Database Tutorial

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RIBBiTR Database Background

Our RIBBITR data is stored in a PostgreSQL database, more commonly called "postgres". Postgres is a free and open source relational database management system (RDBMS). Postgres RDBMS began development in 1982 at UC Berkeley initially under the name Ingres. After many years of development the project ended and Postgres was released under an MIT License that allowed other developers to utilize the code (open source) and continue developing the code. Following this, many evolution's of the query language "SQL" occured. By 1997 PostgeSQL was released and SQL was deemed the unifying language for RDBMS style databases. To this day, developers around the world work to build upon the open source software of PostgreSQL and SQL to improve the software. Side note: RDBMS are one "flavor" of databases with new methods for data management systems being developed constantly, like "graph databases".

Postges is considered a relational database management system (RDBMS) because each observation/row in a table contains a relationship to another observation/row in a different table. By maintaining relationships between data points you ensure the observations in that row will be joined correctly to each table. The rigid structure of the relationship between observations/rows from table to table is maintained through `primary keys` and `foreign keys`. A `primary key` from one table will be joined to the `foreign key` of the other table in which each row/observation will than align correctly between the two tables.

Non-RDBMS Example

For example, if you did not have a RDBMS and you had a `wind_speed` table that contains columns for “site”, “date”, and “wind_speed” and a `water_temp` table containing columns for “site”, “date”, and “water_temp” .

site	date	wind_speed
A	2022-01-03	22
B	2022-08-10	24
C	2022-05-07	36
A	2022-08-12	5
C	2022-09-14	12

site	date	water_temp
A	2022-01-03	3
B	2022-08-10	6
C	2022-05-07	23
A	2022-08-12	18
C	2022-09-14	3

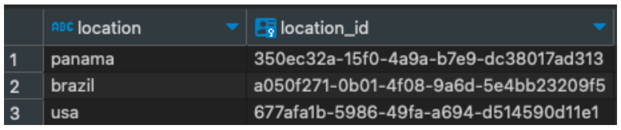
Now say you wanted to join those two tables to have one table containing “site”, “date”, “wind_speed”, and “water_temp” you would `water_wind <- left_join(water_temp, wind_speed, by = c("site", "date")` on the unique relationship of “site” and “date”. Or in human speak, when site and date between the two tables equal each other place the “water_temp” row in the table. With a RDBMS the creation of primary and foreign keys maintains the unique relationship of “site” and “date” between the two tables.

site	date	water_temp	wind_speed
A	2022-01-03	3	22
B	2022-08-10	6	24
C	2022-05-07	23	36
A	2022-08-12	18	5
C	2022-09-14	3	12

RDMS Example

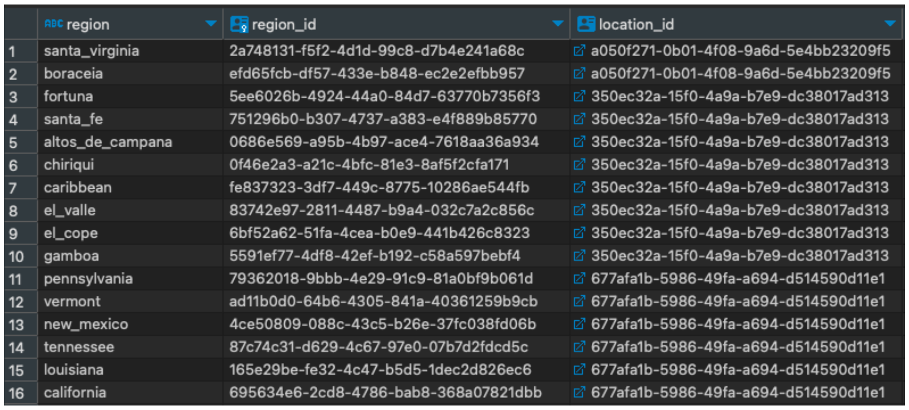
When looking at the `location` table and the `region` table within the `survey_data` schema in the RIBBiTR database we can see how the RDMS preserves the data and reduces space. We have three unique locations where data can be collected "panama", "brazil", and "usa" in which each of those locations can have many regions. For example, "usa" has regions of "california", "new_mexico", "vermount", "tennessee", "louisiana", and "pennsylvania". Through the use of primary and foreign keys we now know how to join those tables. And due to the primary and foreign keys we only need to maintain the unique sites and regions. This saves space by removing repeated values and preserves the data by only having one spelling of "usa". You could imagine with the above example, if sites had upper case and lower case spellings we could improperly join the data.

Location table



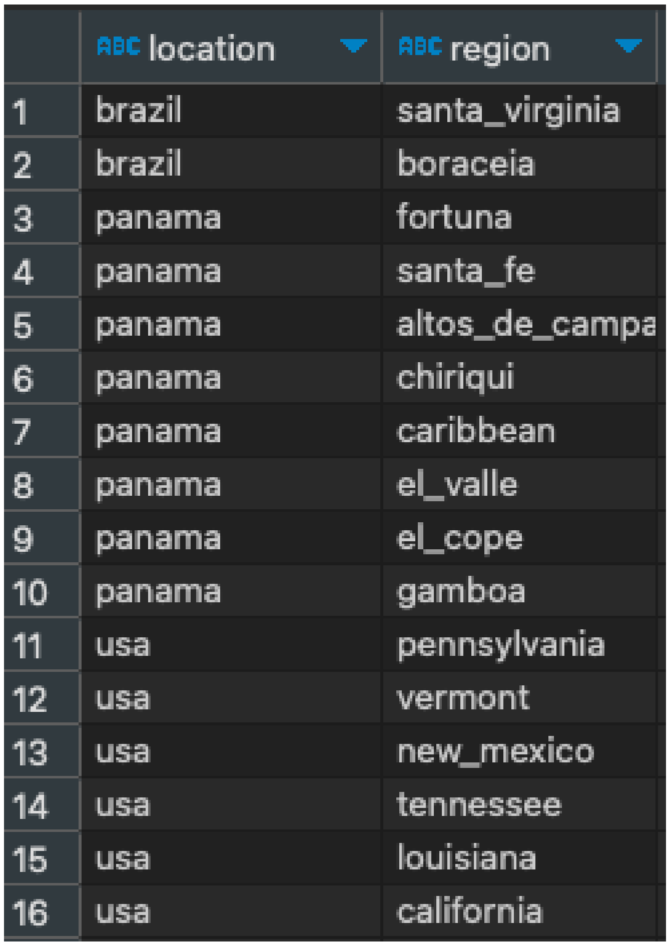
	location	location_id
1	panama	350ec32a-15f0-4a9a-b7e9-dc38017ad313
2	brazil	a050f271-0b01-4f08-9a6d-5e4bb23209f5
3	usa	677afa1b-5986-49fa-a694-d514590d11e1

Region table



	region	region_id	location_id
1	santa_virginia	2a748131-f5f2-4d1d-99c8-d7b4e241a68c	a050f271-0b01-4f08-9a6d-5e4bb23209f5
2	boraceia	efd65fcb-df57-433e-b848-ec2e2efbb957	a050f271-0b01-4f08-9a6d-5e4bb23209f5
3	fortuna	5ee6026b-4924-44a0-84d7-63770b7356f3	350ec32a-15f0-4a9a-b7e9-dc38017ad313
4	santa_fe	751296b0-b307-4737-a383-e4f889b85770	350ec32a-15f0-4a9a-b7e9-dc38017ad313
5	altos_de_campana	0686e569-a95b-4b97-ace4-7618aa36a934	350ec32a-15f0-4a9a-b7e9-dc38017ad313
6	chiriqui	0f46e2a3-a21c-4bfc-81e3-8af5f2cfa171	350ec32a-15f0-4a9a-b7e9-dc38017ad313
7	caribbean	fe837323-3df7-449c-8775-10286ae544fb	350ec32a-15f0-4a9a-b7e9-dc38017ad313
8	el_valle	83742e97-2811-4487-b9a4-032c7a2c856c	350ec32a-15f0-4a9a-b7e9-dc38017ad313
9	el_cope	6bf52a62-51fa-4cea-b0e9-441b426c8323	350ec32a-15f0-4a9a-b7e9-dc38017ad313
10	gamboa	5591ef77-4df8-42ef-b192-c58a597bebf4	350ec32a-15f0-4a9a-b7e9-dc38017ad313
11	pennsylvania	79362018-9bbb-4e29-91c9-81a0bf9b061d	677afa1b-5986-49fa-a694-d514590d11e1
12	vermont	ad11b0d0-64b6-4305-841a-40361259b9cb	677afa1b-5986-49fa-a694-d514590d11e1
13	new_mexico	4ce50809-088c-43c5-b26e-37fc038fd06b	677afa1b-5986-49fa-a694-d514590d11e1
14	tennessee	87c74c31-d629-4c67-97e0-07b7d2fdcd5c	677afa1b-5986-49fa-a694-d514590d11e1
15	louisiana	165e29be-fe32-4c47-b5d5-1dec2d826ec6	677afa1b-5986-49fa-a694-d514590d11e1
16	california	695634e6-2cd8-4786-bab8-368a07821dbb	677afa1b-5986-49fa-a694-d514590d11e1

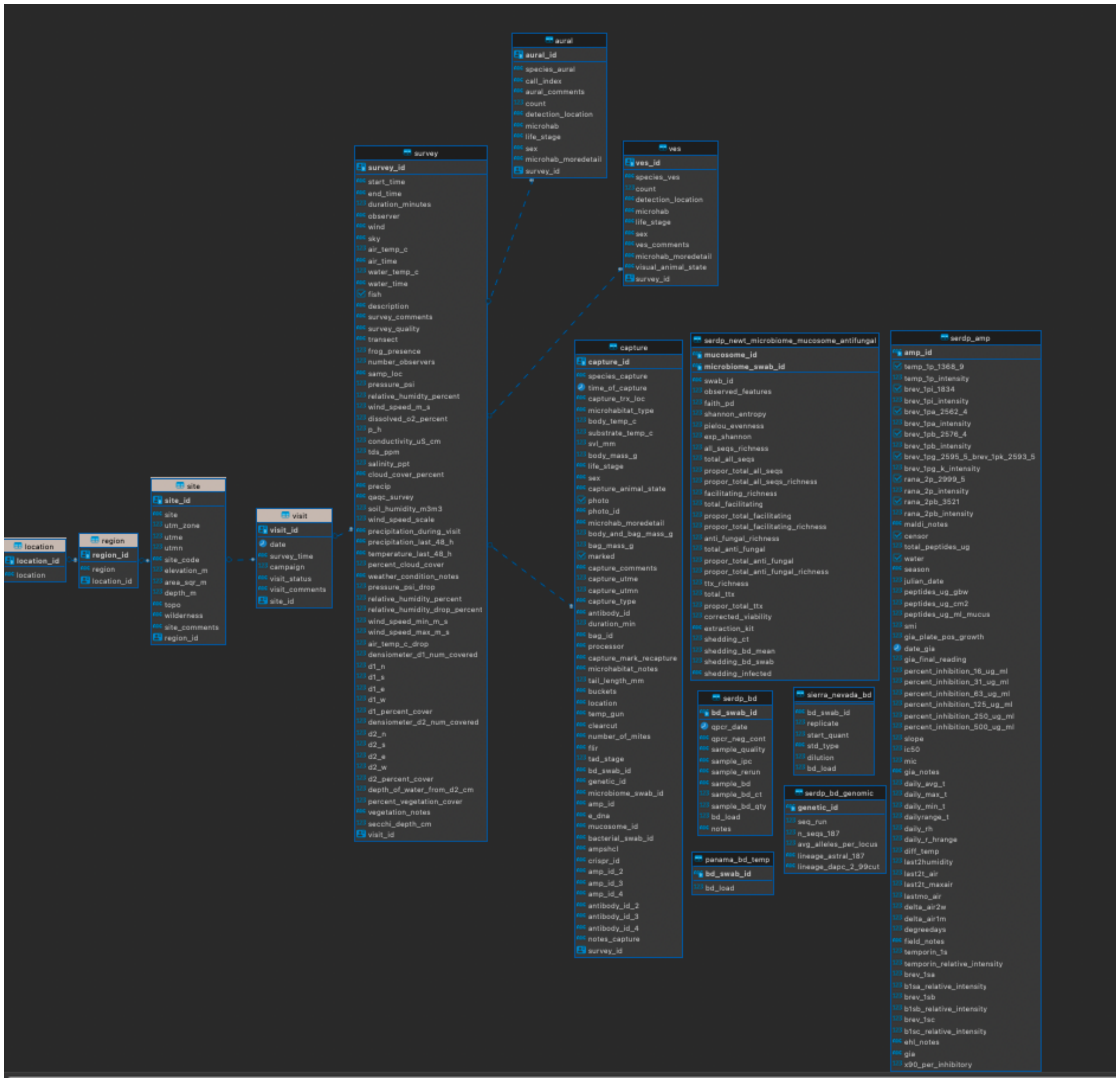
To join these two table we would join the `location` table primary key (location_id) to the `region` table foreign key (location_id). In RStudio, `location_region <- left_join(location, region, by = c("location_id")`



	location	region
1	brazil	santa_virginia
2	brazil	boraceia
3	panama	fortuna
4	panama	santa_fe
5	panama	altos_de_campa
6	panama	chiriqui
7	panama	caribbean
8	panama	el_valle
9	panama	el_cope
10	panama	gamboa
11	usa	pennsylvania
12	usa	vermont
13	usa	new_mexico
14	usa	tennessee
15	usa	louisiana
16	usa	california

We can now see the location column populates the correct value where ever the primary key and foreign key equal each other or in other words, the location_id from both tables equal each other.

Now if we zoom out and look at the entire structure of the `survey_data` schema we can see all the interconnected relationships built between the tables through primary keys and foreign keys. If there is a line connecting the tables we know the same structure follows/trickles through the schema with preserving space and data. Take a look at ribbitr_schema.pdf for more info on each schema.



How to Connect and Interact with the RIBBiTR Data Base

Necessary Library's

```
library(RPostgres)  # The database driver
library(DBI)        # Functions needed to interact with the database
library(rstudioapi) # Package that asked for credentials

# The method below for calling in packages does the same as using `library`
# but will download any packages that are not initally downloaded. This is a
# cleaner method and more user
# friendly for sharing scripts between colleagues

if (!require(librarian)){
  install.packages("librarian")
  library(librarian)
}
# librarian downloads, if not already downloaded, and reads in needed packages
librarian::shelf(RPostgres, DBI, rstudioapi)
```

Connecting

To connect to the database you will use `dbConnect` function from the `DBI` package. You will need the

- database driver: `drv = dbDriver("Postgres")`,
- the database name: `dbname = "ribbitr"`,
- the host: `host = "ribbitr.c6p56tuocn5n.us-west-1.rds.amazonaws.com"`,
- port: `port = "5432"`,
- your username: `user = "<insert_username>"`
- and password: `password = "<insert_password>"`

I strongly recommend not storing `user` and `password` , or any database info with in your script. A secure method for storing this info is in your `.Renviron` file that is stored locally on your device and will never be pushed to github. To edit your `.Renviron` file run this in the console: `usethis::edit_r_environ()` and the file will open. Populate the file based on the sample below, hit save, and restart your R session. You can then use `Sys.getenv()` to call on those variables stored locally on your device. Another method is to use the `rstudioapi` package with the askForPassword() function. Replace Sys.getenv() with askForPassword(). A log in box will appear after running the dbConnect.

Once you have connected to the database it is important to set search_path to the appropriate database schema of interest. This is identical to setting your working directory but for databases. To set search path we will use dbExecute in the DBI package. You will tell the dbExecute the connection and the SQL statement that points to the schema. Note, you must use single quotes around the schema of choice dbExecute(conn = ribbitr_connection, "set search_path = 'survey_data'")

Sample .Renviron file and Database Connection

```
# 1) run this in the console: "usethis::edit_r_environ()"

# 2) copy the sample below and input your own username and password.

# 3) Save and restart your r sessio. Click "session" at the top and "Restart R".
# sample .Renviron file #
dbname = "ribbitr"
host = "ribbitr.c6p56tuocn5n.us-west-1.rds.amazonaws.com"
port = "5432"
user = "username" # you will input your own username
password = "password" # you will input your own password



# connecting to RIBBiTR Database
ribbitr_connection <- dbConnect(drv = dbDriver("Postgres"),
                                dbname = "ribbitr",
                                host = "ribbitr.c6p56tuocn5n.us
                                        -west-1.rds.amazonaws.com",
                                port = "5432",
                                user = Sys.getenv("user"),
                                password = Sys.getenv("password"))



# Same method for connecting to RIBBiTR databse but will give feedback,
# I recommend copying this

tryCatch({
    print("Connecting to Database…")

    ribbitr_connection <- dbConnect(drv = dbDriver("Postgres"),
                                    dbname = "ribbitr",
                                    host = "ribbitr.c6p56tuocn5n.us-
                                            west-1.rds.amazonaws.com",
                                    port = "5432",
                                    user = askForPassword("user"),
                                    password = askForPassword("password"))

    print("Database Connected!")
    },

    error=function(cond) {
            print("Unable to connect to Database.")
    })


# setting your search path
dbExecute(conn = ribbitr_connection,
          statement = "set search_path = 'survey_data'")
```

Interacting

Now you should be connected to the `ribbitr` database with in RStudio and working with in the `survey_data` schema. Interacting with the database through R will involve learning some SQL. Don't stress, SQL is a very intuitive and straight forward language. A more thorough SQL tutorial will follow and please do not hesitate to reach out for help with developing queries. I will now show two methods in how one can query the database.

dbQetQuery

Using `dbQetQuery` in the `DBI` package we can feed the function our database connection `conn = ribbitr_connection` and then the SQL `statement =`. Note, the * symbol in SQL is equivalent as saying "everything" and in R that is .

```
# location table only

# human speak: "select everthing from the location table"
```

```
sql_statement <- "select * from location"

location <- dbGetQuery(conn = ribbitr_connection,
                       statement = sql_statement)


# location and region table joined


# note, if you want to select specific columns from a table you must start
# with table alias, that being either "l" for location or "r" for region.
sql_statement <- "select l.location, r.region
                  from location l
                  join region r on l.location_id = r.location_id"

location_region <- dbGetQuery(conn = ribbitr_connection,
                              statement = sql_statement)


# picking columns of interest from each table and join all tables together.
# Try to always select specific columns of interest from each table.

sql_statement <- "select l.location, r.region, s.site, s.utme, s.utmn, s.utm_zone,
                  v.date, v.survey_time, su.start_time, su.end_time, su.duration_minutes,
                  c.species_capture, c.time_of_capture, c.body_temp_c, c.svl_mm, c.sex
                  from location l
                  join region r on l.location_id = r.location_id
                  join site s on r.region_id = s.region_id
                  join visit v on s.site_id = v.site_id
                  join survey su on v.visit_id = su.visit_id
                  join capture c on su.survey_id = c.survey_id;"

capture_data <- dbGetQuery(conn = ribbitr_connection,
                              statement = sql_statement)
```

Entire SQL Code Chunk

If you are using a Quarto or RMarkdown document with code chunks you can specify in the code chunk that you will be using SQL, the database connection, and what you want the output variable to be.

```
select *
from location
```

```
select l.location, r.region, s.site, s.utme, s.utmn, s.utm_zone,
v.date, v.survey_time, su.start_time, su.end_time, su.duration_minutes,
c.species_capture, c.time_of_capture, c.body_temp_c, c.svl_mm, c.sex

from location l

join region r on l.location_id = r.location_id
join site s on r.region_id = s.region_id
join visit v on s.site_id = v.site_id
join survey su on v.visit_id = su.visit_id
join capture c on su.survey_id = c.survey_id;
```