

A Binturong, or "Bearcat", is a relative of palm civets and the mongoose. It lives in Southeast Asia and is an endangered species (Vulnerable status). It also, weirdly, smells like popcorn. In 2016 a group of scientists found out that binturongs produce a chemical in their urine known as 2-acetyl-1-pyrroline, which they referred to as 2-AP and which is the same chemical that gives popcorn its smell. Binturongs scent mark their territory by peeing and dragging their tail over their pee, spreading their popcorny smell like they're dragging a bucket of it behind them.

**But – do male and female Binturongs produce different amounts of this popcorn smell? And do Binturongs in different areas of their home range have different amounts too?**

Associated with this is some representative fake data (P2 Binturong.csv). It has a column of the 2-AP in picograms per milliliter and the sex and country of origin of a fake group of binturongs. Pull this data into R and run the following tests:

* An ANOVA of the "Sex and Country" column
* A Tukey Test of the Sex and Country column
* A t-test by sex
* An ANOVA by country
* A Tukey Test by Country
* A Shapiro test of the data overall
* A Shapiro test on each group of data
* Find mean, median, standard deviation and sample number by group

You should also find the mean, standard deviation, and number of samples in each group. As you run these tests, pay attention to which tests com up as statistically significant, because not all of them will. Then, consider how normality, differences between means, variation, and sample size might play a role in getting a significant or a non-significant p value.

HINT: the aggregate() function mentioned in the "how to mess up a t-test" lecture will help you do some of this much more quickly!

Finally, see if you can write up the hypothesis being tested here. When you're ready, check your answers below!

## Answers

### Find the mean, sd, etc with aggregate

aggregate(t1$x~t1$y, FUN = mean) shows you the mean is lower in females by group, but that the countries have different means too. The strongest popcorn smell is from Thailand , with males having slightly more. Putting in the standard deviation shows you that Thailand is also more variable though.

But the biggest difference is to look at sample size. Overall, there are way, way more male in the dataset – and there are way more from Thailand.

Uneven sample sizes can obscure trends!

## ANOVAs

m1 <- aov(x~y, data = t1)

summary(m1)

TukeyHSD(m1)

By the "sex and country" column is significant, but only when comparing between countries. Males and females from the same country don't come back as statistically significant. Overall, the countries are mostly different, though Malaysia and Indonesia aren't.

## t-test

t.test(x~z, data = t1)

This is significant, comparing males and females. But when you look at males vs females by country like in the ANOVA, it's not.

## Shapiro test

You can use the subset code to pull apart the dataset into different groups, but overall almost all of it isn't normally distributed. The females from Indonesia and Malaysia are, and the Males from Malaysia are, but everyone else is very asymmetric and right skewed.

## Hypothesis

ALT: If binturongs have different popcorn scent concentration by sex and by range, then an ANOVA by sex and range should have a p value of <-0.05, with each Tukey Test pair showing statistically significant differences.

NULL: If binturongs don't have different popcorn scent concentration by sex and by range, then an ANOVA by sex and range should have a p value of >0.05, or possibly <= 0.05 with only some Tukey-tested pairs showing statistically significant differences.

## Conclusions

There is a sample size & normality problem in this data. It's hard to demonstrate that they are genuinely different, even though the averages suggest they are, because you don't have very many females. When you combine them all by sex and leave the country subgrouping out, you suddenly get statistically significant results because you have a big enough sample size to compensate for the fact that you have very skewed data and more in one group than the other.