# An investigation of genetic potential progression

*An exploration of the currently accepted formulas that attempt to explain the magnitude of GP gains for horses & ponies on Howrse and how GP gains are affected by factors such as BLUP.*

Written during January 2015

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*Glossary of Terms*

| | |
|---|---|
| *GP* | Genetic Potential of a horse or pony |
| *Low GP* | A GP that is well below the top GP on a server (at least less than 40% of the top GP) |
| *High GP* | A GP that is close to the top GP on a server (at least within the top 20% or better) |
| *Top GP* | A GP that is the best on the server at any given time |
| *GP Gain* | The difference in GP between a foal and the average GP of its parents |
| *BLUP* | The BLUP level of a horse (this investigation initially assumes all horses used in every example to have 100 BLUP) |
| $\pm$ | Plus or minus |
| *Breeder* | A player who breeds horses |
| *Top breeder* | A player who breeds horses that have the best or close to the best GP on a particular server |
| *Foundation or Foundation horse* | A horse without player bred parents that has a GP of 350.00 (usually) |

*Introduction*

I preface this investigation with the admission that the practical use in having an accurate GP gain formula is fairly minimal, except in cases where one is calculating such things as use of breeding resources (aging points) over a large GP range. For most purposes, simply understanding that the GP of a foal will be an improvement over its parents irrespective of the average BLUP is sufficient to most players, but understanding how the magnitude of that improvement changes based on certain conditions is important and has been shown to be misinterpreted by the wider community.

This investigation seeks to disprove the currently accepted widespread theories and formulas for predicting GP gains, and proposes a new formula that is constructed step-by-step for the reader with significant research having been done to ensure the accuracy of the theories proposed by the author. By the end of this investigation a near-accurate GP gain formula is presented along with a further discussion of its weaknesses and the research that still needs to be done. By no means does the author of this investigation advocate their new theories as being officially accepted by the employees and creators of Howrse, and only wishes to provide some enlightenment and demonstrate the patterns that are visible as a result of what anyone can observe on the game.

*The Currently Accepted Theory*

The currently accepted and albeit official theory for the calculation of GP gains is that the GP gain is +1.2 GP ± some random variance. Some claim the random variance to be ± 4 or ± 4%, whereas others do not state the specific parameters of the random factor. The underlying problem with this accepted calculation is that however official it is, it's not remotely helpful in making even a semi-precise GP gain calculation.

There is a distinct possibility that this official formula was formulated based on the old mechanics of the game, where an increase of 1.2 GP was possible after the foal was born via the foal games. When this was changed, it may have been seen as easier to simply explain the new formula using the numerical figures (1.2) that people already knew, and that it wasn't the accuracy of the new formula that was seen as important, only that the concept of always getting a gain.

Whether the above is correct or not remains a mystery for the moment however it can be demonstrated that the currently accepted theory is inaccurate, and that it's possible to develop a new theory and formula through observation. There are likely other theories that have been put forth by players, however in almost all cases over the past few weeks, questions pertaining to the GP gain calculation have been met by the currently accepted formula except in cases when the author of this investigation has attempted to say otherwise.

*Disproving The Current Theory*

To start with, the GP gains that you receive when your GP is within the top percentage of the game is less than 1.2, and depending on the server it can be a lot less (0.05, 0.4). Many players seem adamant that there's an 'automatic 1.2 gain', and only when they're challenged and or reminded of the lower than 1.2GP gains suffered by top breeders do they then pull out the 'plus or minus a random factor' card.

The random variance number that is most popularly used is '4', and whether this actually means 4 as in ± 4GP, or 4 as in ± 4% of the GP is unclear and not defined. I'll start with debunking the ± 4GP idea, as the idea mathematically implies that you can have a GP gain that is +1.2 plus or minus up to 4GP. Obviously we know that negative GP gains are no longer possible, so this therefore gives a range of +0.01 to +5.2 as the GP gain calculated from the +1.2 ± 4GP formula.

This can easily be disproven by noticing that the GP gain of a foal over its parents at GP levels near that of a foundation horse (350GP) is well above +5.2. On the International server as of December 2014, the average GP gain from foundations has been observed to be closer to +35GP, and the regional servers under the same circumstances are observed to have an average GP gain of +15GP. In cases where the gains of horses at that level of GP have been lower, the primary factor has been a lower BLUP of the parents.

The ± 4% version of the 'random variance' explanation is even more outlandish, as when it's explained by players it's implied that the total GP formula is +1.2 plus or minus 4% of the GP. If the parents of a foal have a GP of 1,000 then this gives a GP gain of up to 40GP, which even for foundation horses is a stretch. This disproves both theories, and thus the inaccurate nature of the accepted explanation should be clear.

The issue with the commonly accepted theory as stated before is that it's not pinpoint enough, and entirely ignoring for a moment that the math of those theories fails in the reality of the game when observing GP gains, it needs to be understood that putting something down to 'random variance' isn't helpful when there are consistently players who wish to have a semi-precise calculation for GP gain.

An example of this, which is based on multiple different posts by different players, is when a player asks what the GP of their foal will be if the parents have particular GPs. Here are all of the formulas and explanations that have been recently seen posted by various players in response to that type of topic:

(1) GP formula = Parents combined GP / 2

(2) GP formula = (Parents combined GP / 2) + 1.2

(3) GP formula = (Parents combined GP / 2) + 1.2 ± 4

(4) GP formula = (Parents combined GP / 2) + 1.2 ± 4%

If you do the math for some example GPs, you'll see the problem with the above formulas. They don't account for a trend easily visible in the game, which is as you approach the current top GP in the game, your GP gains drop. This is clearly visible if for example one looks at the International server, where foals of foundations achieve GP gains of around +35, and yet the foals of the horses at the top GPs (4000+) only achieve gains of around +0.05.

In fact, formula (4) implies that the higher the GP of the parents, the greater the potential for a higher GP gain, because 4% of 350 is less than 4% of 3,000. This is the opposite of what is observable on the game.

*The Game Manual's Explanation*

The game's manual also says a little bit about GP gain, but it's clearly outdated. The information given is as follows:

> *"If the average BLUP of the parents is below 0, the foal will have a greater chance of having a genetic potential that is lower than that of its parents, and the other way around if the average BLUP is above 0."* [1]

This statement alone hasn't been true for quite some time, as negative GP gains are no longer possible (excluding Donkeys of course). The rest of the information on the GP gain can be disregarded because clearly the information has not been kept up to date and despite the currently accepted formula being labelled as official; clearly the editors of the in-game official help haven't incorporated it into their help pages.

The administrators of the game allegedly make every effort to hinder technical explanations of the game mechanics becoming public knowledge unless they themselves publish it, and this would appear to hold true for a number of mechanics that have very fuzzy technical details including but not limited to: the lesson price formula, and more specifically exactly when it changes from 60 equus lessons to 59 equus lessons, competition prestige, and others. Arguably it's entirely understandable why they don't publish the technicalities behind most mechanics, as frankly the demographic of the game doesn't warrant it along with other reasons. Anyway, the main point is that there's no official information published by Owlient on GP gain that appears recent or accurate.

[1] Howrse Breeder's Manual, International Server, Section 4.2 under 'Genetic potential'

*A Linear Concept*

We've discussed how the foals of low GP horses will have a greater different from the parents (GP gain) than the foals of high GP horses. Figure 1 shows this relationship between the average GP of the parents and the GP gain of the foal at different GPs.

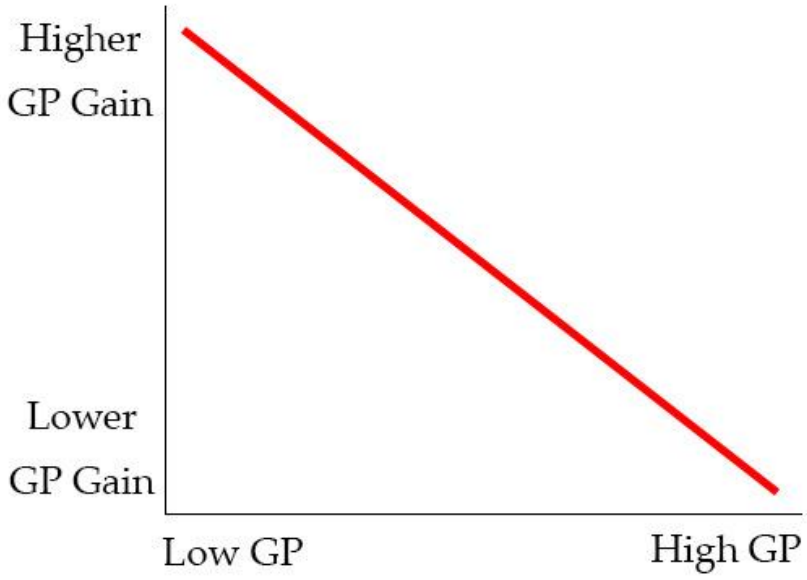


Figure 1: Low GP parents results in high GP gains, high GP parents result in lower GP gains

The above concept makes intuitive sense if you think about how it controls the game. The higher your GP, the more hindered you are in creating horses that are better than the people with lesser GP horses, thus allowing the people with lower GP horses to have a greater chance in becoming even with you. Think of it like a 'tax', where because the high GP breeders must know breeding quite well in order to have high GP horses, whereas the breeders with low GP horses may not have as good a grasp of breeding. Thus, to make it even between breeders of different skill levels, a 'tax' is implemented to ensure that the skilled players don't overtake the lesser skilled players as easily and create a GP monopoly. The high GP breeders still have high GP horses and will continue to have them, but it's harder for them to maintain relative high GP because they're high GP already.

*Creating A New Formula*

It's intuitive that two sets of horses that have the same BLUP but with radically different GPs will result in foals where the GP gain is greater for the parents with a lower average GP. Having shown this graphically and explained why it's a good thing, it's now time to look into the exact trend for GP gain to see just what sorts of GP gains to expect when the parents have a particular average GP.

The graph below (Figure 2) shows the average GP gains at different GPs, where two parents both with 100 BLUP have their foals GPs standardized and checked against many other 100 BLUP horses of the same GP with foals. The data was collected from horses starting at 350GP all the way to the top GP, and in this case on International the top GP was about 4,030. As you'll see in both graphs, the average GP gain at 350 GP increases as the top GP in the server increases.

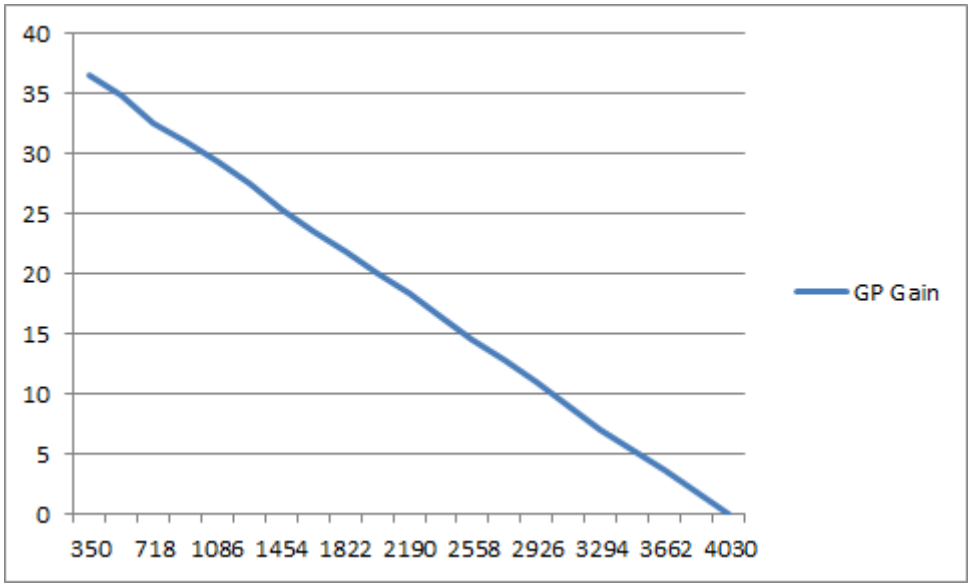


Figure 2: (INT) The average GP gains at a variety of GPs, with the parents having 100BLUP.

Figure 3 is a similar graph taken from the Canadian server as of December 2014.

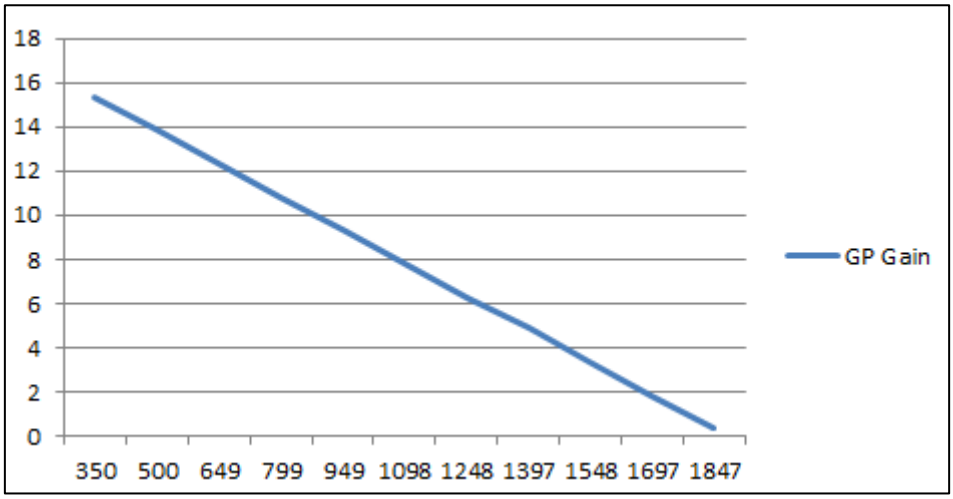


Figure 3: (CA) The average GP gains at a variety of GPs, with the parents having 100BLUP.

In parallel to this data being collected, an attempt was made to create a mathematical formula which would give the expected average GP gain based on the GPs of the parents as well as the top GP in the game. In creating the formula, an interesting trend was discovered that is visible in both of the above graphs (Figure 2 & 3). If you look at the top GP shown in each graph, and compare it to the top value visible on the $y$ axis of the graph, there's a relationship.

Before I continue, it's worth noting that 350GP is in fact not the lowest GP and that if you include a GP of 0 on that graph the GP gains would continue on upwards and to the left. In essence, I propose that at a theoretical GP of 0, the average GP gain follows the formula (*Top GP / 100*). This notion follows the slope of the line in both graphs and it's the most important piece of information because with that initial calculated average GP gain at a theoretical GP of 0 that's based on the top GP, you can work out the line and thus the gains for other GPs.

To create a formula based on the information discussed above, start off with the following:

$$Average\ GP\ Gain\ at\ 0GP = \frac{Top\ GP}{100}$$

The above formula is the GP gain at a theoretical 0 GP, and in order to work out the GP gain at any GP between 0 and the top GP you'll need to think about what percentage the GP you're working with is of the top GP. For the sake of argument, let the top GP in the game be 2,000. A GP of 1,000 would be 50% of our example top GP, a GP of 500 would be 25% of the top GP, and finally a GP of 350 would be 17.5% of the top GP in the example assuming the top GP is 2,000.

You can use this notion of percentages and multiply them against our currently drafted GP gain formula to get the an idea of the average GP gain at a particular GP; however you have to do this in an inverse way because GP gains increase the further the GP is from the top GP, so one must multiply the current working formula by (100 – the % discussed above).

The above information added to the current draft formula would be:

$$Average\ GP\ Gain = \frac{Top\ GP}{100}\ *\ (1 - \frac{Parents\ Average\ GP}{Top\ GP})$$

To recap, the formula above is stating that we're taking the top GP on a server and dividing it by 100, and multiplying that value by one minus the percent that the current GP is of the top GP. For example, if the GP of two horses is 1,000, and you're trying to calculate the GP gain, and the top GP on the server is 4,000 GP (for example), then 1,000 GP is 25% of 4,000 GP and so you'll have (1 – 0.25).

*New Formula Tested*

To test out the current draft formula, use an example top GP of 2,000 together with some testing GPs for some imaginary parents, to work out the GP gain of the foal.

| *Average GP of parents* | *Substituted Formula* | *Calculated Average GP Gain* |
|---|---|---|
| 350 (17.5% of top GP) | 2000 / 100 * (1 – (350 / 2000)) | 16.5 |
| 1,000 (50% of top GP) | 2000 / 100 * (1 – (1000 / 2000)) | 10 |
| 1,500 (75% of top GP) | 2000 / 100 * (1 – (1500 / 2000)) | 5 |
| Top GP is 2,000 | | |

As shown above, the closer in GP horses are to the top GP, the lowest the GP gains of the foals from those horses. An interesting sidenote that may be quite amusing to you is that to get within 100 GP of the top GP takes about the same number of aging points no matter which server you do it on. On International, getting from 350 GP to just behind the top GP of 4,000 takes roughly the same number of aging points as it would on the United Kingdom server to get from 350 GP to behind their top GP of about 1,800. This is all due to the scaling of GP gains against the top GP.

If you perform these calculations yourself, you will notice one problem with the formula so far, and that is if the top GP is a number such as 2,000, and you try to calculate the GP gain from parents with average GP of that same number 2,000 or just under the example top GP of 2,000, you'll get a projected average GP gain of 0 or very close to it. Considering that in reality on the regional servers where the top GP is close to 2,000 and the GP gains are around 0.4, it seems odd that the formula doesn't reflect that. If this is something you've noticed, well done, and this opens up another chapter of the GP gain formula to explain and account for this.

*Extending The Formula*

To put it simply, the GP gain formula is incomplete in the sense that it needs to include the average GP gain that the top GP horses are getting, so that you can ensure that all horses below the top GP get the same or above the GP gain that those top GP horses get. While this investigation has tried to go into great depth regarding the GP gain formula for all horses below the top GP, there is not an established or even theoretical formula that has been worked out by the author of this investigation, and it's suspected that the top GP horses' GP gains are actually governed by an entirely different dynamic that is potentially based on how far ahead GP wise the top breeding group is from other breeding groups. However, all is not lost because as long as one knows roughly what GP gains the top GP horses are getting, one can still calculate GP gains quite accurately.

To make things simple and to complete the basic GP gain formula, simply add in the suspected GP gain that the top GP horses get. Below is a list of the approximate and average values of the top GP gains on a few of the servers as of December 2014.

| | | |
|---|---|---|
| International | Top GP around 4,030 | Gains of around 0.04 |
| US, UK, CA, AU | Top GP around 1,800 – 1,900 | Gains of around 0.4 |
| French | Top GP around 6,000 | Gains of around 0.4 |

Thus, the final GP gain formula as discussed will look like this, and keep in mind there's still more to all of it but this formula will still take you a long way.

$$Average\ GP\ Gain = \frac{Top\ GP}{100} * (1 - \frac{Parents\ Average\ GP}{Top\ GP}) + Top\ GP\ Gain$$

*How BLUP Affects GP Gain*

As expected, there is a little controversy and difference of opinion as to how BLUP affects GP gains, however, alongside a near-accurate GP gain formula is another mathematical formula that explains how BLUP affects the GP gains of a foal from the average GP of the parents.

It's worth briefly touching on what the commonly accepted theory is for the effect of BLUP on GP gain, as there's some merit to it. It is commonly believed that a BLUP of 70 or 75 is all that is needed to achieve maximum GP gain, or at least many believe it's 'good enough' for GP gain. Without even touching on the formula for BLUP, between 70 and 80 BLUP is more or less 'good enough' for GP gains, simply due to the extra time required to achieve 100 BLUP.

Negative GP gains are no longer possible, and thus any BLUP above -100 will result in a GP gain. It would also not make much sense not to reward individuals that choose to BLUP their horses to 100, and finally it makes the programming much easier if you take BLUP into account all the way up to 100. For all of these reasons, GP gain will not be maximised if the BLUP of either parent is less than 100. Below is the mathematical formula for calculating what percentage of the maximum GP gain a foal will receive based on the average BLUP of its parents.

$$\frac{\frac{1}{2}Parents\ Combined\ BLUP + 100}{200}$$

The reason this formula works is because there are 200 points of BLUP (-100 – 100), and thus if the BLUP is 0 it's actually 50% of those 200 BLUP points. With that in mind, 70 BLUP is 85% of the BLUP, 80 BLUP is 90% of the BLUP, etc. Therefore, it makes sense that that's the percentage of the maximum GP gain you'll receive.

*The Complete Formula*

Now that there has been an explained and established formula that calculates a near-accurate prediction of the GP gains of a foal and formula that explains how the average BLUP of the parents will affect the calculated GP gain, it's time to put them together. Sticking the two formulas together is as easy as it sounds, because all that is required is for the GP gain formulas final answer to be multiplied by the BLUP formula.

$$Average\ GP\ Gain = (\frac{Top\ GP}{100} * (1 - \frac{P.A.\ GP}{Top\ GP}) + TGPG) * (\frac{P.A.\ BLUP + 100}{200})$$

Where P.A. means 'Parents average' in the case of parents average GP and parents average BLUP. TGPG is the top GP gain (or an estimate of it at least).

There you have it – a formula that gives a close approximation of the average GP gain of a foal based on the average GP and BLUP of the parents, along with the top GP in the server and likely gains the top GP horses are getting. If you're lazy you can leave out the top GP gain part from the equation (and for low GPs this is fine), but if you do, keep in mind that the calculated average GP gain will then be the additional GP gain over whatever gain the top GP horses get.

There is just two gaping holes left in the equation as it stands now, and I've left these problems alone until now because they're both quite a handful. The first problem is calculating what GP gain the top GP horses get, which as mentioned briefly before remains unsolved and is likely based on criteria such as how far ahead the top GP is from everyone else. The second problem with the formula as it stands now is it doesn't account for random variance, which contrary to what this investigation first stated is still applicable. There is indeed random variation but the author of this investigation believes it to be calculated differently to what you'd likely expect.

*A Revised Random Variance Concept*

As discussed earlier there it is still observed that there's random variation on either side of the average GP gain formula proposed in this investigation. A significant number of tests at this point have not turned up a 100% accurate formula for this random variation, however there is a near-approximation that seems to give a random variation range that holds true in most cases. The formula is shown below, and it implies that the range of possible GPs for a foal is based on the average GP gain plus or minus the random factor.

$$GP\ Gain\ Range = Average\ GP\ Gain \pm \frac{\sqrt{Average\ GP\ of\ Parents}}{100}$$

The formula to calculate the random factor seems to hold true in most cases, and as of yet the author has not seen a case where the GP gain of a horse hasn't fit into the GP gain range from the above formula, however further testing would need to happen. Taking the square root of the average GP of the parents and dividing it by 100 essentially implies that the higher the GP, the more random the variance. This may of course not be true and in fact the random variance may be based off of a static percentage of the average GP gain, however trial and error can be employed to find whatever seems to work the best in most cases.

There isn't enough room to fit the full GP gain formula including the random factor and the BLUP multiplier, so I'll just include this simplified explanation of the formula and one should be able to expand it by using the formulas discussed previously.

$$GP\ Gain\ Range = (Average\ GP\ Gain \pm The\ Random\ Variance) * BLUP\ Coefficient$$

## *Afterword*

The author extends their gratitude to you, the reader, for reading through this investigation regarding the mechanics behind the GP gains on Howrse, and the hope is that this information can be of use or at least tie up the loose ends and perhaps even put an end to the unhelpful information surrounding GP gain calculations already in circulation and those accepted by most players.

Further research needs to be done particularly in testing the formulas proposed by this investigation and finding out where the calculations fail, however the original ambition of the author was to create a near-approximation of the GP gain formula that holds true in most cases.