Pokémon Total Stats by Type, Evolution, and Legendary Status

By Jordyn Lucier and Harley Clifton

I. Introduction

Pokémon was first released as a videogame for Nintendo in Japan in 1996 under the name 'Pocket Monsters' and it quickly became a worldwide hit. Pokémon has since released 122 videogames, a popular trading card game, apps, movies, and a tv show (Alt, 2022). Part of its overwhelming popularity is due to the revolutionary gameplay. In the game, players explore the world looking for Pokémon. Once one is found, the player can attempt to capture it or defeat it in battle to level up the Pokémon they already have. Currently, there are 1,015 unique Pokémon categorized into 18 types, which affect a Pokémon's moves and abilities (Bulbagarden, 2023). Once a Pokémon has gained enough experience or a certain action is performed, it can evolve into a new, stronger Pokémon. Players can also battle Pokémon trainers, which act as milestones in the games, or battle other players to gain experience.

Catching strong Pokémon is an integral part of progressing in the game, as the stronger Pokémon the player has, the stronger Pokémon they can battle and catch. However, it is not very easy to tell how strong a Pokémon is just by looking at it, as none of the stats are shown until you begin battling the Pokémon. If a player engages in a battle with a Pokémon they will not win against or one too weak to be worth the time, the player has the option to run, though it does not always work and could result in the player's Pokémon being hurt. So, it would be helpful to be able to estimate the average base stats for Pokémon based on physical characteristics of the Pokémon. Practically the only categorization method that can be identified visually for most Pokémon is their type. Fire type Pokémon mostly have an orange-red color scheme and many have flames on their body, dark types will have a dark purple/ black color scheme and have shadowy figures, etc. Specifically, researchers wanted to determine the relationship between Pokémon type and total stats, while controlling for evolution and legendary status.

II. Data

This data comes from Alberto Barradas on kaggle.com, who compiled the data from pokémon.com, bulbapedia, and pokémondb. It includes data for the unique ID number, name, type, secondary type, total stats, hit points, attack, defense, special attack, special defense, speed, generation, and speed on 800 unique Pokémon (Barradas, 2016). Another variable was then added to indicate the evolution of the Pokémon, and this data was collected from bulbapedia (Bulbagarden, 2023). Any Pokémon that included two entries (one for each sex) was merged into one, as only the distribution of total stats differ between the sexes, but the total stats themselves do not. This resulted in a dataset of 784 unique Pokémon. Table I includes a description of all variables explored.

Of the variables available, total stats was selected as the response of interest. Since total stats are calculated by summing hit points, attack, defense, special attack, special defense, and speed, these subscores were not of interest to the researchers and thus were left out of their models. Additionally, since only some Pokémon (403 out of the total 784 in this dataset) have a secondary type, secondary types are typically gained as they evolve, and secondary types are hard to identify visually before battle, this variable was deemed unimportant in this analysis. The main predictor of interest was Pokémon type, of which there are 18 levels: bug, dark, dragon, electric, fairy, fighting, fire, flying, ghost, grass, ground, ice, normal, poison, psychic, rock, steel, and water (R Core Team, 2021). The total count of Pokémon for each type can be found in Table II. Most notably, the Pokémon type with the most data available is water type with 111 Pokémon in the database, and the type with the least data is flying type with only 3 in the database.

Enhanced violin plots were created using the ‘ggplot2’ package in R to visualize the relationship between Pokémon type and total stats (Figure 1) (Wickham, 2016). Figure 1 illustrates how total stats are largely similar across the majority of Pokémon types, with the exception of a few outliers, further supporting the need for this analysis.

Researchers suspected a few other variables — such as generation, evolution, and legendary status — may have the potential to substantially impact total stats. Exploratory data analysis was performed to determine whether these variables influence total stats and therefore need to be controlled for. There is a fairly even spread of Pokémon across the generations, with generations 1 through 5 all consisting of between 106 to 166 Pokémon each. However, there is only data available for 74 6th generation Pokémon. To determine whether generation contributed to total stats, a violin plot was created using the ‘ggplot2’ package in R (Figure 2) (Wickham, 2016). This plot shows that the distribution of total stats across the six generations does not differ much. Hence, generation was excluded from the modeling process.

Next, the evolution variable was investigated. In the original dataset, ‘Mega’ Pokémon were counted as evolution 3, but for research purposes this was changed to evolution 4 to reflect how Pokémon evolve from their third evolution into a mega Pokémon. Pokémon counts and mean total stats by evolution are available in Table III. From this table, it seemed the change in mean total stats was somewhat similar across the four evolutions. To gauge variability and nature of the relationship between evolution and total stats, another violin plot was created (Figure 3). The plot shows an increasing linear trend, indicating that evolution is an important factor in predicting total stats and thus needs to be controlled for. The ‘Evolution’ variable was then recoded to be 0-3 instead of 1-4 so the baseline model will be estimates for Pokémon at their first evolution for analysis purposes.

Past experience playing the game led researchers to believe that legendary Pokémon would have much higher total stats on average compared to non-legendary Pokémon. To assess the validity of this suspicion, a violin plot was made to visualize the relationship between legendary status and total stats (Figure 4). The plot confirmed the researchers' predictions; it illustrated that the 58 legendary Pokémon have much higher total stats, on average, compared to the 726 non-legendary Pokémon. Thus, this visualization indicated that legendary status must be controlled for when modeling total stats.

III. Statistical Model with Priors

Our sampling model is as follows:

$$Total\ Stats_i = \sum_{j=1}^{18} Pokémon\ Type + \beta_{19}\ Evolution_i + \beta_{20}\ Legendary_i + \varepsilon_i$$

where $\varepsilon_i \sim N(0, \sigma^2)$ and $Legendary_i$ is an indicator variable that is 1 when the Pokémon is legendary and 0 otherwise. Since exploratory data analysis suggests there is a linear relationships between evolution and total stats, $Evolution_i$ was included in the model as a quantitative variable which equals 0, 1, 2, or 3 based on the observed Pokémon's evolution. Although evolution and legendary status were not of primary interest to the research question, they are included in the model as controls since they are determined to have notable impacts on total stats estimates. Since previous experience playing the game leads the researchers to have moderately strong opinions about the total stats and battling ability of different Pokémon types, the priors for this model will reflect that. The priors chosen for Pokémon types, evolution, and legendary status, and justification for these priors, are available in Table II.

IV. Results

The model was fitted with the pre-specified priors in R using the 'rjags' package (Plummer, 2022). A summary of the model estimates for Pokémon total stats by type, controlling for evolution and legendary status, are available in Table IV.

Based on the model's estimates, the five strongest Pokémon types in descending order are flying, bug, dragon, dark, and rock types. 95% confidence intervals for mean total stats, that control for evolution and legendary status, are superimposed on the original, unadjusted violin plots for the five strongest Pokémon types in Figure 5.

The model indicated that the five weakest Pokémon types – also in descending order – are fairy, ground, poison, normal, and ice types. 95% confidence intervals for mean total stats, that control for evolution and legendary status, are superimposed on the original, unadjusted violin plots for the five weakest Pokémon types in Figure 6.

Model validation was performed by deriving posterior predictive distributions for five select Pokémon that varied in terms of type, evolution, and legendary status. This was done to determine whether our model and posterior distributions mimic the data with reasonable accuracy. The five Pokémon we chose were Fan Rotom, Shroomish, Mega Charizard, Tornadus, and Golem. Details about the type, evolution, and legendary status of each of these Pokémon can be found in Table V. The posterior predictive distributions for each of these Pokémon are displayed in Figure 7.

V. Discussion

Based on this analysis, new players should at first avoid flying, bug, dragon, dark, and rock types, since they are the strongest on average. It may be in new players' best interest to go after fairy, ground, normal, poison, and ice Pokémon as they are the weakest, on average. As a player becomes more experienced, it would be in their best interest to keep flying, bug, dragon, dark, and rock types in their roster to ensure they are working to level up the strongest possible Pokémon.

In retrospect, the priors for Pokémon type tended to overestimate the average total stats since they were not created accounting for evolution and legendary status. Since the priors were fairly influential, this may have skewed the posterior estimates more than desired. If this study were to be redone, researchers would be more intentional with shifting the priors for all Pokémon types to have a lower center.

In further research, seeking data that include the most recent Pokémon releases is recommended. Including the most recent generations of Pokémon would allow for an even more comprehensive analysis. Additionally, it may be useful to re-run a similar analysis with subsets of Pokémon for specific games. A series of indicator variables could be added to the data to specify whether each Pokémon is featured in various games. This would allow players to (1) subset the data to the specific game, (2) assess which Pokémon types are the strongest in that specific game, and (3) determine if the strongest Pokémon types differ across games. Lastly, it would be interesting to see whether the strongest Pokémon types change when legendary Pokémon are excluded from the analysis. This suggestion results from the observation that many of the dragon-type Pokémon are also legendary, which may contribute to the higher average total stats for that group. Also, since legendary Pokémon are obtained once you beat the game, a player cannot specifically go after legendary Pokémon, so it may be of interest to exclude them.

References

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Appendix

Figures

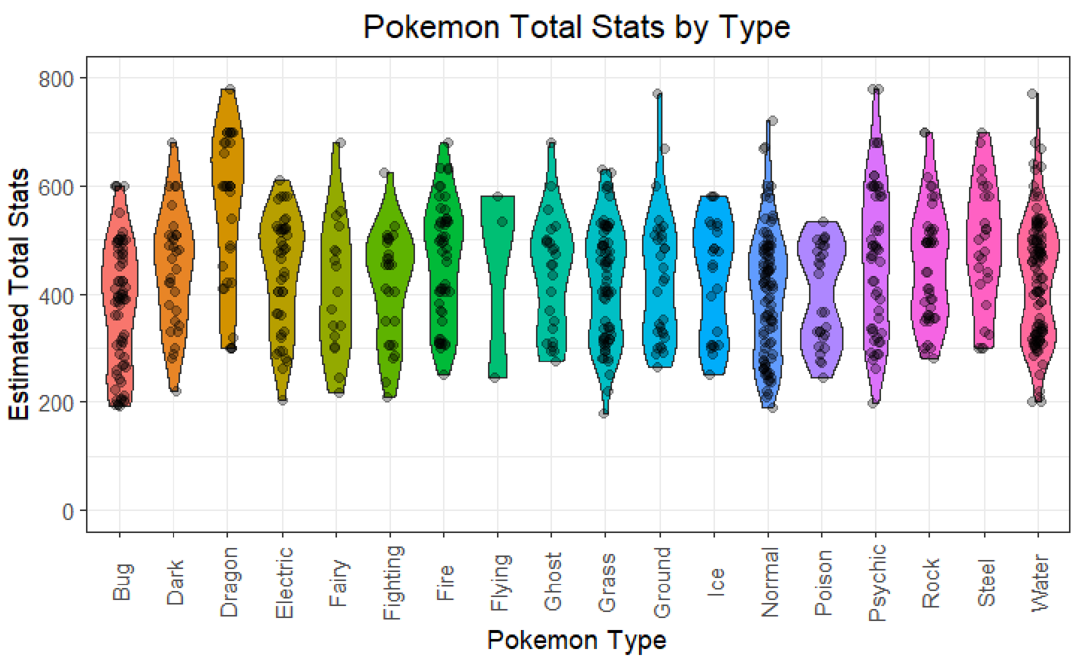

Figure 1: Enhanced Violin Plot of Pokémon Total Stats by Type. Side-by-side violin plots were created to compare the total stats, not adjusted, across the 18 different Pokémon types.

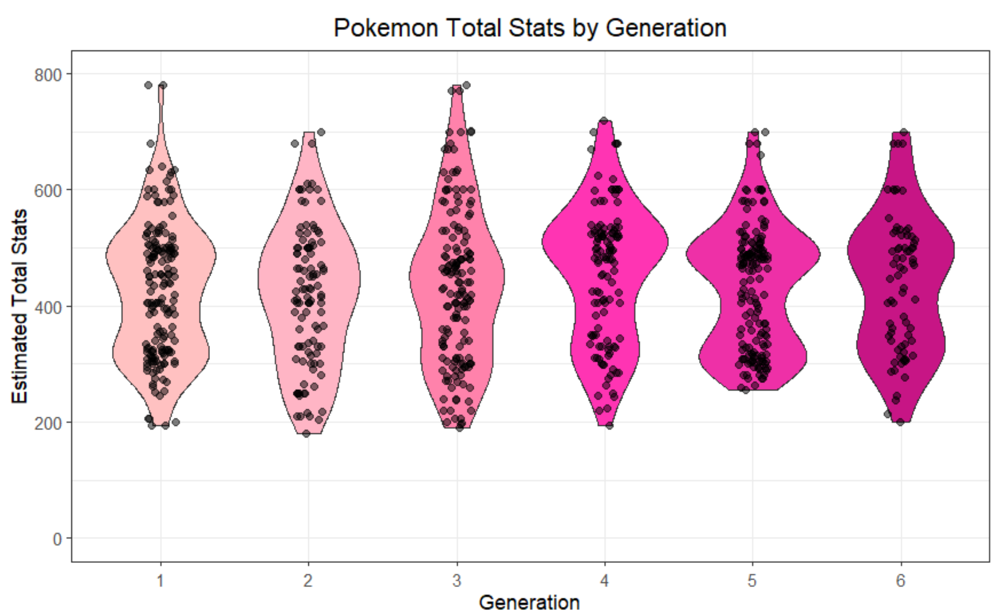

Figure 2: Enhanced Violin Plot of Pokémon Total Stats by Generation. Side-by-side violin plots were created to compare the total stats, not adjusted, across the 6 generations (releases) included in the data set. The plot suggests not much difference in total stats across generations.

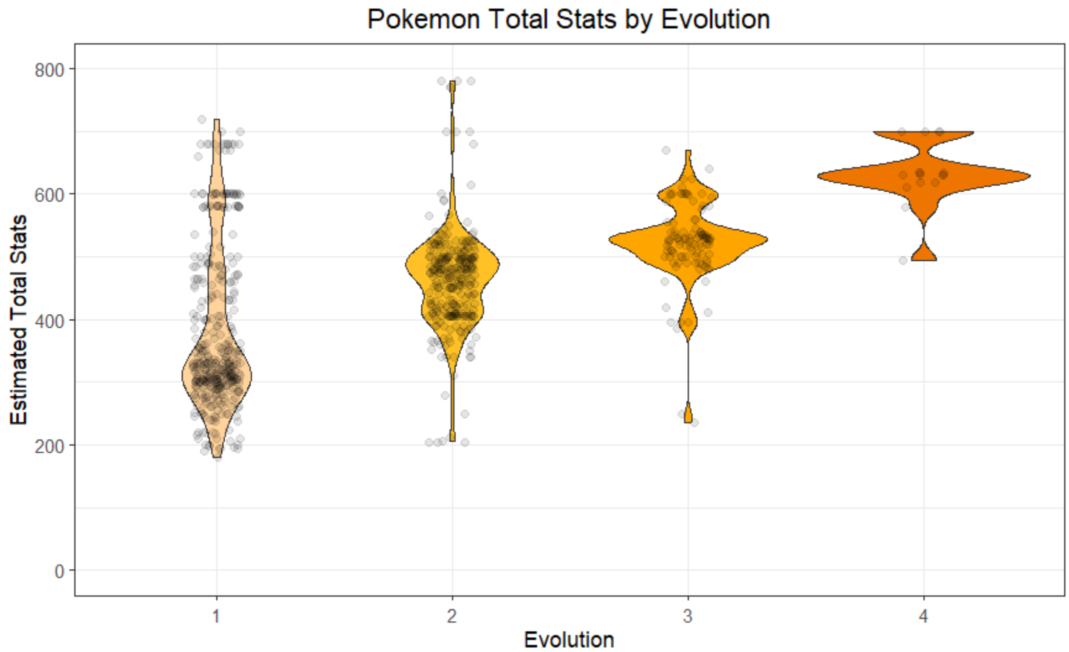

Figure 3: Enhanced Violin Plot of Pokémon Total Stats by Evolution. Side-by-side violin plots were created to compare the total stats, not adjusted, across 4 evolutions. The plot indicates that evolution is an important factor in predicting total stats and thus needs to be controlled for.

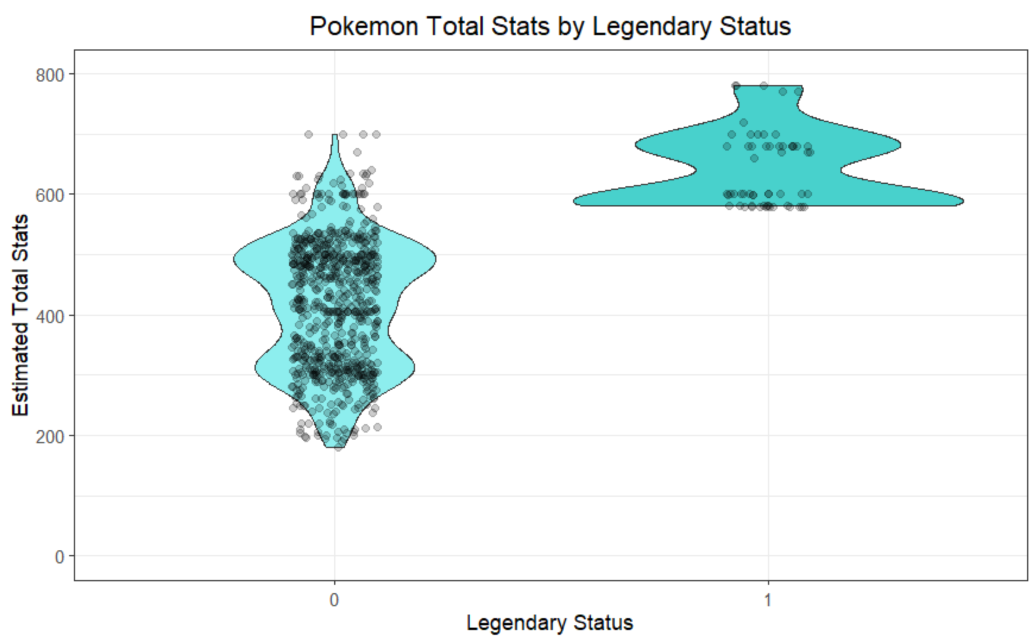

Figure 4: Enhanced Violin Plot of Pokémon Total Stats by Legendary Status. Side-by-side violin plots were created to compare the total stats, not adjusted, for Pokémon that are and are not legendary. Legendary status is 1 if the Pokémon is legendary, and 0 if not. The plot indicates that legendary status is an important factor in predicting total stats and thus needs to be controlled for.

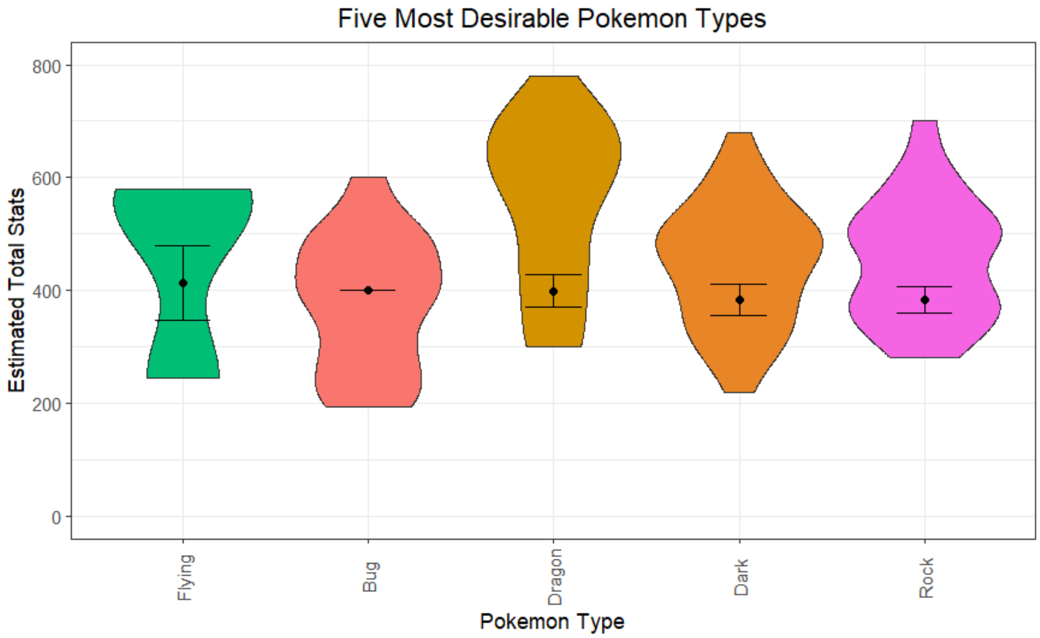

Figure 5: Enhanced Violin Plot of Total Stats by Type for the 5 Most Desirable Pokémon. Side-by-side violin plots were created to compare the total stats, not adjusted, for the 5 most desirable Pokémon types starting with the overall most desirable type. 95% confidence intervals, which have been adjusted for evolution and legendary status, are overlaid on each violin.

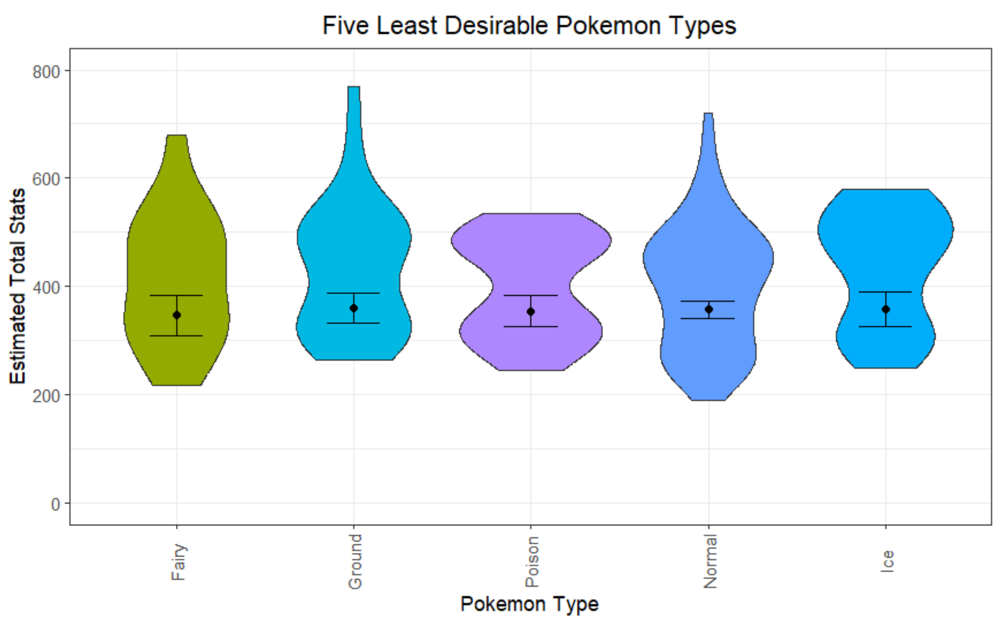

Figure 6: Enhanced Violin Plot of Total Stats by Type for the 5 Least Desirable Pokémon. Side-by-side violin plots were created to compare the total stats, not adjusted, for the 5 least desirable Pokémon types starting with the overall least desirable type. 95% confidence intervals, which have been adjusted for evolution and legendary status, are overlaid on each violin.

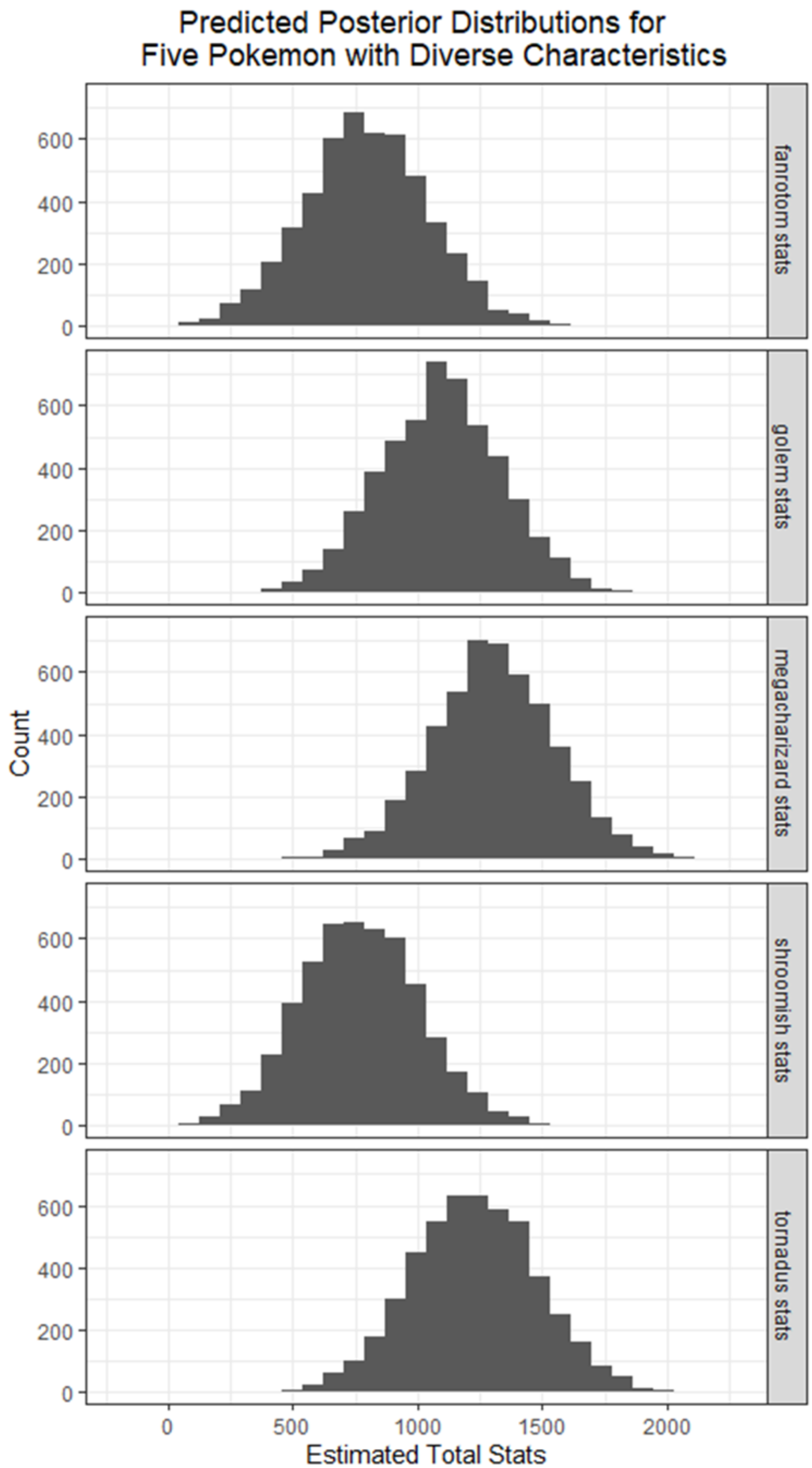

Figure 7: Posterior Predictive Distributions for Five Selected Pokémon.
Posterior Predictive plots were faceted by Pokémon to assess how well the model predicts total stats based on type, evolution, and legendary status.

Tables

Table I: Pokémon Variables and Definitions

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	Description
Dependent Variables	
Total	Sum of all stats, a measure of overall strength
Independent Variables	
Pokémon Type	Pokémon category
HP	How much damage a Pokémon can withstand
Attack	Base modifier for normal attacks
Defense	Damage resistance against normal attacks
Special Attack	Modifier for type-specific attacks
Special Defense	Resistance against opposing Pokémon's type-specific attacks
Speed	Pokémon with the higher speed attacks first
Legendary	= 0, 1; if the Pokémon is legendary
Generation	Generation the Pokémon was first seen in
Evolution	Pokémon's evolution

Table II: Priors and Justifications by Pokémon Type

Table II. Pokémon Types, Priors, and Justifications

Pokémon Type	N	Priors	Justification
Bug	69	$\mu_{bug} \sim N(400, 100)$	Bug types are below average, there is low assurance in this though.
Dark	31	$\mu_{dark} \sim N(475, 100)$	Dark types are slightly better than average, there is low assurance in this
Dragon	32	$\mu_{dragon} \sim N(575, 50)$	Dragon types are very good, high assurance in this answer.
Electric	43	$\mu_{electric} \sim N(450, 75)$	Electric types are average, average assurance in this answer.
Fairy	17	$\mu_{fairy} \sim N(400, 100)$	Fairy types are below average, there is low assurance in this.
Fighting	27	$\mu_{fighting} \sim N(475, 75)$	Fighting types are slightly above average, average assurance
Fire	52	$\mu_{fire} \sim N(475, 75)$	Fire types are slightly above average, average assurance
Flying	3	$\mu_{flying} \sim N(500, 50)$	Flying types are good, high assurance in this answer
Ghost	25	$\mu_{ghost} \sim N(450, 75)$	Ghost types are average, average assurance in this answer
Grass	70	$\mu_{grass} \sim N(425, 75)$	Grass types are below average, average assurance in this answer
Ground	31	$\mu_{ground} \sim N(425, 75)$	Ground types are below average, average assurance in this answer
Ice	24	$\mu_{ice} \sim N(450, 75)$	Ice types are average, average assurance in this answer.
Normal	98	$\mu_{normal} \sim N(400, 25)$	Normal types are far below average, high assurance in this answer.
Poison	28	$\mu_{poison} \sim N(425, 75)$	Poison types are below average, average assurance in this answer.
Psychic	53	$\mu_{psychic} \sim N(475, 75)$	Psychic types are slightly above average, average assurance in this
Rock	44	$\mu_{rock} \sim N(425, 75)$	Rock types are below average, average assurance in this
Steel	26	$\mu_{steel} \sim N(450, 75)$	Steel types are average, average assurance in this answer
Water	111	$\mu_{water} \sim N(450, 75)$	Water types are average, average assurance in this answer
σ^2		$\sigma^2 \sim Unif(0, 1000^2)$	Average stats vary a lot by type, so we would like the upper bound to be as large as possible.
Controls			
Legendary	58	$\mu_{leg} \sim N(100, 100)$	Legendary Pokémon are all quite a bit stronger than normal Pokémon, low assurance in this.
Evolution	4	$\mu_{evolution} \sim N(50, 100)$	A Pokémon evolving increases its stats greatly, though there is low assurance in this.

Table III: Mean Total State and Pokémon Count by Evolution

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Evolution	Pokémon Count	Mean Total Stats
1	376	377.67
2	289	463.13
3	103	522.29
4	16	633.94

Table IV: Estimate Average Total Stats by Type, after controlling for Evolution and Legendary status.

Table IV. Estimated Average Total Stats by Type, Evolution and Legendary Controls

Pokemon Type	Mean Total Stats	95% Confidence Interval
Bug	399.99	(399.80, 400.18)
Dark	382.90	(355.22, 411.38)
Dragon	398.78	(370.78, 427.48)
Electric	365.00	(341.46, 389.49)
Fairy	346.37	(309.49, 383.45)
Fighting	362.99	(334.03, 392.81)
Fire	362.62	(340.80, 384.54)
Flying	412.18	(346.81, 478.31)
Ghost	366.56	(336.02, 397.10)
Grass	347.68	(328.59, 366.81)
Ground	359.23	(331.70, 386.55)
Ice	358.30	(326.57, 389.14)
Normal	356.81	(341.36, 372.18)
Poison	354.53	(325.85, 383.37)
Psychic	362.39	(340.40, 385.15)
Rock	382.85	(359.37, 406.96)
Steel	377.10	(347.23, 407.62)
Water	362.62	(347.25, 378.04)

Table V: Details on the Type, Evolution, and Legendary Status for the Five Selected Pokémon.

Table V. Posterior Check

Pokémon	Type	Legendary Status	Evolution	Total Stats	P(Est. Total Stats>500)
Fan Rotom	Electric	0	2	520	0.892
Shroomish	Grass	0	1	295	0.992
Golem	Ground	0	3	495	0.999
Mega Charizard	Fire	0	4	634	0.859
Tornadus	Flying	1	1	580	0.997