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1. Calculate the mean mass and its standard deviation at each site.

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>load(file.choose()) #simulies.orford.lovering
> ls.str()
    simulies.orford.lovering : 'data.frame':       615 obs. of  4 variables:
    $ Site  : Factor w/ 2 levels "Lovering","Orford": 2 2 2 2 2 2 2 2 2 2 ...
    $ Sp    : Factor w/ 1 level "mixtum/fuscum": 1 1 1 1 1 1 1 1 1 1 ...
    $ Days  : int  78 78 78 78 78 78 78 78 78 78 ...
    $ Length: num  4.1 2.8 2.2 3.2 3.2 3.1 3.1 4.1 4.1 3.2 ...
> Exp=simulies.orford.lovering$Length^3.05
> M=1.36*Exp
> head(M)
   [1] 100.58418  31.43192  15.06358  47.23309  47.23309  42.87381
> simulies.orford.lovering$Mass<-M
> head(simulies.orford.lovering)
             Site           Sp Days Length      Mass
        1 Orford mixtum/fuscum   78    4.1   100.58418
        2 Orford mixtum/fuscum   78    2.8    31.43192
        3 Orford mixtum/fuscum   78    2.2    15.06358
        4 Orford mixtum/fuscum   78    3.2    47.23309
        5 Orford mixtum/fuscum   78    3.2    47.23309
        6 Orford mixtum/fuscum   78    3.1    42.87381
> mean(1,2,5)
   [1] 1
> mean(c(1,2,4))
   [1] 2.333333
> sd(c(1,2,4))
   [1] 1.527525
> by(simulies.orford.lovering$Mass, simulies.orford.lovering$Site, mean)
        simulies.orford.lovering$Site: Lovering
        [1] 13.14521
------------------------------------------------------------
        simulies.orford.lovering$Site: Orford
        [1] 43.02693
> by(simulies.orford.lovering$Mass, simulies.orford.lovering$Site,sd)
        simulies.orford.lovering$Site: Lovering
        [1] 23.77115
------------------------------------------------------------
        simulies.orford.lovering$Site: Orford
        [1] 48.01717
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2. Using the mean mass of *P. mixtum/fuscum* at Lovering as a reference and the standard deviations observed at each site, calculate the power of a two-tailed t test for independent means
   a) if the mass difference was 5 µg, α=0.05, and that 100 larvae were sampled at each site
      Power (1-β) = 0.15313
   b) if the mass difference was 20 µg, α=0.05, and that 100 larvae were sampled at each site
      Power (1-β) = 0.96034
   c) if the mass difference was 50 µg, α=0.05, and that 100 larvae were sampled at each site
      Power (1-β) = 1
   d) comment on how changing the mass difference affects power.
      Mass difference here corresponds to the difference between the means of the two groups of study. If mean difference rises, so does effect size, since it is defined as the difference between the two means weighted by the standard deviations. The higher the effect size, the higher the power of the test.

3. Calculate the required sample size to detect, with a two-tailed t test for independent means, a difference of 50 µg between the means
   a) with a power of 80% and α=0.05
      11 samples for each location
   b) with a power of 80% and α=0.001
      23 samples for each location
   c) with a power of 95% and α=0.05
      16 samples for each location
   d) comment on how changing power and α affects the required sample size.
      Maximizing α or power requires more samples. The optimal comes with a balance between both that does not require excessive effort.

4. Calculate the detectable effect size (d) with a two-tailed t-test on independent means, given the observed standard deviations. Calculate the difference in average mass, in µg, that can be detected given your estimate of the minimum detectable effect size (d) at 4a, b, and c.
   a) with a power of 80%, α=0.05, and measurements on 10 larvae at each site
      Effect size d = 1.32494

      Difference in average mass = $1.32494\ x\sqrt{\frac{23.77115^2+48.01717^2}{2}}$ = 50.19683 µg
   b) with a power of 80%, α=0.05, and measurements on 200 larvae at each site
      Effect size d = 0.28083

      Difference in average mass = $0.28083\ x\sqrt{\frac{23.77115^2+48.01717^2}{2}}$ = 10.63955 µg
   c) with a power of 80%, α=0.05, and measurements on 20 larvae at one site and 380 larvae at the second site
      Effect size d = 0.64428

      Difference in average mass = $0.64428\ x\sqrt{\frac{23.77115^2+48.01717^2}{2}}$ = 24.40926 µg
   d) comment on how changing sample sizes affect d.
      Smaller sample sizes make difficult to detect small differences. With bigger sample sizes results are more sensitive, allowing us to detect smaller changes in the means.