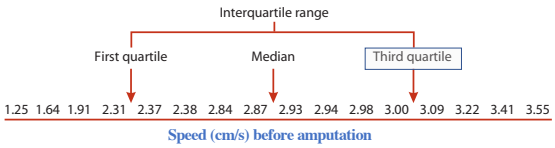
Positioning Q_3: $j = 0.75n = (0.75)(16) = 12$

where *n* is the number of observations. If *j* is an integer (*whole number, not a fraction*), then the 3rd quartile is the average of $Y_{(j)}$ and $Y_{(j+1)}$ = $Y_{(12)}$ and $Y_{(12+1)}$ =(3.00 + 3.09) / 2 = 3.045 cm/s

Third quartile (Q_3) = 3.045 cm/s

15

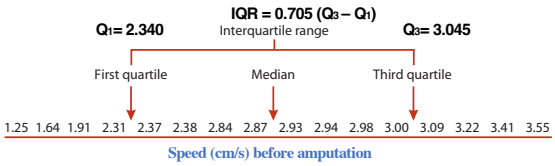
Interquartile range: the corresponding measure of spread for the median



If *j* was not an integer, round *j* (e.g., say j was 12.72 then *j* = 13). We would then have picked the 13th value in the ranked distribution (i.e., 3.09 cm/s)

16

Interquartile range: the corresponding measure of spread for the median



The ***interquartile range*** (IQR) for the speed data before amputation is then $Q_3 - Q_1 = 3.045 - 2.340 = 0.705$ cm/s

17

Remember: the mean reflects all values in a distribution but is influenced by extreme values. The median, while not as representative of the entire distribution, is resistant to the influence of extreme values.

$Y = 53, 58, 62, 64, 68, 72, 73, 77, 86, 87, 88, 92$

$\bar{Y} = 73.3$

$Q_2 = 72.5$

$Y = 53, 58, 62, 64, 68, 72, 73, 77, 86, 87, 88, 192$

$\bar{Y} = 81.7$

$Q_2 = 72.5$

18

Let's take a "power break" – 1 minute

19

The median is the middle measure of a set of observations (distribution)

If the number of observations (*n*) is ***even***, then the median is calculated differently:

Tidarren (spider)

It gives an "arm" (or a pedipalp) for a female spider.

Running speed (cm/s) of male *Tidarren* spiders before and after voluntary amputation of one pedipalp.

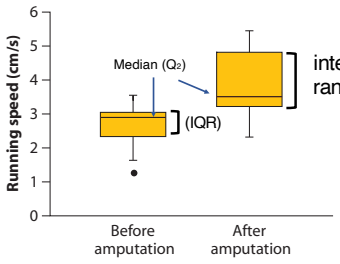
Oxyopes salticus

Spider	Speed before	Speed after
1	1.25	2.40
2	2.94	3.50
3	2.38	4.49
4	3.09	3.17
5	3.41	5.26
6	3.00	3.22
7	2.31	2.32
8	2.93	3.31

Spider	Speed before	Speed after
9	2.98	3.70
10	3.55	4.70
11	2.84	4.94
12	1.64	5.06
13	3.22	3.22
14	2.87	3.52
15	2.37	5.45
16	1.91	3.40

20

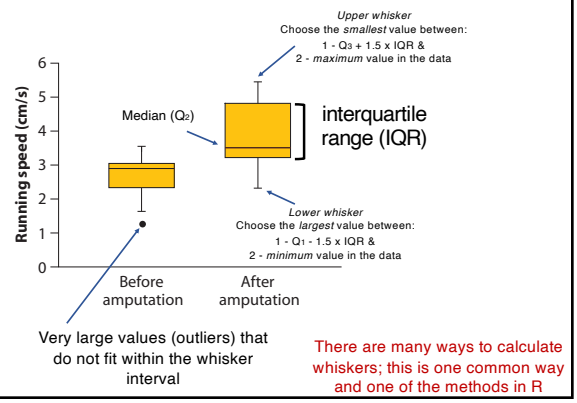
Representing data distributions by their quartiles:
Boxplot (box-and-whisker plot)



John Tukey
(box-and-whisker 1977)

21

Representing data distributions by their quartiles: Boxplot (box-and-whisker plot)



There are many ways to calculate whiskers; this is one common way and one of the methods in R

22

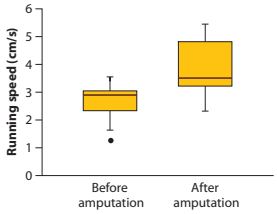
Representing data distributions by their quartiles: Boxplot (box-and-whisker plot)

What are the advantages of a box plot?

Graphically displays a variable's location and spread at a glance.

It provides an indication of the data's symmetry and skewness.

Unlike many other data display methods, boxplots also show outliers.



source - www.netmba.com/statistics/plot/box/

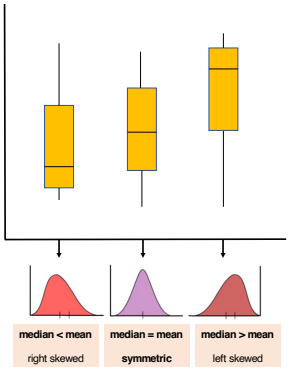
23

Representing data distributions by their quartiles: Boxplot (box-and-whisker plot)

What are the advantages of a box plot?

Graphically displays a variable's location and spread at a glance.

It can often provide an indication of the data's symmetry and skewness, though this is not always the case.

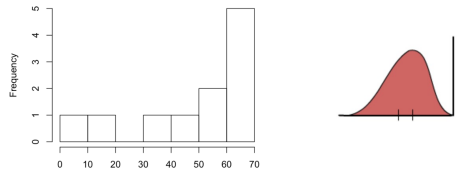


24

Representing data distributions by their quartiles: Boxplot (box-and-whisker plot)

Three fictional data sets to illustrate the calculation and properties of distributions using their boxplots (shown in the next slide) – can you spot their differences?

Left-skewed distribution: 9,11,31,44,52,58,61,61,63,64,66

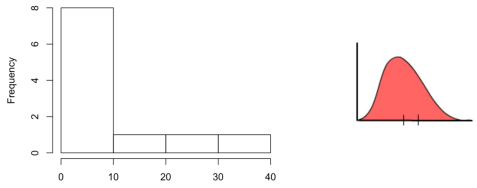


25

Representing data distributions by their quartiles: Boxplot (box-and-whisker plot)

Three fictional data sets to illustrate the calculation and properties of distributions using their boxplots (shown in the next slide) – can you spot their differences?

Right-skewed distribution: 1,2,3,4,5,6,7,10,20,30,40

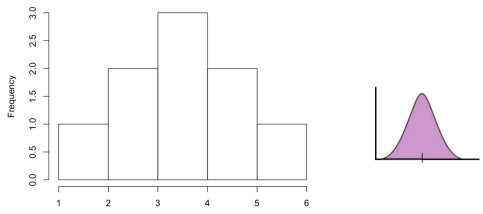


26

Representing data distributions by their quartiles: Boxplot (box-and-whisker plot)

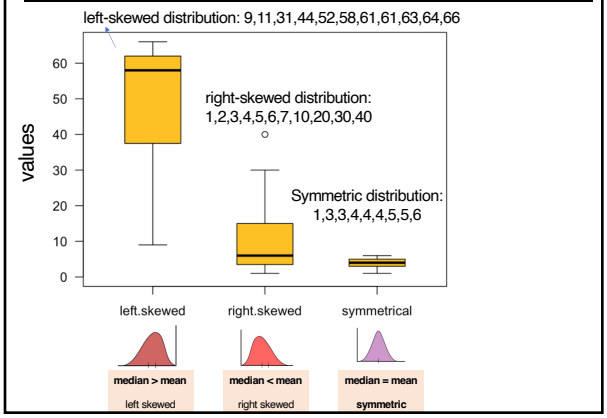
Three fictional data sets to illustrate the calculation and properties of distributions using their boxplots (shown in the next slide) – can you spot their differences?

Symmetric distribution: 1,3,3,4,4,4,5,5,6



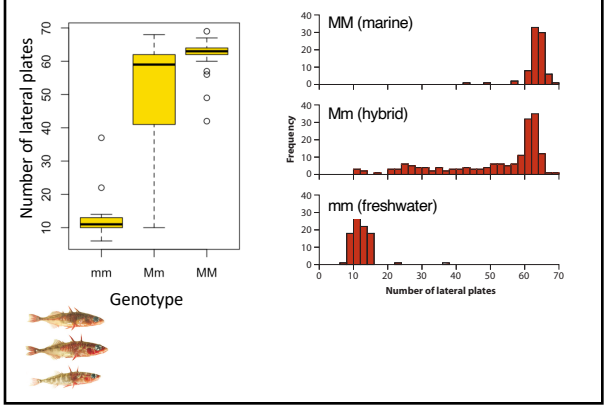
27

Boxplot (box-and-whisker plot): contrasting distributions



28

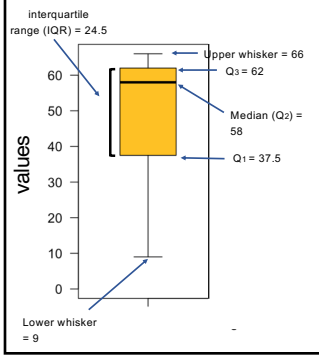
Boxplot (box-and-whisker plot): contrasting distributions



29

Not for the Faint of Heart: no need to know these calculations but some students always ask

9,11,31,44,52,**58**,61,61,63,64,66



Q_1 = (31+44) / 2 = 37.5
Median (Q_2) = 58
Q_3 = (63+64) / 2 = 62.0

IQR (Interquartile range) = 62.0 - 37.5 = 24.5

Lower whisker = 9; calculation:
Choose the *largest* value between:
1 - Q_1 - 1.5 x IQR = 37.5 – 1.5 x 24.5 = 0.75
2 - *minimum* value in the data = **9**

Upper whisker = 66; calculation:
Choose the *smallest* value between:
1 - Q_3 + 1.5 x IQR = 62 + 1.5 x 24.5 = 98.8
2 - *maximum* value in the data = 66

30

Statistics is based on samples!

The primary goal of statistics is to estimate (infer) an unknown quantity of an entire population based on sample data.

Statistics is the science of making decisions with incomplete knowledge, using samples to represent populations that often have unknown sizes.

However, sample quantities (mean, median, standard deviation, etc.) vary from sample to sample, introducing a level of uncertainty.

Next lecture - Estimating with uncertainty

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