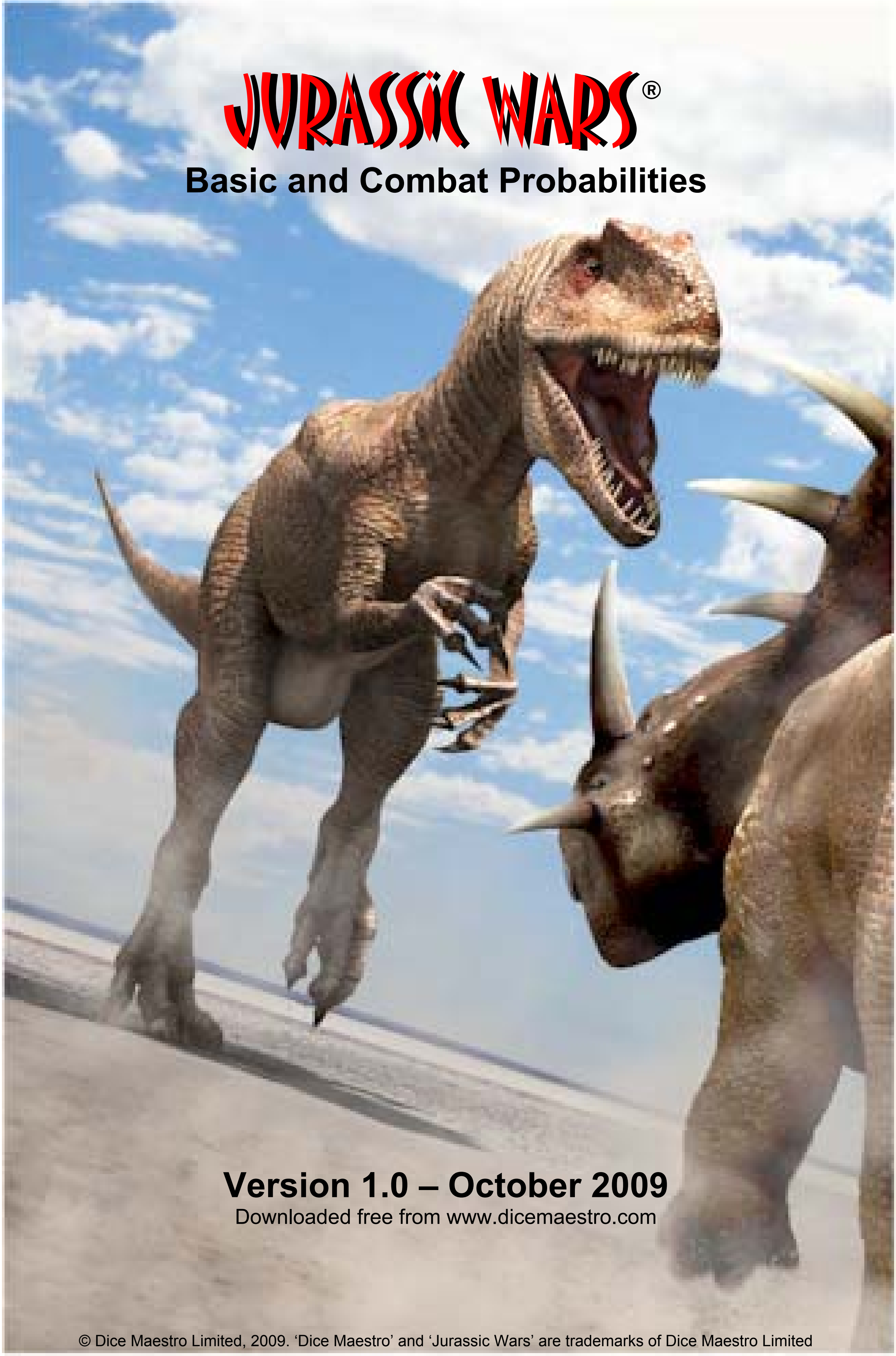

JURASSIC WARS®

Basic and Combat Probabilities

Version 1.0 – October 2009

Basic Probabilities

Jurassic Wars is a dice-based game and so luck is a major element in determining the winner but it is mistaken to believe that judgement has no role to play. Just as Butler observed that “Probability is the very guide to life” probability is also the very guide to *Jurassic Wars*. Even though a game can be won without understanding the underlying probability at all, games will not be consistently won against players who do.

In Jurassic Wars Basic Probabilities are the chances of scoring hits between generic dice ratings such as 3-Green versus 2-Red. Unlike Combat Probabilities they do not take the rank of the dinosaur into consideration.

The most fundamental point is to understand the difference between the green and the red dice. We need to remember that the red die has a star on three faces and so there are 3 ways out of 6 that a red die will make a hit. Therefore, the probability the red die will make a hit is ½. We will write this as Pr (Red 1-Hit) = 0.5. There are also three ways that a red die will turn up blank and make no hit. Therefore Pr (Red 0-Hit) = 0.5. A green die has a star on only two faces and so there are only 2 ways of 6 that the green die will make a hit or Pr (Green 1-Hit) = 0.33 and 4 ways out of six it will make no hit or Pr (Green 0-Hit) = 0.67.

What is the basic probability that a 1-Red beats a 1-Green? We can calculate this in two ways. First we can calculate it theoretically. The table below shows all four outcomes of a throw each between a red die and a green die.

	Green 0-Hit	Green 1-Hit
Red 0-Hit	No hits – dice re-thrown	Green scores a hit
Red 1-Hit	Red scores a hit	Equal hits – dice re-thrown

Table 1: Possible outcomes of 1-Red versus 1-Green

We can see that out of the four outcomes, red scores a hit, green scores a hit and there are two draws or re-throws. We can ignore draws because in the event of a draw both dice are re-thrown until a difference is obtained. Therefore, we get the following probability matrix for scoring hits.

	Pr (Green 0-Hit) = 0.33	Pr (Green 1-Hit) = 0.67
Pr (Red 0-Hit) = 0.5	-	0.165
Pr (Red 1-Hit) = 0.5	0.335	-

Table 2: Probability ratio of 1-Red versus 1-Green

We can derive the probabilities we’re interested in by dividing each number by the total of the two. From this it is easy to calculate that the Pr (Green scores a hit) = 0.33 and Pr (Red scores a hit) = 0.67. As we are dealing with only one die for each combatant if follows that whoever scores the hit wins the combat. Therefore, we have theoretically arrived at the following two basic probabilities:

Pr (1-Red beats 1-Green) = 0.67 or 67%

Pr (1-Green beats 1-Red) = 0.33 or 33%

The second way to calculate the probabilities is by computer simulation. Dice Maestro modeled the game mechanism and simulated well over 10 million individual combats during the development of the game. The Basic Probability table shows the results of 10,000 combats each between the different combinations of dice. For the table we can see that 1-Red beats 1-Green on 6,670 times out of 10,000. This equates to a probability of 0.667 - and hence the computer model is extremely accurate. The advantage of using the model is that some of the theoretical calculations with larger numbers of dice become fiendishly involved and highly complex.

The Basic Probability table reveals some surprising results. What is the probability that 2-Red beats 1-Red? A little reflection probably suggests that it would be 0.67 or something close to it. In fact, the table shows that 2-Red wins on 9,005 times out of 10,000 or with a probability of 0.9. This can be checked theoretically. From Table 3 it can be seen that Player 2 (with 2-Red) scores a hit against Player 1 (with 1-Red) on four out of the eight possible outcomes. As Player 1 is throwing with only 1 red die, these are sufficient to win the combat for Player 2. Player 1 scores a hit against Player 2 just once but the outcome is not a victory for Player 1 because Player 2 loses one die and both players then roll with one red die each. The outcome of *this* subsequent round of throws is that both players have an equal chance of winning and therefore the expected outcome of the whole combat is 4½ wins for Player 2 compared to only ½ for Player 1. Rounding up, this works out at 9:1, as the computer model accurately shows.

Player 1	Player 2		
Red Die	1st Red Die	2nd Red Die	Outcome
0-Hit	0-Hit	0-Hit	Draw and re-throw
0-Hit	0-Hit	1-Hit	Player 2 Wins
0-Hit	1-Hit	0-Hit	Player 2 Wins
0-Hit	1-Hit	1-Hit	Player 2 Wins
1-Hit	0-Hit	0-Hit	Player 2 Loses 1 Die
1-Hit	0-Hit	1-Hit	Draw and re-throw
1-Hit	1-Hit	0-Hit	Draw and re-throw
1-Hit	1-Hit	1-Hit	Player 2 Wins

Table 3: Possible outcomes of 1-Red versus 2-Red

We now have two more Basic Probabilities: Pr (1-Red beats 2-Red) = 0.10 or 10% and Pr (2-Red beats 1-Red) = 0.90 or 90%. The Basic Probability table provides the probabilities for all possible combinations of combat. The margin of error is approximately 1%.

Combat Card Effects

During a game does it matter which combat card is played and when. Emphatically yes. The Basic Probability can help us understand the effect of each type of combat card. The effect of Surprise Attack is the easiest to see. When played it reduces the dice rating of the opposing dinosaur by 1. So, using the above example, if Player 1 plays a Surprise Attack Card, Player 2 is reduced from 2-Red to 1-Red. Hence, the probability that Player 1 wins the combat against Player 2 leaps from 0.1 to 0.5.

The effect of First Blood is a little more complicated to calculate. First Blood only affects the first throw of a combat. Table 4 shows the outcomes of the first throw in combat in our running example. It can be seen that both players win one combat outright while in three others the effect is to reduce Player 2 to 1-Red, which means in subsequent throws each player is rolling with 1 red die each. Across these five possible outcomes the probability of success is equal. However, three possible outcomes are draws and this means in subsequent throws Player 1 is back to 1-Red *without* any First Blood effect but Player 2 remains 2-Red. We are back to the original distribution as shown in Table 3. This provides the edge to

Player 2. The final outcome is Pr (2-Red beats 1-Red with First Blood) = 0.67 or put another way: the probability that Player 1 wins the combat increases from 0.1 to 0.33.

This shows that Surprise Attack is generally a more effective card than First Blood. Extreme Aggression is the most unpredictable Combat card because it involves re-throwing. Quite simply, it can be the most effective card of all (e.g. throwing a no-score and then re-throwing three hits) or be totally ineffective. However, it will be more effective when used with carnivores because a re-roll of red dice is more likely to score than a re-roll of green dice. Judgement is required if Combat cards are to be used effectively.

Player 1 With First Blood	Player 2		
Roll of Red Die	Roll of 1st Red Die	Roll of 2nd Red Die	Outcome
0-Hit + 1	0-Hit	0-Hit	Player 2 Loses 1 Die
0-Hit + 1	0-Hit	1-Hit	Draw and re-throw
0-Hit + 1	1-Hit	0-Hit	Draw and re-throw
0-Hit + 1	1-Hit	1-Hit	Player 2 Wins
1-Hit + 1	0-Hit	0-Hit	Player 1 Wins
1-Hit + 1	0-Hit	1-Hit	Player 2 Loses 1 Die
1-Hit + 1	1-Hit	0-Hit	Player 2 Loses 1 Die
1-Hit + 1	1-Hit	1-Hit	Draw and re-throw

Table 4: Possible outcomes on the *first throw* of 1-Red with First Blood versus 2-Red

Combat Probabilities

Combat probabilities take rank into consideration and provide the probabilities for combats between specified dinosaurs. Rank is not merely a rough guide to combat effectiveness of a dinosaur it actually affects combat because in combats where three successive draws occur the lower-ranked dinosaur loses a die. This means that among dinosaurs of the same dice rating, say 3-Red, the higher ranked will have an edge overall.

This is most easily seen when we examine the 3-Red dinosaurs versus the *Ankylosaurus* (Rank 2). In combats with the *Tyrannosaurus* (Rank 1), if three successive draws occur the advantage goes to the *Tyrannosaurus*. But this is not the case when the *Ankylosaurus* is in combat with either the *Tarbosaurus* (Rank 5) or *Allosaurus* (Rank 3); now the herbivore is ranked higher and it gains the advantage.

The Combat Probabilities table provides all the possible combats – the probabilities are generated by computer simulation. From the table we see that against the *Ankylosaurus* we have the following probabilities of victory for the three carnivores:

Tyrannosaurus 57.3%
Allosaurus 51.1%
Tarbosaurus 51.6%

There is no statistical difference between the last two but there is a significant edge – approximately 6% - to the *Tyrannosaurus* compared to the other two 3-Red dinosaurs. This edge grows the more likely that ranked is used in combat e.g. if it were invoked after two consecutive draws rather than three. With the rule variation of unlimited draws (see *Rules Variations and Game Versions* document) this edge disappears and there is no advantage to higher rank dinosaurs. Players can decide which they prefer.

They fought tooth and claw for 160M years… Let the battles begin again.

Jurassic Wars® Basic Probabilities

Assumes unlimited rolls per combat (i.e. non-standard standard rules).

Read across for wins and down for defeats. Example: The probability that 1-Red wins against 1-Green is 66.7% (6670 / 10000) and loses is 33.3% (3330 / 10000)

Base: 10k combats	**1-Red**	**2-Red**	**3-Red**	**1-Green**	**2-Green**	**3-Green**	**4-Green**
1-Red	5000	995	80	6670	2675	620	95
2-Red	9005	5000	1585	9590	7450	4300	1805
3-Red	9920	8415	5000	9980	9510	7930	5460
1-Green	3330	410	20	-	1340	205	15
2-Green	7325	2550	490	8660	5000	1945	520
3-Green	9380	5700	2070	9795	8055	5000	2340
4-Green	9905	5195	4540	9985	9480	7660	5000

Note: Figures in the table have been rounded to the nearest 5.

Read across for victories and down for defeats. For example, reading across 1-Red is expected to win 6,670 times for every 10,000 combats against a 1-Green. Reading down 1-Red is expected to lose 3,330 times for every 10,000 combats against 1-Green (or reading across 1-Green is expected to win 3,330 times). From this it is easy to derive the Pr (1-Red beats 1-Green) = 66.7%. The odds of 1-Red winning against 1-Green are 2 to 1 on, or 3 for 2. The Pr (1-Green beats 1-Red) = 33.3%. The odds for a 1-Green victory are 2 to 1 against, or 3 for 1.

They fought tooth and claw for 160M years… Let the battles begin again.

Jurassic Wars® Combat Probabilities

Assumes standard rules and does **not** take into account the Game Period.

Read across for wins and down for defeats. Example: The probability that the *Dryosaurus* wins against the *Troödon* is 29% (2893 / 10000) and loses is 71% (7107 / 10000)

Base: 10k combats	**20**	**19**	**18**	**17**	**16**	**15**	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Dryosaurus (20)		2893	1017	2911	1007	321	976	332	155	352	171	348	151	354	17	14	17	22	20	13
Troödon (19)	7107		2160	4325	2120	829	2084	827	458	875	445	861	450	832	68	77	76	79	63	71
Iguanodon (18)	8983	7840		6800	4388	2303	4386	2294	1634	2333	1693	2312	1708	2181	429	415	411	375	449	456
Sarcosaurus (17)	7089	5675	3200		2150	839	2135	863	467	836	461	814	442	818	66	66	63	66	57	84
Styracosaurus (16)	8993	7880	5612	7850		2303	4417	2297	1574	2271	1625	2361	1617	2334	424	426	443	413	447	417
Dromaeosaurus (15)	9679	9171	7697	9161	7697		6983	4629	3896	4608	3912	4569	3826	4519	1542	1437	1595	1410	1605	1424
Amargasaurus (14)	9024	7916	5614	7865	5583	3017		2302	1655	2313	1669	2296	1642	2301	465	449	449	422	449	421
Deinonychus (13)	9668	9173	7706	9137	7703	5371	7698		3854	4537	3868	4605	3818	4660	1574	1396	1592	1472	1621	1318
Apatosaurus (12)	9845	9542	8366	9533	8426	6104	8345	6146		5322	4535	5335	4672	5322	2103	1959	2123	1877	2158	1784
Utahraptor (11)	9648	9125	7667	9164	7729	5392	7687	5463	4678		3807	4630	3884	4614	1576	1427	1640	1475	1647	1373
Stegosaurus (10)	9829	9555	8307	9539	8375	6088	8331	6132	5465	6193		5361	4605	5373	2161	1842	2090	1970	2048	1886
Carnotaurus (9)	9652	9139	7688	9186	7639	5431	7704	5395	4665	5370	4639		3834	4543	1643	1424	1580	1447	1633	1361
Triceratops (8)	9849	9550	8292	9558	8383	6174	8358	6182	5328	6116	5395	6166		5357	2128	1928	2110	1887	2094	1929
Megalosaurus (7)	9646	9168	7819	9182	7666	5481	7699	5340	4678	5386	4627	5457	4643		1646	1445	1638	1447	1622	1342
Sauropelta (6)	9983	9932	9571	9934	9576	8458	9535	8426	7897	8424	7839	8357	7872	8354		4275	4699	4336	4719	4319
Tarbosaurus (5)	9986	9923	9585	9934	9574	8563	9551	8604	8041	8573	8158	8576	8072	8555	5725		5207	4733	5109	4808
Shunosaurus (4)	9983	9924	9589	9937	9557	8405	9551	8408	7877	8360	7910	8420	7890	8362	5301	4793		4315	4758	4414
Allosaurus (3)	9978	9921	9625	9934	9587	8590	9578	8528	8123	8525	8030	8553	8113	8553	5664	5267	5685		5164	4745
Ankylosaurus (2)	9980	9937	9551	9943	9553	8395	9551	8379	7842	8353	7952	8367	7906	8378	5281	4891	5242	4836		4266
Tyrannosaurus (1)	9987	9929	9544	9916	9583	8576	9579	8682	8216	8627	8114	8639	8071	8658	5681	5192	5586	5255	5734	