TL; DR

"Stats" are numbers used to determine outcomes in battles. There are seven types of stats listed in Table 1. They depend on:

- Base stat (Table 2)
- DNA base pair count (Figure 2)
- Genetic mutations (Table 3)
- Level (Figures 5, 6, 7, and 9)

0.1 Keys

This chapter contains a bit of basic (Algebra-II–level) math. Most mathematical symbols will not be explained in detail, but two useful definitions are below:

$$\lceil x \rceil \rightarrow \text{The } \texttt{ceil} \text{ function} \qquad \text{[Round “x” up]}$$
$$\lfloor x \rfloor \rightarrow \text{The } \texttt{floor} \text{ function} \qquad \text{[Round “x” down]}$$

On a technical note, the arguments of the traditional `floor` and `ceil` functions are first rounded to three decimal places to account for float imprecision.

There are seven types of stats that affect combat. These may be seen in Table 1 below.

Stat Types

Full Name	Short Name	Description
HP	HP	Health
Physical Attack	PhA	Physical offensive ability, such as strength
Physical Defense	PhD	Physical defensive ability, such as toughness
Special Attack	SpA	Noncorporeal offensive ability, such as mentality
Special Defense	SpD	Noncorporeal defensive ability, such as willpower
Haste	Hst	Reduces cast and cooldown time
Critical Hit	Crt	Chance to increase damage

Table 1: The stat types used throughout this document.

These closely resemble the Pokémon stats [1], with the "physical" attack and defense being explicitly named. However, there are a couple of exceptions:

- Since this is not a turn-based game, there is no Speed stat.

- Instead, there is a Haste stat, which affects cooldown timers and cast times. The Haste equation can be seen in Eq. (4) on page 11. Moreover, an example table may be seen in Table 8 on page 13.

- While Pokémon have an implicit Crit stat, the value is the same for all Pokémon. This is not true for Monsters, who have an explicit Critical Hit stat.

Table 2 displays the color scheme used throughout this document in regards to stat *quality* rather than type. The quality is also loosely based on Pokémon stats [1].

Stat Quality

Base Stat	Description
0	Minimum
50	Bad
100	Average
120	Good
150	Specialist
200	Boss

Table 2: The color key used throughout this document. Each color corresponds to a different level of "goodness".

Table 2 comes with the following design notes:

- No Monster's base stat will be below zero at any time.

- "Average" will ideally be just that: nearly the average of all Monsters' base stats in that category. For example, all (obtainable) Monsters combined will have an average HP close to 100.

- A "Specialist" will usually be required to give up another stat. For example, if a Monster has a base HP of 150, they should have a base PhD of 50 to preserve the average.
  - This may not be true if the typing, movepool, or aura of the Monster is bad. In that case, the Monster needs good stats in order to be viable.
  - The same is true for Monsters that have *too* good of a movepool or aura; their stats may be justified in being low across the board.

- A "Boss" base stat certainly may exceed 200. However, by design no obtainable Monster should regularly have a base stat of 200.

0.2 Base Pairs

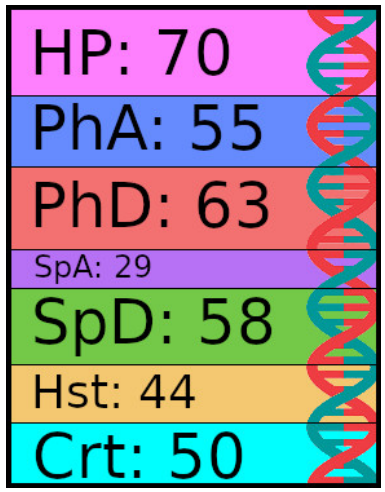


Figure 1: Mockup of the idea that the stats are linked to genes and that the strength of each stat comes from how many base pairs make up the gene.

In addition to the base stat, there are also "base pairs," which augment the base stat. Each stat type has a different base pair count (think DNA), and the number of base pairs can vary from 1–100 (inclusive). Base stats are similar to "IVs" from the Pokémon series [1]. See, e.g., Eq. (2). Specifically, the base pairs contribution to the base stats has the form in Eq. (1).

$$\left(\frac{\texttt{pairs}}{100}\right)^{0.25} \tag{1}$$

An example plot of base pairs vs. Physical Attack may be seen below in Figure 2.

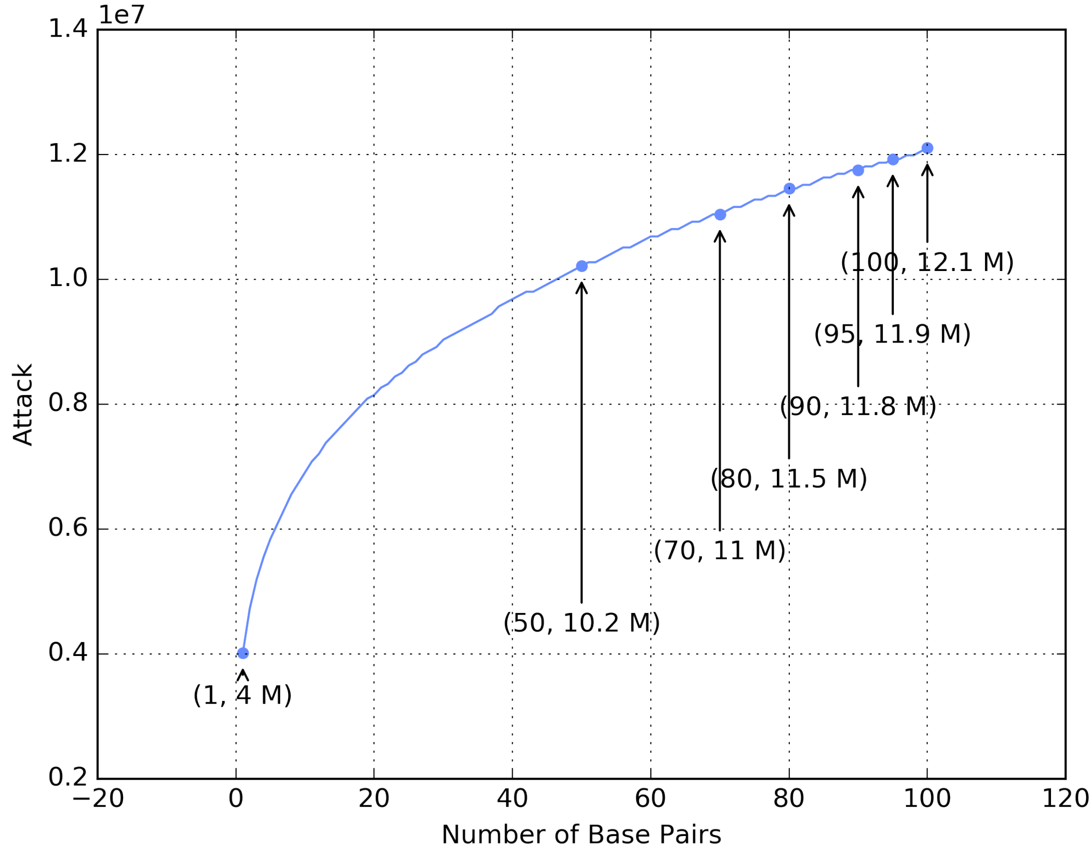


Figure 2: Base pair count vs. the Physical Attack stat for a Monster at level 100 with an average base Physical Attack (100). The "wiggles" in the plot are from the way PhA is calculated (via floor function; see Eq. (2)).

In Figure 2, one may observe that the minimum is fairly forgiving, still yielding 1/3 of the full effect. The returns saturate at around 90 base pairs, which yield 97% of the full effect. Therefore, if one desires a Monster with "almost perfect" (within 3% of perfect) base pairs in 5 out of the 7 stat types, there is a $0.10^5 = 0.00001\% = 1/100,000$ chance. Is that too much grinding? Well, those numbers can be changed by talents and other methods mentioned in the "grinding and difficulty" section in another chapter.

Base pairs are generated uniformly by default. That is, every randomly-generated Monster has an equal chance of having a base pair count of 100 or a base pair count of 1 for each stat type. However, the distributions of individual Monster GameObjects may be altered to increase the likelihood of base pairs (such as a gift Monster, the starter Monsters, or a promotional Monster) or to decrease the likelihood of base pairs (I'm not sure why you would want to do that).

0.3 Mutations

Similar to a Pokémon's Nature [1], a Monster may have genetic mutations in its stats genome. It may be thought of as additional base pairs in a particular stat or a separate entity altogether; the concept is still in its infancy and will likely grow and change. However, the idea is that there should be another randomizer that may be pseudo-controlled by talents that makes a Monster unique. Below is a table of the current ideas.

Mutations List

Mutation	Pro	Con
None	—	—
Berserker Gene	+15% PhA	−10% PhD −10% SpD
Gigantism	Max height, weight	—

Figure 3: List of current mutation ideas.

Currently, they are somewhat boring. However, they should not be too wild—that is what talents are for. For the remainder of the document, assume that there is no mutation.

0.4 The Standard Stat

The "standard" stat refers to the common set of stats that all follow the same rule. Explicitly, these are:

- PhA
- PhD
- SpA
- SpD

The equation for the caclulation of standard stats is based on Pokémon stats [1], but with key differences.

$$\texttt{stat} = \left\lfloor 2 \cdot \texttt{base} \cdot \left(\frac{\texttt{pairs}}{100}\right)^{0.25} \cdot \frac{\texttt{level}}{100} + 5 \right\rfloor \times 3^{\left\lfloor \frac{\texttt{level}}{10} \right\rfloor} \tag{2}$$

One may immediately notice a few differences between Eq. (2) and the stat equation in [1]:

- The lack of EVs and IVs:

  - EVs were customizations that the player could choose, and are replaced by talents.
  - IVs were radomly generated and served to make each Pokèmon unique. These have been replaced by base pairs.

- The factor of $3^{\left\lfloor \frac{\texttt{level}}{10} \right\rfloor}$. This is referred to as the "stat jump" that occurs every ten levels. There are a few reasons for this factor, but two are immediately clear:
  - Pacing control for the developer
  - Something for the player to look forward to every ten levels

Effectively, the stats nearly triple every ten levels. Therefore, a level 20 Monster has roughly a 3x advantage over a level 19 Monster, as seen below in Figure 4 and Table 3.

The range of level 1–20 are especially important, as it is hoped that the player is "hooked" during this delicate time.

Data for all levels and selected base pairs may be seen in Figure 5, which is also below. In this figure, it is important to note that a good (base stat 120) Monster with the maximum number of base pairs (100 base pairs) is similar to a specialist (base stat 150) with an average number of base pairs (50 base pairs). In practice, this may put an over-emphasis on getting good base pairs, but that data will only come with playtesting. For now, it is assumed that an informed player (i.e., level 30+) will understand this importance and grind accordingly as difficulty dictates.

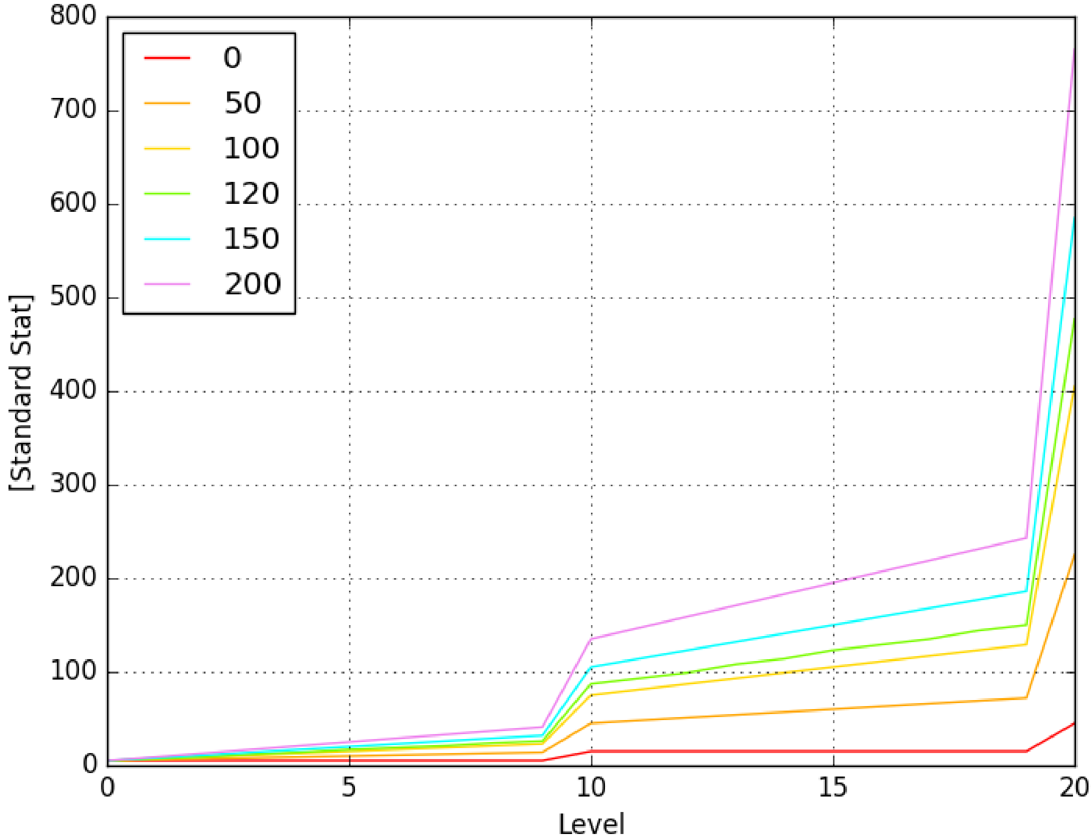


Figure 4: The early game plot of a standard stat by level for a base pair value of 100.

[Standard Stat]

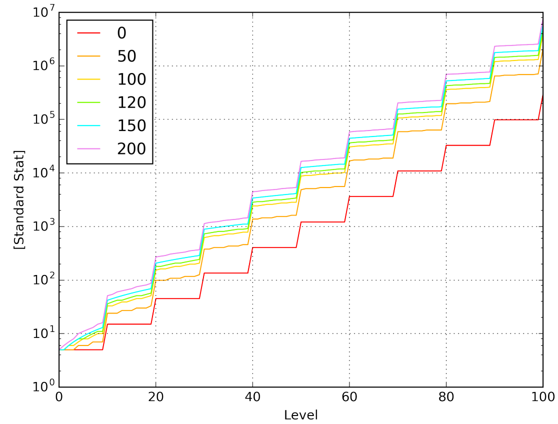
	Level				
Base Stat	1	9	10	19	20
0	5	5	15	15	45
50	6	14	45	72	225
100	7	23	75	129	405
120	7	26	87	150	477
150	8	32	105	186	585
200	9	41	135	243	765

Table 3: The early game table of a standard stat by level for a base pair value of 100.

Standard-stat: 1 Base Pair [min]

[Standard Stat]

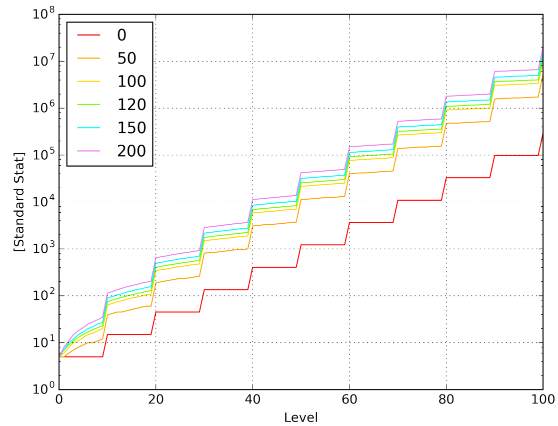
	Level		
Base Stat	20	50	100
0	45	1.2 k	295.2 k
50	99	4.9 k	2.1 M
100	153	8.7 k	4 M
120	180	10.2 k	4.7 M
150	207	12.6 k	5.8 M
200	270	16.5 k	7.7 M



Standard-stat: 50 Base Pairs [average]

[Standard Stat]

	Level		
Base Stat	20	50	100
0	45	1.2 k	295.2 k
50	189	11.4 k	5.3 M
100	342	21.6 k	10.2 M
120	405	25.5 k	12.2 M
150	495	31.8 k	15.2 M
200	648	42 k	20.1 M



Standard-stat: 100 Base Pairs [max]

[Standard Stat]

	Level		
Base Stat	20	50	100
0	45	1.2 k	295.2 k
50	225	13.4 k	6.2 M
100	405	25.5 k	12.1 M
120	477	30.4 k	14.5 M
150	585	37.7 k	18 M
200	765	49.8 k	23.9 M

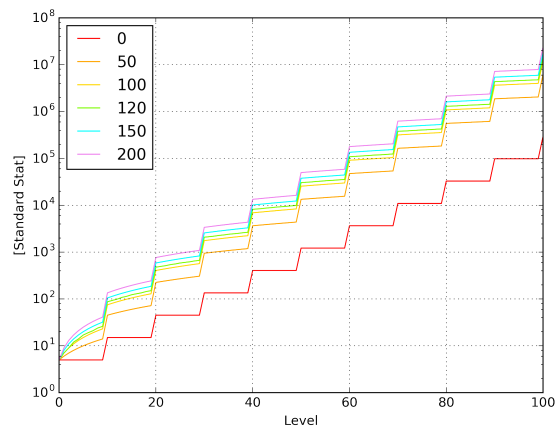


Figure 5: An overview of the so-called "standard" stat for base pair values of 1, 50, and 100.

0.5 HP

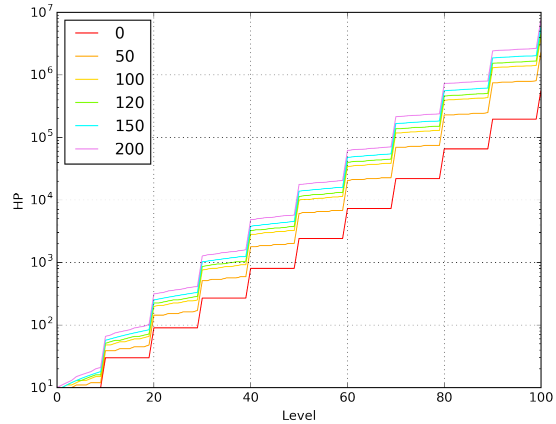
The HP stat is quite close to the standard stat, being calculated as shown in Eq. (3) below.

$$\mathtt{HP} = \left\lfloor 2 \cdot \mathtt{base} \cdot \left(\frac{\mathtt{pairs}}{100}\right)^{0.25} \cdot \frac{\mathtt{level}}{100} + 10 \right\rfloor \times 3^{\left\lfloor \frac{\mathtt{level}}{10} \right\rfloor} \tag{3}$$

Even though the only difference between Eqs. (2) and (3) is (+10) instead of (+5), it makes a large difference in raw values, as seen by Figure 6.

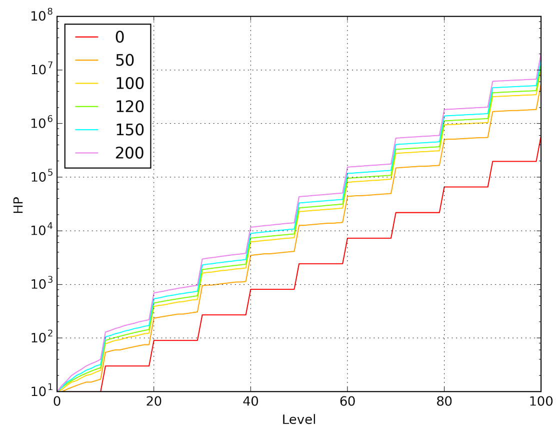
HP: 1 Base Pair [min]

HP			
	Level		
Base Stat	20	50	100
0	90	2.4 k	590.5 k
50	144	6.1 k	2.4 M
100	198	10 k	4.3 M
120	225	11.4 k	5 M
150	252	13.9 k	6.1 M
200	315	17.7 k	8 M



HP: 50 Base Pairs [average]

HP			
	Level		
Base Stat	20	50	100
0	90	2.4 k	590.5 k
50	234	12.6 k	5.6 M
100	387	22.8 k	10.5 M
120	450	26.7 k	12.5 M
150	540	33 k	15.5 M
200	693	43.3 k	20.4 M



HP: 100 Base Pairs [max]

HP			
	Level		
Base Stat	20	50	100
0	90	2.4 k	590.5 k
50	270	14.6 k	6.5 M
100	450	26.7 k	12.4 M
120	522	31.6 k	14.8 M
150	630	38.9 k	18.3 M
200	810	51 k	24.2 M

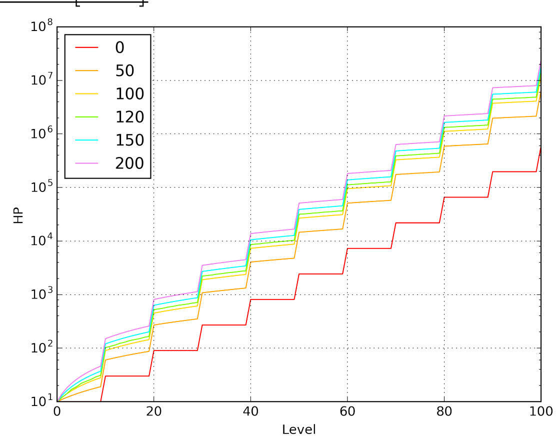


Figure 6: An overview of the HP stat for base pair values of 1, 50, and 100.

0.6 Haste

Haste reduces both cooldown and cast time via

$$\texttt{Time} = \frac{\texttt{Base Time}}{1 + \texttt{Haste}/100} \tag{4}$$

Haste is calculated by

$$\texttt{Haste} = \texttt{level} \cdot \left(\texttt{A} \cdot \texttt{base}^2 \cdot \left(\frac{\texttt{pairs}}{100} \right)^{0.25} + \texttt{B} \cdot \left\lfloor \frac{\texttt{level}}{10} \right\rfloor \right) \tag{5}$$

where

$$\begin{aligned} \texttt{A} &= 0.00002 && \text{[Base stat scaling factor]} \\ \texttt{B} &= 0.017 && \text{[Level scaling factor]} \end{aligned}$$

A similar overview for all levels and a selection of base pairs can be seen in Figure 7. The selection for these particular values for `A` and `B` require observing the 100 base pairs case of Figure 7. Here, the targets were:

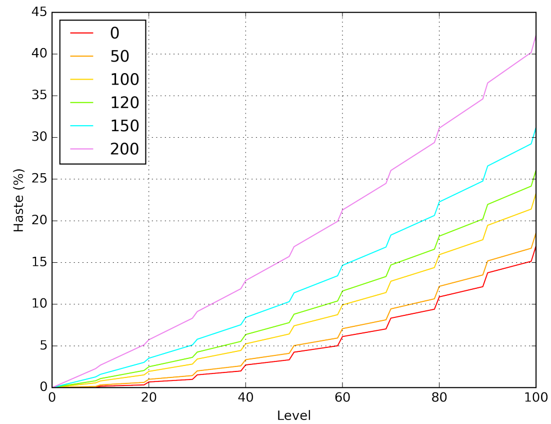
- "Average" at level 100 should have around 33% Haste
- "Good" at level 100 should have around 50% Haste
- A "specialist" at level 100 should have around 66% Haste
- A "specialist" at level 20 should start to see the advantage of having high Haste
- A "boss" at level 100 should have a "large" amount of Haste compared to the other categories

With these criteria in mind, the form of Eq. (5) was chosen, along with `A` and `B`. A player's point-of-view example can be seen in Table 8.

Haste: 1 Base Pair [min]

Haste (%)

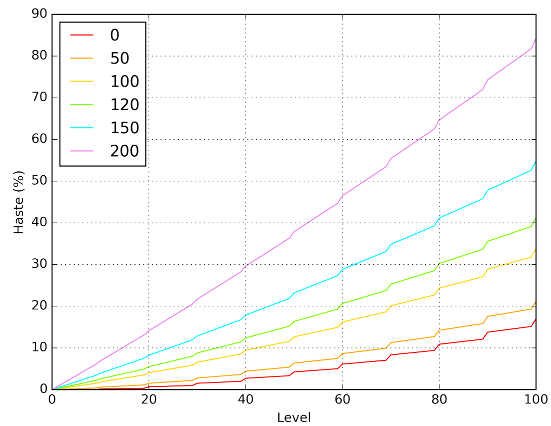
Base Stat	Level 20	Level 50	Level 100
0	0.7	4.2	17
50	1	5	18.6
100	1.9	7.4	23.3
120	2.5	8.8	26.1
150	3.5	11.4	31.2
200	5.7	16.9	42.3



Haste: 50 Base Pairs [average]

Haste (%)

Base Stat	Level 20	Level 50	Level 100
0	0.7	4.2	17
50	1.5	6.4	21.2
100	4	12.7	33.8
120	5.5	16.4	41.2
150	8.2	23.2	54.8
200	14.1	37.9	84.3



Haste: 100 Base Pairs [max]

Haste (%)

Base Stat	Level 20	Level 50	Level 100
0	0.7	4.2	17
50	1.7	6.8	22
100	4.7	14.3	37
120	6.4	18.7	45.8
150	9.7	26.8	62
200	16.7	44.2	97

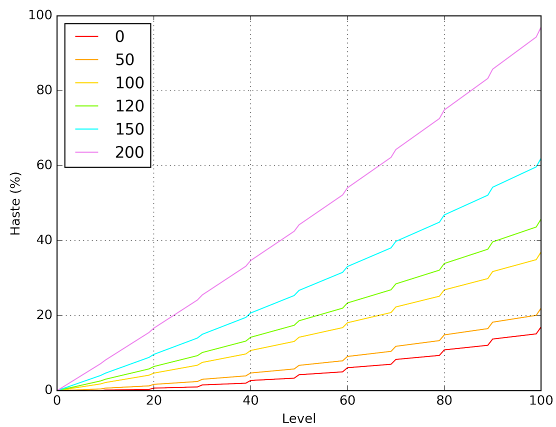


Figure 7: The Haste stat for base pair values of 1, 50, and 100.

Haste CD Reduction
Base CD: 10s

Base Stat at Lv. 100	New Cooldown
0	8.5
50	8.2
100	7.3
120	6.9
150	6.2
200	5.1

Figure 8: The new cooldowns (CDs) for an ability that usually has a cooldown of 10 s. The calculation assume that the Monster is at level 100 and has 100 base pairs.

0.7 Critical Hit

Like Haste, the Critical Hit stat is displayed as a percentage-based stat, and so the scaling of the standard stat does not apply. However, while Haste represents a catch-all "fun" or "quality of life" mechanic (only making matches faster for equal opponents), the Critical Hit stat is more niche:

- The Critical Hit stat represents the chance that an attack will be "critical".
- "Critical" damage is normally increased by 1.5x. However, that value may change with talents, auras, buffs, or on a Monster-by-Monster basis.
- "Critical" damage ignores defensive buffs. Therefore, Monsters who specialize in the Critical Hit stat are wallbreakers who must have some drawback against non-walls.
- If the Critical Hit stat is above 100%, the critical damage is increased instead by that amount. For example, if a Monster has 120% Critical Hit, the "critical" damage is guaranteed and it deals 1.7x instead of 1.5x. This is so that players have a route to be heavy-handed on stacking the Critical Hit stat should they so choose.

The Critical Hit forumla is the most complicated of all, and hence may be the most difficult to balance. It can be seen below by Eq. (6):

$$\texttt{Critical Hit} = 0.8 \cdot \left(\texttt{C}_{\lceil 10 \rceil} - \texttt{C}_{\lfloor 10 \rfloor}\right) \cdot \frac{\texttt{level} - \texttt{L}_{\lfloor 10 \rfloor}}{10} + \texttt{C}_{\lfloor 10 \rfloor} \tag{6}$$

From this, it can be seen that Critical Hit is interpolated at 80% (and based on level between two constants): $\texttt{C}_{\lfloor 10 \rfloor}$ and $\texttt{C}_{\lceil 10 \rceil}$. These are called the `Sub-Crit` functions.

$$\begin{aligned}
\texttt{C}_{\lfloor 10 \rfloor} &= \texttt{Sub-Crit} \text{ evaluated at } (\texttt{level} = \texttt{L}_{\lfloor 10 \rfloor}) \\
\texttt{C}_{\lceil 10 \rceil} &= \texttt{Sub-Crit} \text{ evaluated at } (\texttt{level} = \texttt{L}_{\lceil 10 \rceil}) \\
\texttt{L}_{\lfloor 10 \rfloor} &= 10 \cdot \left\lfloor \frac{\texttt{level} + 0.1}{10} \right\rfloor && \text{[The previous decalevel]} \\
\texttt{L}_{\lceil 10 \rceil} &= 10 \cdot \left\lceil \frac{\texttt{level} + 0.1}{10} \right\rceil && \text{[The next decalevel]}
\end{aligned}$$

The `Sub-Crit` function is defined as "the Critical Hit every ten levels", which is shown by Eq. (7):

$$\texttt{Sub-Crit} = \texttt{A} \cdot \texttt{base}^{\texttt{B}} \cdot \left\lceil \frac{\texttt{level}}{10} \right\rceil \cdot \left(\frac{\texttt{pairs}}{100}\right)^{0.25} + \texttt{C} \left\lfloor \frac{\texttt{level}}{10} \right\rfloor \tag{7}$$

where

$$\begin{aligned}
\texttt{A} &= 0.0000000036 && \text{[Base stat scaling factor]} \\
\texttt{B} &= 4.2 && \text{[Base stat exponential factor]} \\
\texttt{C} &= 0.625 && \text{[Level scaling factor]}
\end{aligned}$$

Of course, if the Critical Hit stat would ever be negative, it would instead be zero.

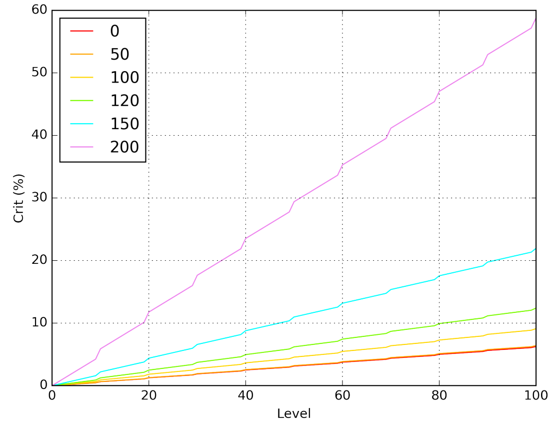
True Pokéfans will be able to deduce the significance of the constant $\texttt{C} = 0.625$: at the minimal base stat of zero, the Critical Hit is 6.25%—the very value of the hidden stat in the main series games. The other two constants, `A` and `B`, were chosen with the 100 base pairs case of Figure 9 in mind:

- The "average" at level 100 is not over 20% (although it could stand to be much lower)
- "Good" at level 100 is considered a 1 in 4 chance to crit
- A "specialist" at level 100, who no doubt relies heavily on critical hits, has at least a 50% chance to crit
- A "specialist" at level 20 who is still considered "early game" should start to see the advantage of crits coming once every 10 hits

Crit: 1 Base Pair [min]

Crit (%)

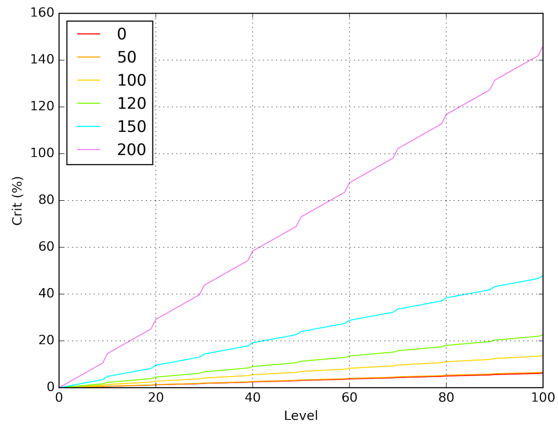
	Level		
Base Stat	20	50	100
0	1.2	3.1	6.2
50	1.3	3.2	6.4
100	1.8	4.6	9.1
120	2.5	6.2	12.4
150	4.4	11	21.9
200	11.8	29.4	58.8



Crit: 50 Base Pairs [average]

Crit (%)

	Level		
Base Stat	20	50	100
0	1.2	3.1	6.2
50	1.3	3.3	6.7
100	2.8	6.9	13.9
120	4.5	11.3	22.6
150	9.6	24	48
200	29.2	73	146



Crit: 100 Base Pairs [max]

Crit (%)

	Level		
Base Stat	20	50	100
0	1.2	3.1	6.2
50	1.3	3.4	6.7
100	3.1	7.6	15.3
120	5.1	12.8	25.7
150	11.2	27.9	55.9
200	34.5	86.2	172.4

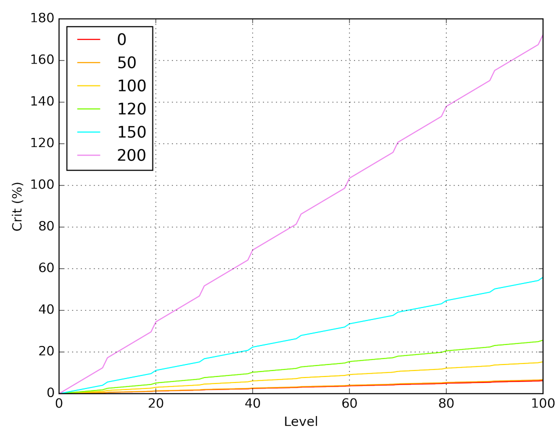


Figure 9: The Critical Hit stat for base pair values of 1, 50, and 100.

0.8 Levels and Experience

Levels are a truncation of cumulative experience points (CXP). That is,

$$\texttt{level} = \left\lfloor \texttt{CXP}^{1/3} \right\rfloor \tag{8}$$

or

$$\texttt{Minimum CXP} = \texttt{level}^3 \tag{9}$$

The experience required for a single level, then, is

$$\texttt{Exp Required to Level} = (\texttt{level} + 1)^3 - \texttt{level}^3 \tag{10}$$

As an example, level 100 requires one million experience points. Is this too many? Well, that depends on how experience is doled out.

$$\texttt{Exp Yield} = \texttt{b} * \Delta\texttt{L} * \frac{\texttt{Exp Required to Level}}{\texttt{A} + \texttt{B} * \texttt{level} + \texttt{C} * \texttt{level}^3} \tag{11}$$

Here,

$$\begin{aligned}
\texttt{b} &= \texttt{base exp yield} && \text{[Normally 1]} \\
\Delta\texttt{L} &= 1.5^{\lfloor \texttt{level difference/2} \rfloor} && \text{[Level Difference Boost]} \\
\texttt{A} &= 0.7 && \text{[Early-Game Factor]} \\
\texttt{B} &= 0.2 && \text{[Mid-Game Factor]} \\
\texttt{C} &= 0.00006 && \text{[End-Game Factor]}
\end{aligned}$$

$\texttt{b}$ is on a Monster-by-Monster basis and can also be changed with settings (e.g., "grind" amount).

$\Delta\texttt{L}$ rewards the player for "punching up" and taking on higher level Monsters. If an enemy's level is +2 higher than the player, the player receives +50% more experience; if the enemy is at +4, this increases to +125%; and so on. This number caps at +10 levels ($1.5^5 = 7.59 = +660\%$) and bottoms at zero.

$\texttt{A}$, $\texttt{B}$, and $\texttt{C}$ have been chosen by tuning Figures 10 and 11. Here, the number of KOs to level has been found via

$$\begin{aligned}
\texttt{Num KOs to Level} &= \frac{\texttt{Exp Required to Level}}{\texttt{Exp Yield}} \\
&= \frac{\texttt{A} + \texttt{B} * \texttt{level} + \texttt{C} * \texttt{level}^3}{\texttt{b} * \Delta\texttt{L}}
\end{aligned}$$

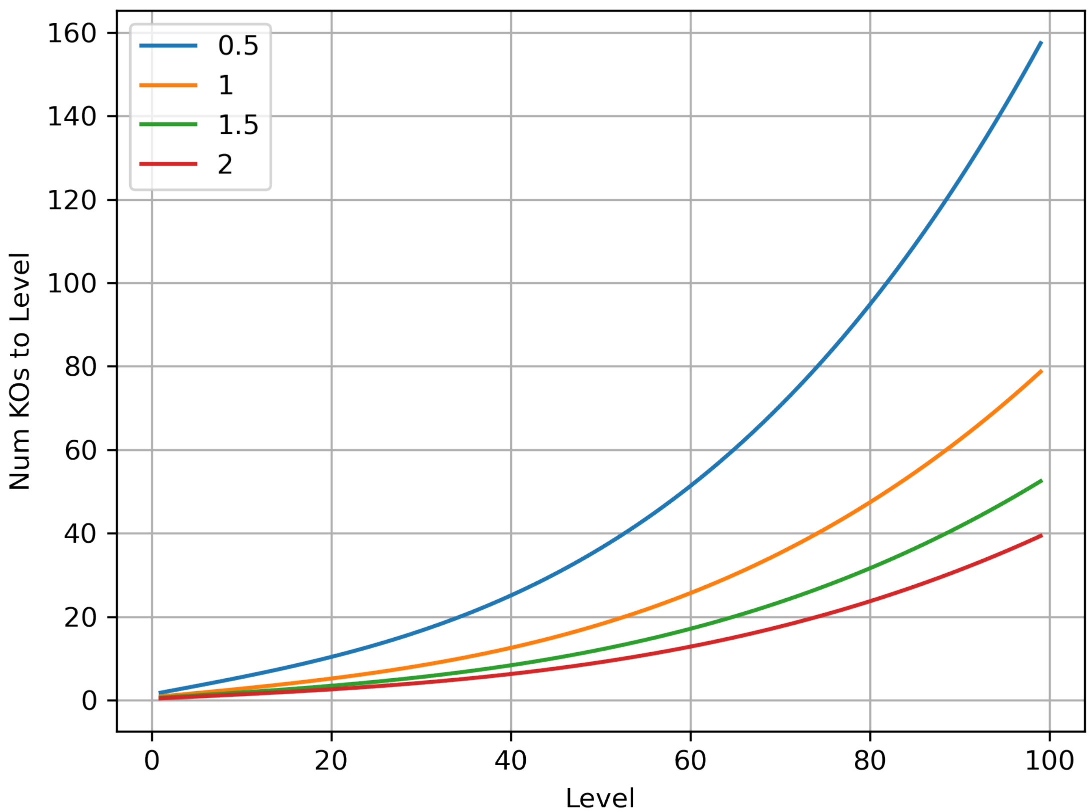


Figure 10: Number of Monsters of equal level to KO in order to level up. For example, assuming a base yield of 1, a Monster at level 50 must KO 18.2 level-50-Monsters in order to reach level 51.

Num KOs to Level

	Level						
Base Exp Yield	1	5	10	20	49	50	99
0.5	1.8	3.4	5.5	10.4	35.1	36.4	157.4
1	0.9	1.7	2.8	5.2	17.6	18.2	78.7
1.5	0.6	1.1	1.8	3.5	11.7	12.1	52.5
2	0.5	0.9	1.4	2.6	8.8	9.1	39.4

Figure 11: Number of Monsters of equal level to KO in order to level up. For example, assuming a base yield of 1, a Monster at level 50 must KO 18.2 level-50-Monsters in order to reach level 51.

Of course, it's also useful to see the numbers if the player is punching up at a +2 level difference:

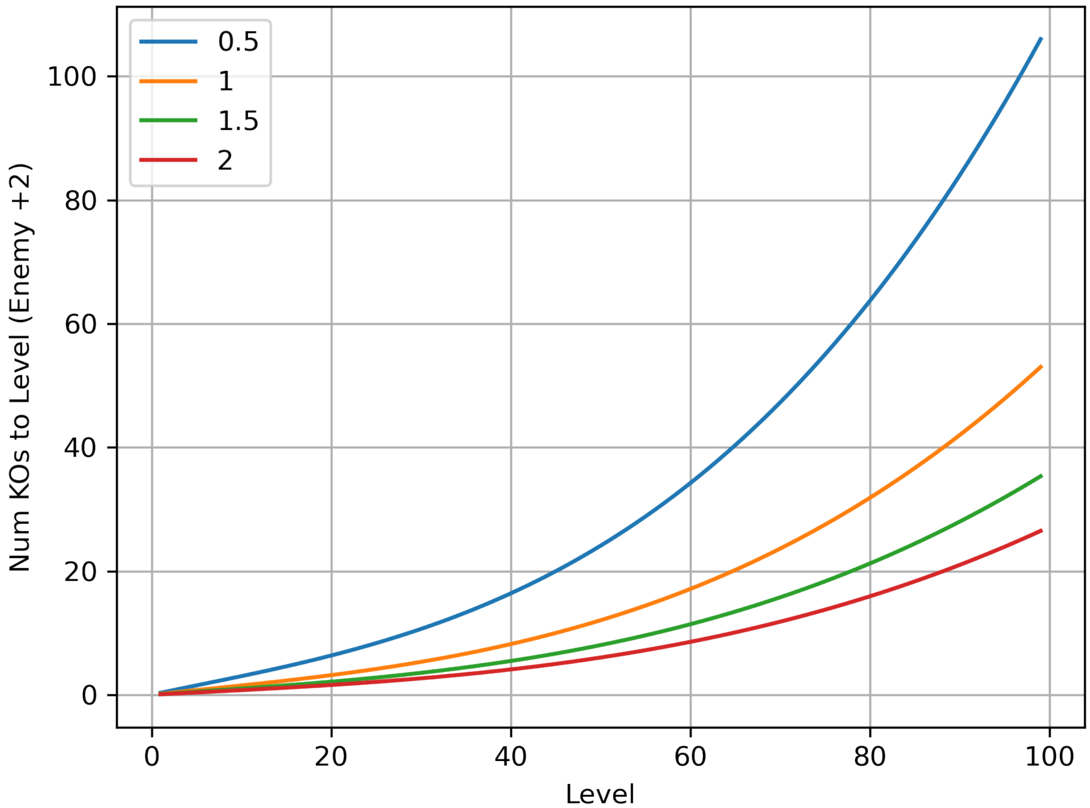


Figure 12: Figure 10, but with the enemy at +2 levels.

Num KOs to Level (Enemy +2)

	Level						
Base Exp Yield	1	5	10	20	49	50	99
0.5	0.3	1.5	3	6.4	23.2	24.1	106
1	0.2	0.8	1.5	3.2	11.6	12.1	53
1.5	0.1	0.5	1	2.1	7.7	8	35.3
2	0.1	0.4	0.8	1.6	5.8	6	26.5

Figure 13: Figure 11, but with the enemy at +2 levels.

Bibliography

[1] E. Gildardo Sanchez-Ante, “Sistemas Inteligentes: Reportes Finales Ago-Dic 2013,” *Reporte Tecnico RT-0002-2013*, Dec. 2013, page 140.