```
# Fuzzy clustering of the Doubs fish data

fish <- read.csv(file.choose(), row.names=1)     # Doubs fish data
fish <- fish[-8,]
dim(fish)

# Chord transformation

spe.ch = decostand(fish, "normalize")

# On élimine le site 8: aucun poisson capturé
spe.ch <- spe.ch[-8,]  #

# Heat map

source("coldiss.R")        # Load function coldiss() from file "coldiss.R"
coldiss(dist(spe.ch), nc=10, byrank=TRUE, diag=TRUE)


========

# Fuzzy clustering by c-means, function fanny()

require(cluster)
# Find 4 fuzzy groups using fanny()
# memb.exp = degree of fuzziness (1 = close to crisp)
spe.fuz <- fanny(spe.ch, k=4, memb.exp=1.5)
# summary(summary(spe.fuz))

# Site membership
spe.fuz$membership

spefuz.g <- spe.fuz$clustering   # Closest hard clustering

# Nearest crisp clustering
spe.fuz$clustering

# Silhouette plot
plot(silhouette(spe.fuz), main="Silhouette plot - Fuzzy
 clustering", cex.names=0.8, col=spe.fuz$silinfo$widths+1)

##### A better result with k=5?
spe.fuz5 <- fanny(spe.ch, k=5, memb.exp=1.5)

par(mfrow=c(1,2))
plot(silhouette(spe.fuz), main="Silhouette plot - Fuzzy
 clustering", cex.names=0.8, col=spe.fuz$silinfo$widths+1)
plot(silhouette(spe.fuz5), main="Silhouette plot - Fuzzy
 clustering", cex.names=0.8, col=spe.fuz5$silinfo$widths+1)
#####

# Ordination of fuzzy clusters (PCoA)
dc.pcoa <- cmdscale(dist(spe.ch))
dc.scores <- scores(dc.pcoa, choices=c(1,2))
```

```
k=4
par(mfrow=c(1,2))
# quartz(title="Fuzzy clustering of fish data - Ordination plot")

plot(scores(dc.pcoa), asp=1, type="n",
    main="Ordination of fuzzy clusters (PCoA)")
abline(h=0, lty="dotted")
abline(v=0, lty="dotted")
for (i in 1:k) {
    gg <- dc.scores[spefuz.g == i,]
    hpts <- chull(gg)
    hpts <- c(hpts, hpts[1])
    lines(gg[hpts,], col=i+1)
    }
stars(spe.fuz$membership, location=scores(dc.pcoa), draw.segments=TRUE,
    add=TRUE, scale=FALSE, len=0.1, col.segments=2:(k+1))
legend(locator(1), paste("Cluster", 1:k, sep=" "),
    pch=15, pt.cex=2, col=2:(k+1), bty="n")
# Click on the graph to position legend

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# Fuzzy clustering by c-means, function cmeans()

require(e1071)
# Find 4 fuzzy groups using cmeans()
# m = degree of fuzziness (1 = crisp)
cmeans.out = cmeans(spe.ch,centers=4, m=2)  # m is degree of fuzziness
summary(cmeans.out)
cmeans.out$cluster     # Closest hard clustering

# k=4
# quartz(title="Fuzzy clustering of fish data - Ordination plot")
plot(scores(dc.pcoa), asp=1, type="n",
    main="Ordination of fuzzy clusters (PCoA)")
abline(h=0, lty="dotted")
abline(v=0, lty="dotted")
for (i in 1:k) {
    gg <- dc.scores[cmeans.out$cluster == i,]
    hpts <- chull(gg)
    hpts <- c(hpts, hpts[1])
    lines(gg[hpts,], col=i+1)
    }
stars(cmeans.out$membership, location=scores(dc.pcoa), draw.segments=TRUE,
    add=TRUE, scale=FALSE, len=0.1, col.segments=2:(k+1))
legend(locator(1), paste("Cluster", 1:k, sep=" "),
    pch=15, pt.cex=2, col=2:(k+1), bty="n")
# Click on the graph to position legend

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```