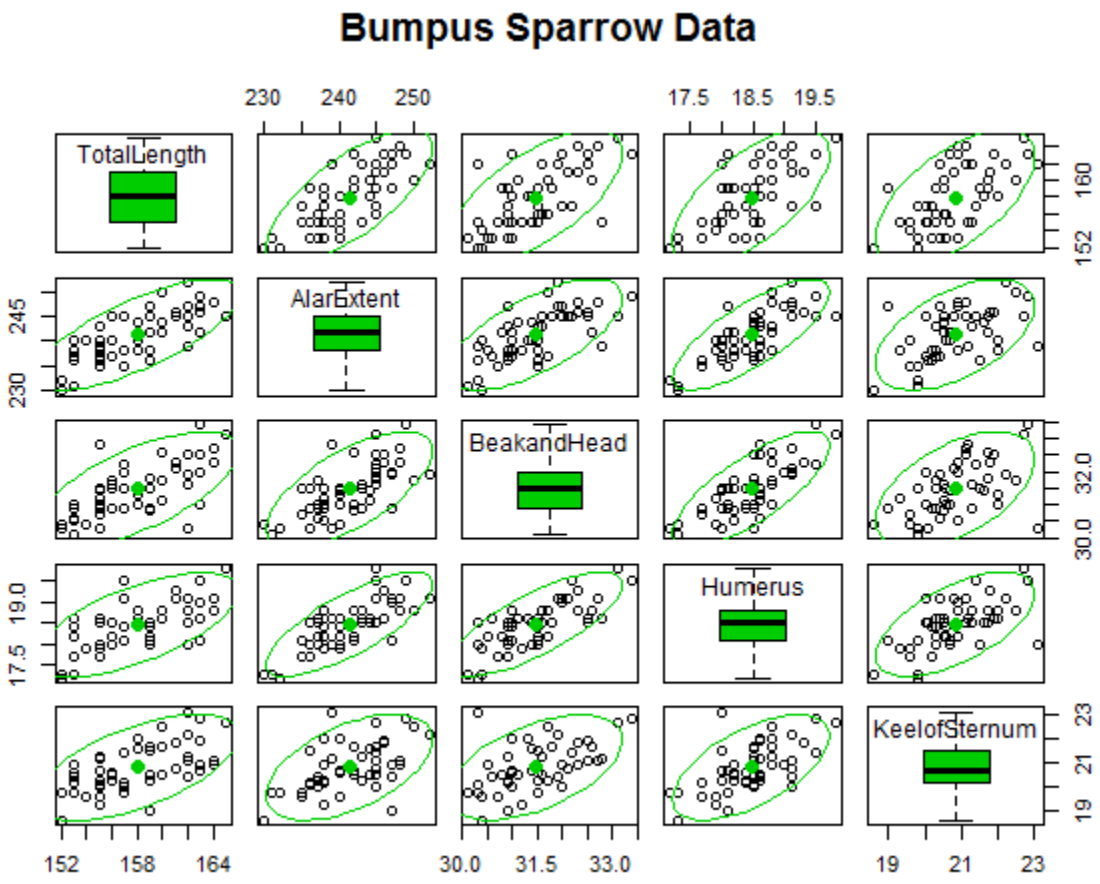
R Commands for Assessing Univariate and Multivariate Normality: Q-Q Plots

```
#
# R commands for assessing univariate and multivariate Normal and X^2 Q-Q plots
#
# This uses the Bumpus Sparrow Data found on Class Handout #3
#
TX<-c(1,156,245,31.6,18.5,20.5,1,
2,154,240,30.4,17.9,19.6,1,
3,153,240,31,18.4,20.6,1,
4,153,236,30.9,17.7,20.2,1,
5,155,243,31.5,18.6,20.3,1,
6,163,247,32,19,20.9,1,
7,157,238,30.9,18.4,20.2,1,
8,155,239,32.8,18.6,21.2,1,
9,164,248,32.7,19.1,21.1,1,
10,158,238,31,18.8,22,1,
11,158,240,31.3,18.6,22,1,
12,160,244,31.1,18.6,20.5,1,
13,161,246,32.3,19.3,21.8,1,
14,157,245,32,19.1,20,1,
15,157,235,31.5,18.1,19.8,1,
16,156,237,30.9,18,20.3,1,
17,158,244,31.4,18.5,21.6,1,
18,153,238,30.5,18.2,20.9,1,
19,155,236,30.3,18.5,20.1,1,
20,163,246,32.5,18.6,21.9,1,
21,159,236,31.5,18,21.5,1,
22,155,240,31.4,18,20.7,0,
23,156,240,31.5,18.2,20.6,0,
24,160,242,32.6,18.8,21.7,0,
25,152,232,30.3,17.2,19.8,0,
26,160,250,31.7,18.8,22.5,0,
27,155,237,31,18.5,20,0,
28,157,245,32.2,19.5,21.4,0,
29,165,245,33.1,19.8,22.7,0,
30,153,231,30.1,17.3,19.8,0,
31,162,239,30.3,18,23.1,0,
32,162,243,31.6,18.8,21.3,0,
33,159,245,31.8,18.5,21.7,0,
34,159,247,30.9,18.1,19,0,
35,155,243,30.9,18.5,21.3,0,
36,162,252,31.9,19.1,22.2,0,
37,152,230,30.4,17.3,18.6,0,
38,159,242,30.8,18.2,20.5,0,
39,155,238,31.2,17.9,19.3,0,
40,163,249,33.4,19.5,22.8,0,
41,163,242,31,18.1,20.7,0,
42,156,237,31.7,18.2,20.3,0,
43,159,238,31.5,18.4,20.3,0,
44,161,245,32.1,19.1,20.8,0,
45,155,235,30.7,17.7,19.6,0,
46,162,247,31.9,19.1,20.4,0,
47,153,237,30.6,18.6,20.4,0,
48,162,245,32.5,18.5,21.1,0,
49,164,248,32.3,18.8,20.9,0)
```

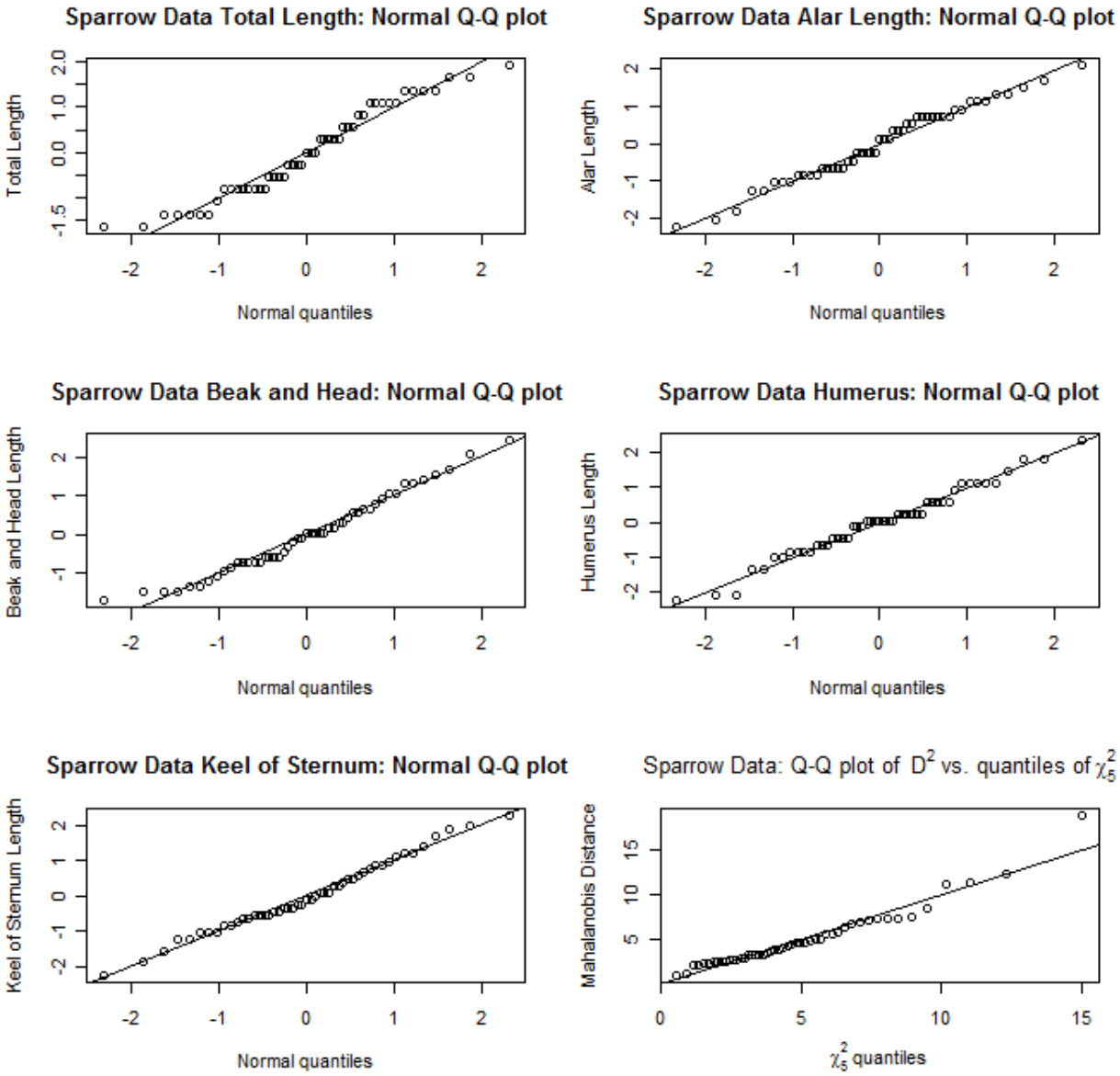
```
#
# Scatterplots of Bumpus Sparrow Data
#
X<-matrix(data=TX,ncol=7,byrow=TRUE)
Spar <-
data.frame(Bird=X[,1],TotalLength=X[,2],AlarExtent=X[,3],BeakandHead=X[,4],Humerus=X[,
5],KeelofSternum=X[,6],Survived=X[,7])
library(car)
spm(Spar[,2:6],diagonal=list(method="boxplot"),smooth=FALSE,regLine=FALSE,ellipse=
list(levels=c(0.90), robust=FALSE, fill=FALSE),main=c("Bumpus Sparrow Data"))
#
# Assessing Univariate Normality of Bumpus Sparrow Data
#
par(mfrow=c(3,2))
Qtiles<-qnorm(ppoints(49))
qqplot(Qtiles,(Spar[,2]-mean(Spar[,2]))/sd(Spar[,2]),main = "Sparrow Data Total
Length: Normal Q-Q plot",xlab="Normal quantiles",ylab="Total Length")
abline(0,1)
qqplot(Qtiles,(Spar[,3]-mean(Spar[,3]))/sd(Spar[,3]),main = "Sparrow Data Alar Length:
Normal Q-Q plot",xlab="Normal quantiles",ylab="Alar Length")
abline(0,1)
qqplot(Qtiles,(Spar[,4]-mean(Spar[,4]))/sd(Spar[,4]),main = "Sparrow Data Beak and
Head: Normal Q-Q plot",xlab="Normal quantiles",ylab="Beak and Head Length")
abline(0,1)
qqplot(Qtiles,(Spar[,5]-mean(Spar[,5]))/sd(Spar[,5]),main = "Sparrow Data Humerus:
Normal Q-Q plot",xlab="Normal quantiles",ylab="Humerus Length")
abline(0,1)
qqplot(Qtiles,(Spar[,6]-mean(Spar[,6]))/sd(Spar[,6]),main = "Sparrow Data Keel of
Sternum: Normal Q-Q plot",xlab="Normal quantiles",ylab="Keel of Sternum Length")
abline(0,1)
shapiro.test(Spar[,2]); shapiro.test(Spar[,3]); shapiro.test(Spar[,4]);
shapiro.test(Spar[,5]); shapiro.test(Spar[,6]);
#
# Assessing Multivariate Normality of Bumpus Sparrow Data
#
par(mfrow=c(1,1))
MeanSpar<-colMeans(Spar[,2:6])
SSpar<-cov(Spar[,2:6])
MHX<-mahalanobis(Spar[,2:6], MeanSpar, SSpar)
Qtiles<-qchisq(ppoints(49),df=5)
qqplot(Qtiles, MHX,main = expression("Sparrow Data: Q-Q plot of " * ~D^2 * " vs.
quantiles of" * ~ chi[5]^2),xlab=expression(chi[5]^2 * " quantiles"),ylab="Mahalanobis
Distance")
abline(0, 1)
#
# Bumpus Sparrow Data by Survival Status
#
spm(Spar[,2:6],diagonal=list(method="boxplot"),smooth=FALSE,regLine=FALSE,ellipse=
list(levels=c(0.75), robust=FALSE, fill=FALSE),main=c("Bumpus Sparrow Data by Survival
Status"),groups=Spar$Survived,by.group=TRUE)
SparSurv<-Spar[1:21,2:6]
SparDead<-Spar[22:49,2:6]
MeanSpar1<-colMeans(SparSurv)
MeanSpar2<-colMeans(SparDead)
SSpar1<-cov(SparSurv)
SSpar2<-cov(SparDead)
MHX1<-mahalanobis(SparSurv, MeanSpar1, SSpar1)
MHX2<-mahalanobis(SparDead, MeanSpar2, SSpar2)
```

```
par(mfrow=c(3,2))
Qtiles1<-qchisq(ppoints(21),df=5)
qqplot(Qtiles1, MHX1, main = expression("Survived: Q-Q plot of " * ~D^2 * " vs.
quantiles of" * ~ chi[5]^2),xlab=expression(chi[5]^2 * " quantiles"),ylab="Mahalanobis
Distance")
abline(0, 1)

Qtiles2<-qchisq(ppoints(28),df=5)
qqplot(Qtiles2, MHX2, main = expression("Died: Q-Q plot of " * ~D^2 * " vs. quantiles
of" * ~ chi[5]^2),xlab=expression(chi[5]^2 * " quantiles"),ylab="Mahalanobis
Distance")
abline(0, 1)
```



Q-Q Plots for Assessing Univariate & Multivariate Normality




```
data:  Spar[, 2]
W = 0.9509, p-value = 0.04014

data:  Spar[, 3]
W = 0.9789, p-value = 0.5192

data:  Spar[, 4]
W = 0.9738, p-value = 0.3391

data:  Spar[, 5]
W = 0.981, p-value = 0.6068

data:  Spar[, 6]
W = 0.9868, p-value = 0.8534
```