

A7_LI_ZHIJUN_Dragon

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2022-03-08

```
library(dplyr)
library(ape)
library(Biostrings)
```

Import Nexus Data

```
DragonNexus <- read.nexus.data("./input/DragonMatrix.nex")
head(DragonNexus)

## $`0.1FishXXX`
## [1] "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0"
## [20] "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0"
## [39] "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0"
## [58] "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0"
## [77] "0" "0"

## $`0.2SnakeXXX`
## [1] "1" "1" "1" "1" "0" "0" "0" "0" "1" "1" "1" "0" "0" "1" "1" "1" "1" "0" "1" "1"
## [20] "0" "0" "0" "0" "0" "0" "1" "1" "0" "0" "0" "0" "0" "0" "0" "0" "1" "0" "0" "0"
## [39] "1" "0" "0" "0" "1" "0" "0" "0" "1" "0" "0" "0" "0" "0" "0" "0" "1" "1" "1" "1"
## [58] "1" "1" "0" "0" "0" "0" "0" "0" "0" "1" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0"
## [77] "0" "0"

## $`0.3MammalX`
## [1] "1" "0" "0" "0" "0" "0" "0" "0" "0" "1" "1" "1" "0" "0" "0" "0" "0" "0" "0" "0"
## [20] "0" "0" "0" "1" "0" "0" "0" "1" "1" "1" "0" "0" "0" "0" "0" "1" "1" "0" "0" "0"
## [39] "1" "1" "0" "0" "1" "0" "0" "0" "0" "0" "0" "0" "0" "0" "0" "1" "0" "0" "0" "0"
## [58] "0" "0" "0" "1" "1" "0" "0" "0" "0" "0" "1" "0" "0" "0" "0" "0" "1" "0" "0" "0"
## [77] "0" "0"

## $`1GermanXXX`
## [1] "0" "1" "0" "0" "1" "1" "0" "0" "1" "1" "1" "0" "0" "0" "0" "0" "0" "1" "1"
## [20] "0" "0" "0" "1" "0" "1" "1" "0" "1" "1" "1" "0" "0" "0" "0" "0" "1" "1" "0" "1"
## [39] "0" "0" "0" "1" "1" "0" "1" "0" "1" "1" "0" "0" "0" "0" "0" "0" "1" "1" "1" "0"
## [58] "0" "0" "0" "1" "0" "0" "1" "0" "0" "1" "0" "0" "?" "?" "?" "?" "0" "0" "1"
## [77] "1" "1"

## $`2FrenchXXX`
## [1] "0" "1" "0" "0" "1" "1" "0" "1" "0" "1" "1" "0" "0" "1" "1" "1" "0" "1" "0" "0"
## [20] "0" "0" "0" "0" "0" "1" "1" "1" "1" "1" "1" "0" "0" "0" "0" "0" "1" "1" "1" "0"
## [39] "1" "0" "0" "0" "1" "1" "0" "0" "0" "0" "0" "0" "0" "0" "0" "1" "1" "1" "0" "0"
```

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## [58] "0" "0" "1" "0" "0" "1" "0" "0" "0" "1" "1" "0" "0" "0" "1" "1" "0" "0" "0" "1"
## [77] "1" "0"
##
## $`3FrenchXXX`
## [1] "0" "1" "0" "0" "1" "1" "1" "0" "0" "0" "1" "0" "0" "0" "0" "0" "0" "0" "?"
## [20] "?" "?" "1" "0" "1" "0" "0" "1" "1" "1" "0" "0" "0" "0" "1" "1" "0" "1"
## [39] "1" "1" "0" "1" "1" "1" "0" "1" "0" "0" "0" "0" "0" "0" "1" "1" "1" "0"
## [58] "0" "0" "0" "1" "0" "0" "1" "0" "0" "1" "0" "0" "0" "0" "1" "1" "0" "0" "1"
## [77] "1" "1"

names(DragonNexus)

## [1] "0.1FishXXX" "0.2SnakeXX" "0.3MammalX" "1GermanXXX" "2FrenchXXX"
## [6] "3FrenchXXX" "4DutchXXXX" "5EnglishXX" "6AmericanX" "7FrenchXXX"
## [11] "8EnglishXX" "9FrenchXXX" "10FrenchXX" "11SpanishX" "12Japanese"
## [16] "13Japanese" "14Japanese" "15Japanese" "16Japanese" "17Japanese"
## [21] "18Japanese" "19Japanese" "20Japanese" "21Japanese" "22Japanese"
## [26] "23Japanese" "24Japanese" "25Japanese" "26Japanese" "27Japanese"
## [31] "28Japanese" "29Japanese" "30ItalianX" "31ItalianX" "32ItalianX"
## [36] "33XXXXXXXX" "34GermanXX" "35EnglishX" "36GermanXX" "37DutchXXX"
## [41] "38SpanishX" "39ItalianX" "40ItalianX" "41EnglishX" "42ItalianX"
## [46] "43SpanishX" "44ItalianX" "45ItalianX" "46EnglishX" "47ItalianX"
## [51] "48DutchXXX" "49IndianXX" "50Japanese" "51Japanese" "52Japanese"
## [56] "53Japanese" "54IranianX" "55IranianX" "56IranianX" "57IranianX"
## [61] "58TurkishX" "59IranianX" "60IranianX" "61TurkishX" "62TurkishX"
## [66] "63UkraineX" "64UkraineX" "65RussiaXX" "66UkraineX" "67RussiaXX"
## [71] "68GreeceXX" "69ItalianX" "70American" "71BritishX" "72BritishX"
## [76] "73BritishX" "74BritishX" "75RayaXXXX" "76EldenRin" "77Velkhana"

```

Distance Matrix

```

DragonNexusDF <- data.frame(matrix(unlist(DragonNexus), ncol = 78, byrow = T))
row.names(DragonNexusDF) <- names(DragonNexus)
head(DragonNexusDF)

```

```

##          X1 X2 X3 X4 X5 X6 X7 X8 X9 X10 X11 X12 X13 X14 X15 X16 X17 X18 X19
## 0.1FishXXX 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## 0.2SnakeXX 1 1 1 0 0 0 0 1 1 1 0 0 1 1 1 1 0 1 1
## 0.3MammalX 1 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0
## 1GermanXXX 0 1 0 0 1 1 1 0 0 1 1 1 1 0 0 0 0 0 1
## 2FrenchXXX 0 1 0 0 1 1 0 1 0 1 1 0 0 1 1 1 1 0 1
## 3FrenchXXX 0 1 0 0 1 1 1 0 0 0 1 1 0 0 0 0 0 0 ?
##          X20 X21 X22 X23 X24 X25 X26 X27 X28 X29 X30 X31 X32 X33 X34 X35 X36
## 0.1FishXXX 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## 0.2SnakeXX 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0
## 0.3MammalX 0 0 0 1 0 0 0 1 1 1 0 0 0 0 0 0 0 1 1
## 1GermanXXX 0 0 0 0 1 0 1 1 1 1 1 0 0 0 0 0 0 1 1
## 2FrenchXXX 0 0 0 0 0 0 0 1 1 1 1 1 0 0 0 0 0 1 1
## 3FrenchXXX ? ? 1 0 1 0 0 1 1 1 1 0 0 0 0 0 0 1 1
##          X37 X38 X39 X40 X41 X42 X43 X44 X45 X46 X47 X48 X49 X50 X51 X52 X53
## 0.1FishXXX 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## 0.2SnakeXX 0 0 1 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0
## 0.3MammalX 0 0 1 1 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0
## 1GermanXXX 0 1 0 0 0 0 1 1 0 1 1 0 0 0 0 0 0 0 0

```

```

## 2FrenchXXX 0 0 1 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0
## 3FrenchXXX 0 1 1 1 0 1 1 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0
## X54 X55 X56 X57 X58 X59 X60 X61 X62 X63 X64 X65 X66 X67 X68 X69 X70
## 0.1FishXXX 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
## 0.2SnakeXX 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
## 0.3MammalX 1 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0 0 0
## 1GermanXXX 1 1 1 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 1 0 0 ?
## 2FrenchXXX 1 1 0 0 0 0 1 0 0 0 1 0 0 0 0 1 1 0 0 0 0
## 3FrenchXXX 1 1 1 0 0 0 0 1 0 0 0 1 0 0 0 1 0 0 1 0 0
## X71 X72 X73 X74 X75 X76 X77 X78
## 0.1FishXXX 0 0 0 0 0 0 0 0
## 0.2SnakeXX 0 0 0 0 0 0 0 0
## 0.3MammalX 0 0 0 1 0 0 0 0
## 1GermanXXX ? ? ? 0 0 1 1 1
## 2FrenchXXX 0 1 1 0 0 1 1 0
## 3FrenchXXX 0 1 1 0 0 1 1 1

DragonDist <- dist(DragonNexusDF, method = 'binary')

## Warning in dist(DragonNexusDF, method = "binary"): NAs introduced by coercion
DragonDistMat <- as.matrix(DragonDist)

```

Visualize the Matrix

```

library(reshape2)
library(ggplot2)
library(ggtree)

```

trait weightings

```

WeightsDat <- read.csv("./input/Weights.csv")

Weights <- paste0(WeightsDat$Weight, collapse = "")
Weights <- strsplit(Weights, split= "")[[1]]

WeightsNum <- rep(NA, length(Weights))

for(i in 1:length(WeightsNum)){
  if(Weights[i] %in% LETTERS){
    WeightsNum[i] <- which(LETTERS == Weights[i]) + 9
  } else {
    WeightsNum[i] <- Weights[i]
  }
}

WeightsNum <- as.numeric(WeightsNum)

# multiply the weight value by the trait vector for each dragon
WtDragonNexus <- DragonNexus # Make a new weighted data frame object

for (i in 1:length(DragonNexus)){
  RepWeight <- DragonNexus[[i]] == 1
  WtDragonNexus[[i]][RepWeight] <- WeightsNum[RepWeight]
  RepWeight <- NA
}

```

```

}

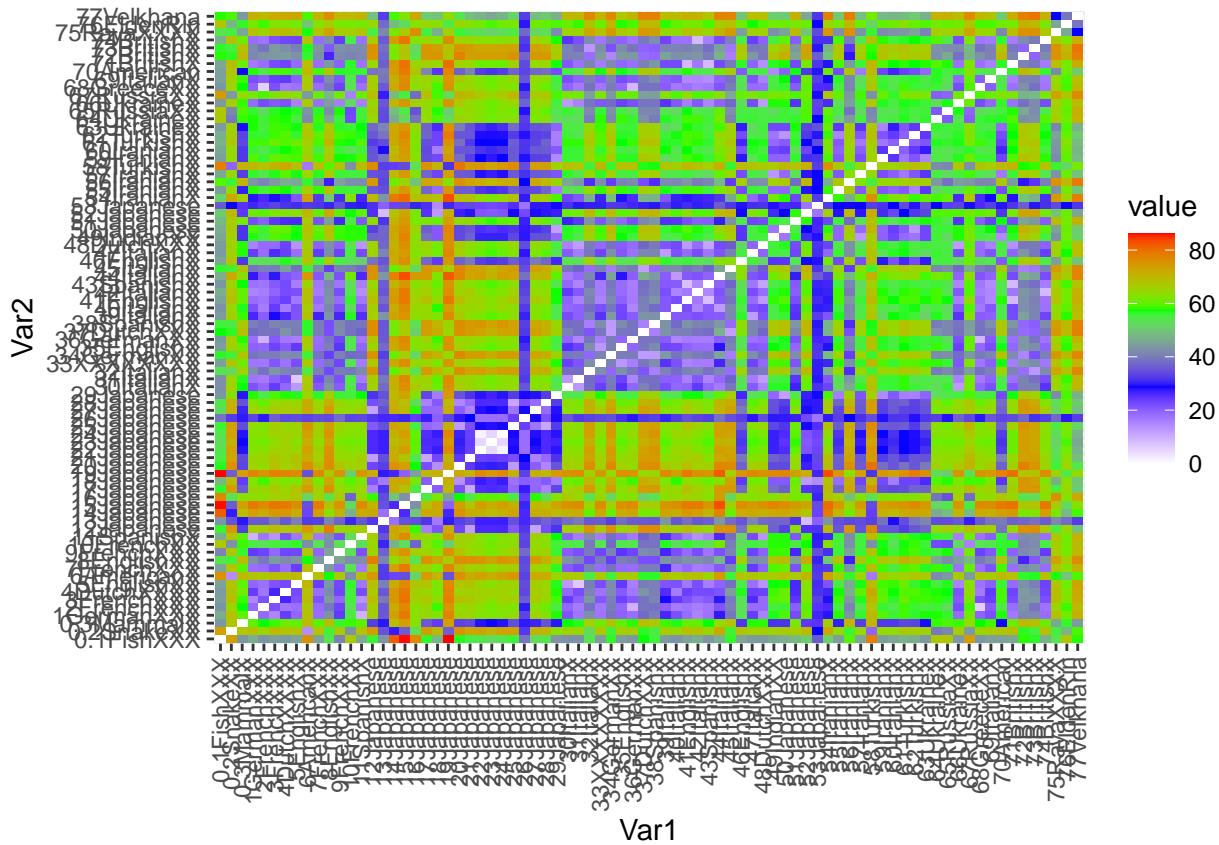
# re-calculate the distance matrix
WtDragonNexusDF <- data.frame(matrix(unlist(WtDragonNexus), ncol = 78, byrow = T))
row.names(WtDragonNexusDF) <- names(WtDragonNexus)
WtDragonDist <- dist(WtDragonNexusDF, method = 'euclidean')

## Warning in dist(WtDragonNexusDF, method = "euclidean"): NAs introduced by
## coercion
WtDragonDistMat <- as.matrix(WtDragonDist)

# rearrange the data from an n×n matrix to a n2×3 matrix
WtPData <- melt(WtDragonDistMat)

# plot the matrix
ggplot(data = WtPData, aes(x = Var1, y = Var2, fill = value)) +
  geom_tile() +
  scale_fill_gradientn(colours = c("white", "blue", "green", "red")) +
  theme(axis.text.x = element_text(angle = 90, hjust = 1, vjust = 0.5))

```



Dragon Phylogeny

Tree Building

```
WtDragonTreeNJ <- nj(WtDragonDist)
```

```

# check 'tip.labels'
head(WtDragonTreeNJ$tip.label)

## [1] "0.1FishXXX" "0.2SnakeXX" "0.3MammalX" "1GermanXXX" "2FrenchXXX"
## [6] "3FrenchXXX"

# remove leading numbers
Country <- gsub("[0-9\\\\.]+([\\^X]+)X*", "\\\\$1", WtDragonTreeNJ$tip.label)

# replace the unwanted '3' with 'Unknown'
Country <- gsub("\\d", "Unknown", Country)

# group 'tip.labels' by their corresponding country
CountryGroups <- split(WtDragonTreeNJ$tip.label, Country)

names(CountryGroups)

## [1] "American" "British"   "Dutch"     "EldenRin"  "English"   "Fish"
## [7] "French"    "German"    "Greece"    "Indian"    "Iranian"   "Italian"
## [13] "Japanese"  "Mammal"   "Raya"      "Russia"    "Snake"     "Spanish"
## [19] "Turkish"   "Ukraine"  "Unknown"   "Velkhana"

# use the groupOTU function to apply the grouping information for plotting
WtDTcol <- groupOTU(WtDragonTreeNJ, CountryGroups)

```

Visualize the Phylogenetic Tree

```

# again use the groupOTU function to highlight the selected three groups
WtDTcolHi <- groupOTU(WtDTcol, c(CountryGroups$Raya, CountryGroups$EldenRin, CountryGroups$Velkhana))
ggtree(WtDTcolHi, layout = "circular", aes(color = group)) +
  geom_tiplab(size = 1.8, aes(angle = angle)) +
  scale_colour_manual(name = "Dragon Type",
    values = c("Black", "Blue"),
    labels = c("Other Dragon", "My Dragon"))

```

Report

Sisu (Figure 2) is the last dragon of Kumandra. She is a long, blue, spindly looking dragon with short dorsal fins on her back, and possesses a mane of white-bluish-violet hair. Except for a antlers horn type, her tail is shaped like Split Y.

The grafted dragon (Figure 3), from the Elen Ring, belongs to Enia at Roundtable Hold, holding the embodiment of Godrick's power in its head.

Besides, Velkhana (Figure 4) is an elder dragon with the power to freeze all in its path. While simply looking at the appearance of the dragons of choice, Velkhana and the grafted dragon share great similarity, especially in wing type and toe morphology.

However, once take the evolving rate of different traits among dragons, according the the phylogenetic tree (Figure 1), all these three dragons are closely related; in particular, Sisu and Velkhana have the most recent ancestor.

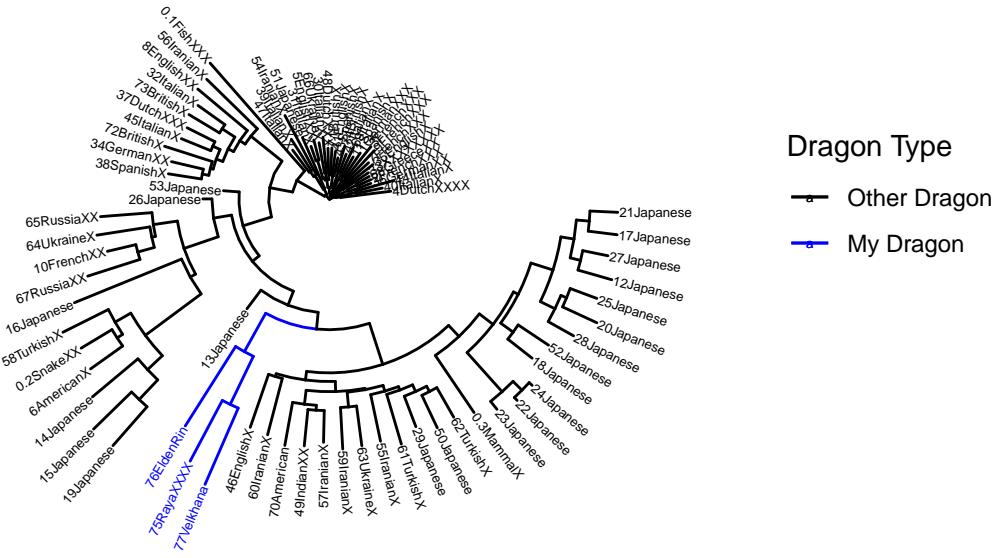


Figure 1: Phylogenetic tree of dragons. The three dragons of choice (Sisu labeled as Raya, the grafted dragon labeled as EldenRin, and Velkhana) are highlighted in blue.



Figure 2: Sisu. Credit to mintmovi3: <https://www.deviantart.com/mintmovi3/art/Raya-and-the-Last-Dragon-2021-Sisu-png-875599741>



Figure 3: Grafted Dragon in Elden Ring. Credit to Hidetaka Miyazaki: <https://rankedboost.com/elden-ring/grafted-dragon/>



Figure 4: Velkhana in Monster Hunter World: Iceborne. Credit to Hironobu Takeshita: <https://monsterhunter.fandom.com/wiki/Velkhana>